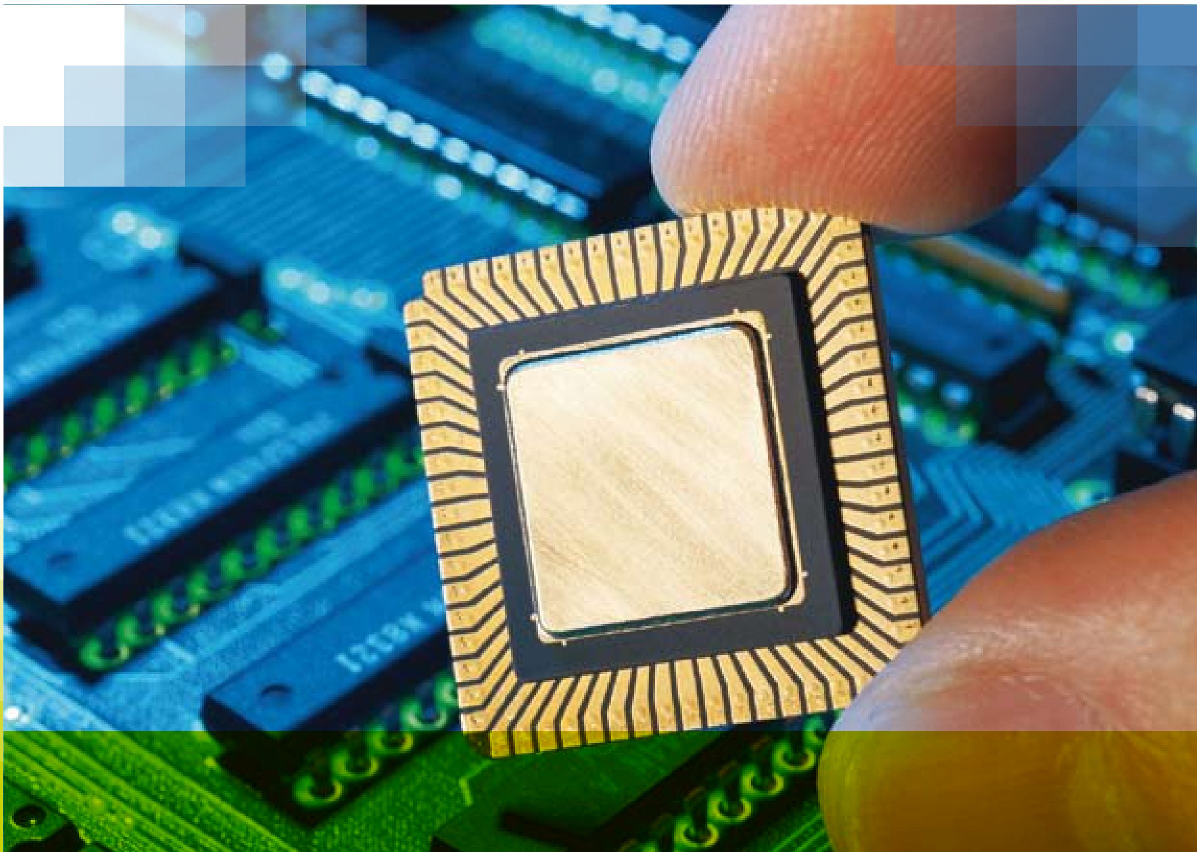
MASTERING INNOVATION
SHAPING THE FUTURE

ESIA 2008 Competitiveness Report

2008

EECA ESIA

European Semiconductor Industry Association



FOREWORD

Welcome to the new 2008 report of the European Semiconductor Industry Association, titled *'Mastering Innovation – Shaping the Future'*.

ESIA believes that this report is well timed, since this year we have celebrated the 50th anniversary of the Integrated Circuit. This invention has driven the growth of an entire industry and has revolutionised society by enabling a wide range of other products and services that improve people's lives. None of the goods or services that make modern life possible, such as today's mobile communications or the internet to name just two domains, would be possible without the integrated circuit.

Also, in 2008, we have seen many strategic and transformational moves within the European semiconductor industry. And, with difficult economic conditions prevailing, it is fair to say that the semiconductor industry in Europe now is at a crossroads. Many of the paradigms that ruled semiconductor industry economics in the 20th century are no longer valid. This drives changes – described in this report – that require our industry to adapt and to refocus on those issues that are key to future success. In the course of this transformation process, not only the industry will be affected, but also the environment in which it operates.

Against this background, this second ESIA Competitiveness Report calls for concerted actions by all relevant stakeholders – including EU authorities, EU Member States and EU knowledge institutions. Taking such actions is a prerequisite for Europe to take advantage of the opportunities offered by the changing industry and technology landscape.

ESIA is very pleased to present this report that makes recommendations on the choices that both industry players and authorities need to make at this crossroads, as these will determine the long term success for an innovative semiconductor industry in Europe and for European prosperity.

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Frans van Houten
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Enrico Villa
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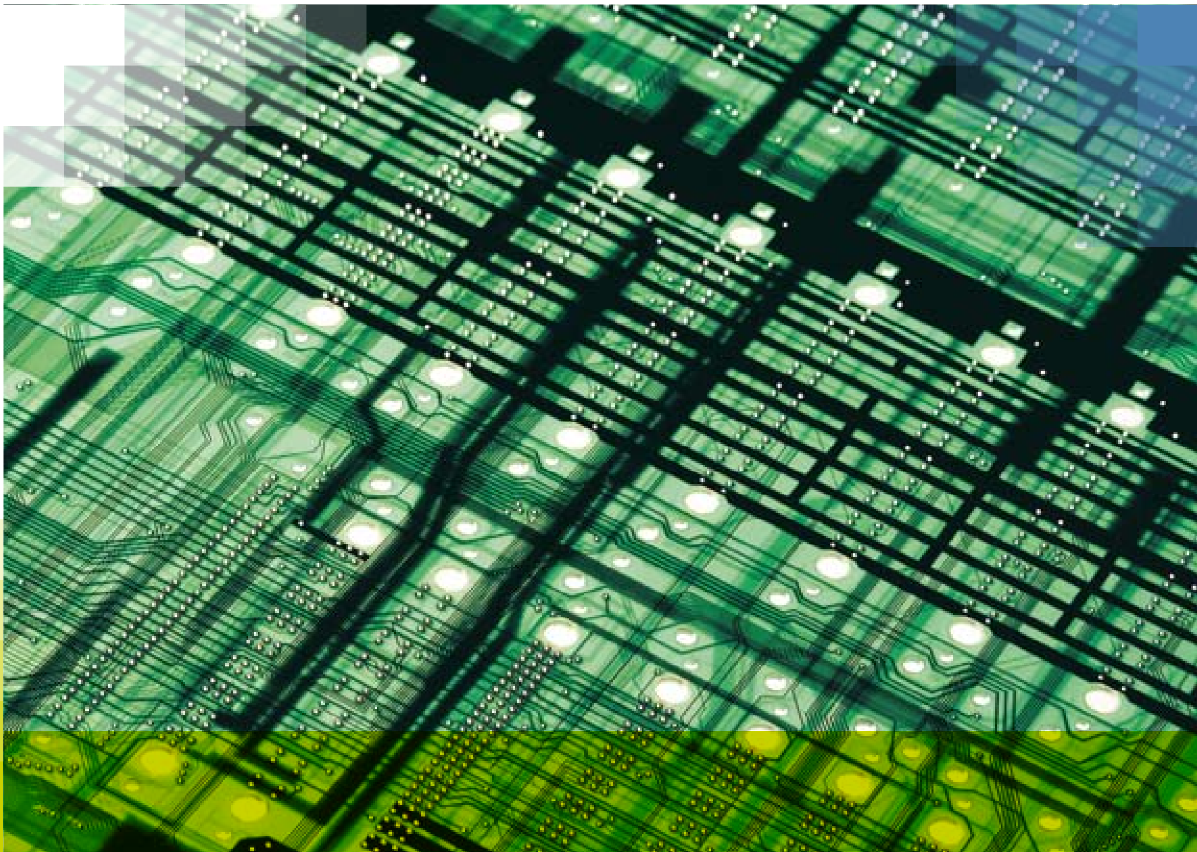

EXECUTIVE SUMMARY

Semiconductors are crucial to Europe's competitiveness. They enable 90 percent of the key technologies and innovations required for advancing a sustainable information and communication economy and directly contribute to generating approximately 10 percent of both European and worldwide GDP. Therefore, a vital semiconductor industry is essential if Europe is to remain one of the world's leading knowledge-based economies and realise the European Union's ambition of putting the Information Society at the heart of its strategy for the 21st century.

In the late 80's and early 90's of the last century, the semiconductor industry in Europe went through a major recovery. During this phase, many local and national champions consolidated. While this was a painful adaptation, the European semiconductor industry emerged stronger than before, generating a robust European presence in the global semiconductor market by the end of the 20th century.

This leadership position was built in a favourable political and economic environment - that also attracted significant foreign investments - and depended on continuous R&D efforts, which continue to be among the highest of all industries. Such efforts are required for engineering, designing and manufacturing products for leading electronic equipment manufacturers in application areas such as wireless communications, automotive, identification, power management and industrial equipment. Even today, these application areas continue to be areas of European strength.

However, the semiconductor industry continues to change. Following the semiconductor boom and bust cycle during the years 2000 and 2001, the map of the global semiconductor landscape has been redrawn: the roles of the various economic regions of the world have been redistributed as new players have emerged and competitive pressures continue to increase. At the same time, the complexity of semiconductor products is increasing dramatically while the investments required to sustain an up-to-date manufacturing base explode. In this global environment, the semiconductor industry in Europe needs to stay ahead of its competition, even though – according to our analysis - the attractiveness of Europe has deteriorated from what it was in 2005.

The key question, therefore, is how to retain and restore competitiveness in Europe in light of the need to address the opportunities emerging from the changes in the industry described above. Europe must reassess existing paradigms and reconsider its priorities in order to take advantage of these industry transformations.

In answer to this question, twelve major trends concerning the focus areas of *'R&D'*, *'Applications'* and *'Production'* are identified in this report. These trends will determine what the semiconductor industry in Europe will look like in the future. The assessment of these trends shows whether they are working for or against European interests. It also indicates the ways Europe can turn the opportunities suggested by these developments into a sustainable competitive advantage for the region and for its semiconductor industry.

According to ESIA, Europe must react to these shifts in the industry and benefit from the opportunities they offer by mastering innovation while taking measures to shape its own future. *'Mastering innovation'* reflects the need for Europe to stimulate a European-led market pull for new application areas and strongly to support investments in micro-/nano electronics R&D to build a European leadership position in a targeted way. *'Shaping the future'* reflects the need for Europe to create the environment needed for these investments to bear fruit so that they can drive overall European prosperity. Here a broad set of measures is required in order to create an appropriate business and investment climate, both for R&D and for sustaining European-based manufacturing capabilities.

ESIA is convinced that leadership in the evolving information society can only be achieved and sustained if Europe retains a vital semiconductor industry. Access to and control over micro- and nanoelectronics remains a precondition for any advanced economy. Therefore, ESIA calls on all relevant stakeholders and decision makers – including EU authorities, EU Member States, universities and research institutes - for concerted action in implementing the measures described in this report and to assure that Europe 'masters innovation' and 'shapes its own future' with a strong semiconductor capability.

Mastering Innovation	Shaping the Future
Stimulating a Europe-led "market pull" for new applications, paving the way toward emerging markets.	Adopt a number of specific regulatory and legislative flanking measures in support of the semiconductor industry.
Establish micro-/nanoelectronics as one of the overriding European R&D investment priorities for EU framework programmes and public-private partnerships.	Leverage the public R&D funding potential that exists in Europe.
	Encourage the role of education as the foundation of intellectual innovation capital and a solid science base.
	Encourage the maintenance and renewal of the European-based manufacturing capability.

Mastering Innovation	
Stimulating a Europe-led "market pull" for new applications paving the way toward emerging markets	Focusing industry-wide innovation incentives on semiconductor systems know-how for new applications.
	Leveraging all the European semiconductor industry's strengths to maintain industries' electronics innovation leadership in the global market.
	Launching cross-industry, cross-border initiatives (clusters, public-private partnerships, etc.) stressing the contributions of semiconductors in specific technology areas.
	Orchestrating a Euro-microelectronics invention awareness programme and encouraging the end-use industry base, from large-scale companies to SMEs.
	Setting objectives for reaching standard agreements for new applications quickly and efficiently in critical development areas demanding high technical performance and quality levels.
Establish micro-/nanoelectronics as one of the overriding European R&D investment priorities for EU framework programmes and public-private partnerships	Seeking a broad alignment of all stakeholders, i.e. the EU Commission collectively represented by DG Enterprise, Information Society, Research, and Competition, EU Member States, companies, universities and research institutions, with the proposed programmes and agendas.
	Promoting and leading international cooperation on issues that are shared with the European industry.
	Fostering the necessary collaborative conditions by creating incentives for all possible forms of clusters, public-private partnerships and ecosystems.
	Applying an improved and Europe-wide generalised / harmonised tax credit scheme for R&D; if necessary by establishing topical specifications related to micro-/nanoelectronics in order to apply it on a case by case basis.
	Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education followed by developing multi-disciplinary curricula in academic training.

Shaping the Future	
Adopt a number of specific regulatory and legislative flanking measures in support of the semiconductor industry	Supporting policy actions at both European and international levels aimed at limiting disadvantageous currency distortions, e.g. the EURO vs. the USD.
	Stimulating the development of regulatory frameworks for labour policies that anticipate and manage change better, e.g. along the lines of the recommendations in the EU green paper.
	Removing possible legislative roadblocks to the introduction of new technologies and systems, in particular in the EHS arena.
	Working in close collaboration with the industry in order to anticipate legislative initiatives and measures in sensitive application areas (e.g. energy, ecology, mobility, health) that will be of significant importance, in particular with regard to the development of nanotechnologies.
Leverage the public R&D funding potential that exists in Europe	Restoring in targeted, EU-wide priority R&D programmes increased public funding levels in alignment with the Lisbon agenda.
	Making available all possible incentive schemes, from R&D tax credits to loans and grants as well as from EU structural funds to national and local measures.
	Encouraging the creation and expansion of new firms in high-technology sectors in order to allow Europe to achieve its R&D potential, calling on EU financial markets and venture capital investment capabilities.
Encourage the role played by education as the foundation of intellectual innovation capital and a solid science base	Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/ microelectronic sciences.
	Leveraging the 'institutional' capabilities academia (universities and research institutes) and regional and local government bodies provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering, etc.
	Opening much more jointly-coordinated and regulated industry training or PhD specialisation opportunities with established R&D institutions.
	Facilitating the mobility of highly-skilled human resources in science and technology (S&T) disciplines allowing for a more targeted cross-border intake of both students and a young R&D labour force.
Encourage the maintenance and renewal of European-based manufacturing capability	Devising a set of framework policies for existing sites that supports the development of manufacturing capabilities for a large range of innovative products and technologies.
	Supporting initiatives that encourage new EU and national-based development programmes aimed at enhancing innovation and manufacturing capabilities in specific application segments.
	Setting adequate priorities to encourage, at EU and national levels, the creation of economic value by diversifying the capabilities of both the device manufacturers and equipment & material suppliers.
	Encouraging the development in Europe of new tools, methods, equipment or materials needed both for 'more Moore' and 'more than Moore' technologies.

INTRODUCTION 1

WHY THIS REPORT

Our 2005 ESIA Competitiveness Report[1] described the semiconductor industry as a key enabler driving advanced technologies and paving the way for creating the applications of the future. In its report in 2006, the EU's High-Level ICT Group confirmed this view, highlighting the industry's manufacturing experience and expertise as "*a key element of Europe's competitiveness*"[2] and acknowledging the semiconductor industry as a major contributor to innovation, productivity gains and job creation.

Despite this recognition of the industry's importance and the awareness created in 2005, the competitive environment has not improved. There is still no level global playing field, even though this is essential for boosting the competitiveness of Europe's semiconductor industry vis-à-vis the rest of the world. Instead, certain weaknesses in the overall economic environment in Europe have added to the competitiveness challenges. These include:

- rapid deterioration of the exchange rate of the EURO relative to the USD,
- public R&D funding policies in the EU and its Member States that do not keep pace with rising R&D costs,
- the complexity of defining dedicated industrial policies setting priorities and framework conditions for specific strategic industrial activities,
- continued low overall interest within the various European educational systems in education for electronics in general and specifically for generating curricula relevant to nanoelectronics.

Although similar factors may be relevant in other geographical locations, we believe that Europe has been hit particularly hard by them. These factors are jeopardizing the competitiveness of the semiconductor industry in Europe, even though that industry remains a major player in the global market.

Viewed in the context of increasing competitive pressures on Europe, the semiconductor industry landscape is evolving rapidly. Over the past few years the semiconductor industry has experienced significant global shifts that have redistributed the roles of the respective world economic regions in the world semiconductor market. There are major trends that are having a profound impact on the semiconductor industry both globally and within Europe. These trends are posing big challenges, of course, but they are also generating new opportunities that are pushing the major industrial players to redefine their technology and business strategies globally.

Because it is affected directly, Europe needs to address the opportunities that emerge from this global shift. Europe must reconsider its mindset and reassess existing paradigms in order to understand these shifts appropriately and to take advantage of the associated trends. It must ask, namely: What opportunities will the newly-emerging semiconductor landscape offer Europe that will ensure a sustainable semiconductor presence for the benefit of the industry and the European economy? This is a challenge, in ESIA's view, shared by both the industry and European policy makers.

Over the past few years the semiconductor industry has experienced significant global shifts that have redistributed the roles of the respective world economic regions

The purpose of this Report, therefore, is to create a broader understanding of specific industry trends and explore their impact on the industry in Europe and on the European economy as a whole. In brief, it addresses the complex question of whether Europe is still attractive for the semiconductor industry and whether the semiconductor industry remains attractive for Europe. ESIA is greatly concerned that, unless action is taken now, the situation may reach a point of no return that will be detrimental both to the industry and to Europe.

1 cf. EECA-ESIA. The European Semiconductor Industry: 2005 Competitiveness Report; Brussels, 2005. [ESIA 2005]
2 European Commission. DG Industry and Enterprise. Fostering the competitiveness of Europe's ICT industry. EU ICT Task force report. November 2006. p.21 [ICT Competitiveness 2006]

TO WHOM IS THIS REPORT ADDRESSED?

The intended audience for this Report consists of all major stakeholders of the semiconductor industry: public authorities at EU and Member State levels; major industrial players in the European economy who integrate semiconductors into their products or services to add functionality; design houses, systems integrators, and finally, semiconductor industry suppliers.

It is crucial that all stakeholders understand the issues of the changing landscape, including the competitive opportunities it offers, and that they be made more aware of why the semiconductor industry remains an essential enabling sector for the future of the European economy at large. Semiconductor companies are reassessing their strategies, be it by aligning their R&D efforts globally, or by balancing their mix of in-house and outsourced manufacturing, in order to deal with a highly competitive environment and to be able to leverage the advantages Europe enjoys in the global market.

The cause is not lost for a strong semiconductor industry in Europe. Public authorities are devising new agendas in areas such as energy saving, environmental conservation, safety in transportation, or all-age health care management. Realising these agendas must be enabled by semiconductor innovations that will make the solutions work. Public authorities therefore play a key role in aligning the interests of 'Europe' and those of the semiconductor industry operating in Europe.

For all semiconductor industry players in Europe this report provides an overview and analysis of how major trends in the industry are playing out from a European perspective. It provides a framework for setting priorities in areas that best match the competitive opportunities in the market and hence justify a continued strong and successful semiconductor presence in Europe. Ultimately, this will benefit all end-user customers by providing them access to the innovative products and solutions semiconductors enable.

APPROACH TAKEN

The report starts with a description of today's competitive environment of Europe and a review of key data of the semiconductor industry. We then have undertaken a systematic analysis of a number of critical trends affecting the semiconductor industry. The methodology of this trend analysis has carried over into an assessment of how these trends impact the industry globally and in Europe, as well as into an evaluation of the ways the interests of the industry match the interests of Europe. Based on this analysis of individual trends, we have made a synthesis to highlight *competitive opportunities.*

Europe wants to remain a world region recognized for creating innovative technologies and products, while the semiconductor industry wants to leverage and promote the advantages Europe represents. These interests are mutually reinforcing. Obviously, the analysis will also reveal areas where no common interest seems to exist, and this may also lead to a beneficial reassessment of existing policies and strategies by all parties.

The trends reviewed all align in multiple and various ways with the opportunities and challenges highlighted in three focal areas: *R&D, Applications* and *Production.* The matching potential that can be derived from the combined interests of the semiconductor industry with the broad scope of those of Europe underscores the enormous potential of the semiconductor industry in Europe. The purpose of such an assessment is to offer a way forward for Europe, pointing to directions as to how best capture the trends and making them to work in and for Europe.

THE SEMICONDUCTOR INDUSTRY IN EUROPE

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This section is comprised of two parts: First, it takes a look at some of the main competitiveness challenges facing Europe's semiconductor industry at the end of the opening decade of 2000. Starting from the analysis made in 2005 (see Fig. 3, Scenarios below), it highlights those competitiveness dimensions that determine the European semiconductor industry's position in the global playing field, dimensions that continue to overshadow progress made in other areas or in areas where Europe remains in a stable position. Second, it provides a complete picture of today's semiconductor industry in Europe and reinforces many of the points observed in the industry's external environment.

A powerful industrial base in Europe

"During the past two decades, Europe has succeeded in establishing a powerful industrial base in semiconductor manufacturing, materials and equipment as well as in semiconductor applications. There has been a steady improvement of Europe's industry in the worldwide ranking of integrated circuit (IC) manufacturers, and Europe's industry now leads in several application areas." (..) "In the foreseeable future, the role of electronics and information systems will further increase as European society is faced with structural problems such as ageing of the population, exploding healthcare costs, transportation bottlenecks, rising energy costs and the need to increase productivity to be competitive on a worldwide basis. European citizens are expecting better health systems, safer cars, improved energy management, improved telecommunications and information access, better entertainment and security everywhere. These societal challenges are also major opportunities for European industry. The challenge is to be the first to address these new lead markets and to become worldwide market leaders in a number of these domains."

cf. [CATRENE White Book 2007] pp.21, 6.

2.1. EUROPE'S COMPETITIVE ENVIRONMENT 2008

The key strategic position of micro- & nanoelectronics as a constant source of innovation and driver of economic growth and competitiveness, both within the information and communications technology (ICT) industry and within the economy as a whole, continues to be recognised and emphasised at all levels[1]. Figures 1 and 2 illustrate the high value added for GDP and the market value across all ICT sectors, both fuelled to a significant extent by semiconductor technologies. (Fig.1, 2) The fact that regions or states continue to target their industrial policy specifically on this area bears witness to the enabling importance of semiconductors reaching well beyond the industry itself. [2]

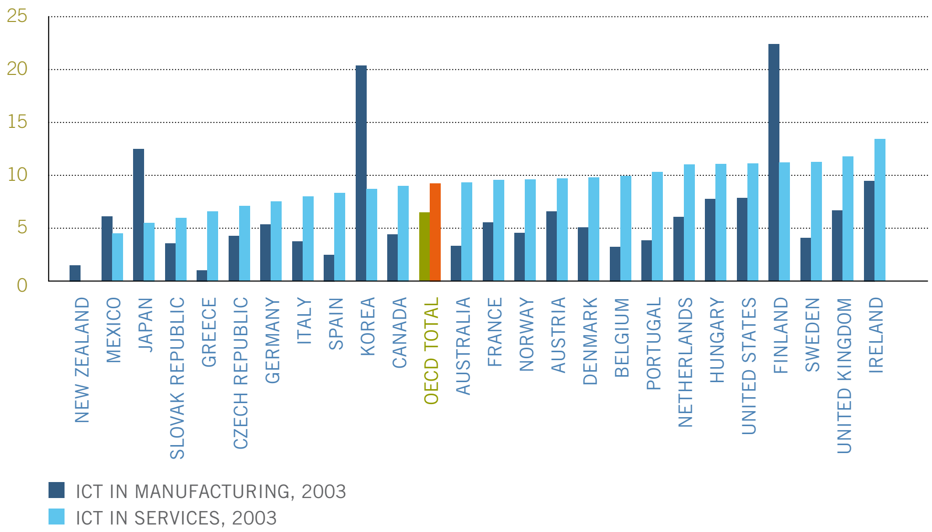
There is indeed an understanding that a virtuous cycle exists between the competitiveness of the ICT segment on the one hand, including microelectronics and semiconductors, and that of an economic region / country on the other. A strong and highly innovative semiconductor industry contributes to the competitiveness of the economy, while at the same time a dynamic economic environment is likely to encourage the industry to try and benefit from the competitive advantage and value added advanced technologies provide.

Such a virtuous cycle has seen the semiconductor industry in Europe become a major player in the worldwide semiconductor market over the last two decades and has enabled European industries in wireless communication, automotive, or industrial equipment among others to become global leaders in their segments. While this is well-understood the question in 2008 is whether such a virtuous cycle can continue to function in Europe and thereby contribute to sustaining the competitiveness of the European semiconductor industry.

1 See e.g. [ESIA 2005], [Aho Report 2005], [ISTAG Report 2006], [ICT Competitiveness 2006], [Key Figures 2007], [ENIAC SRA 2007], [CATRENE Whitebook 2007], [Electra 2008], [Rapport Saunier 2008], all stressing that micro- and nanoelectronics are the key enabling technologies for electronics and information and communications technology (ICT) and in many cases a "constitutive technology" of the solution itself. Indeed, there cannot be enough of these initiatives, and ESIA companies have been directly or indirectly involved in these, supporting many of the recommendations put forward.

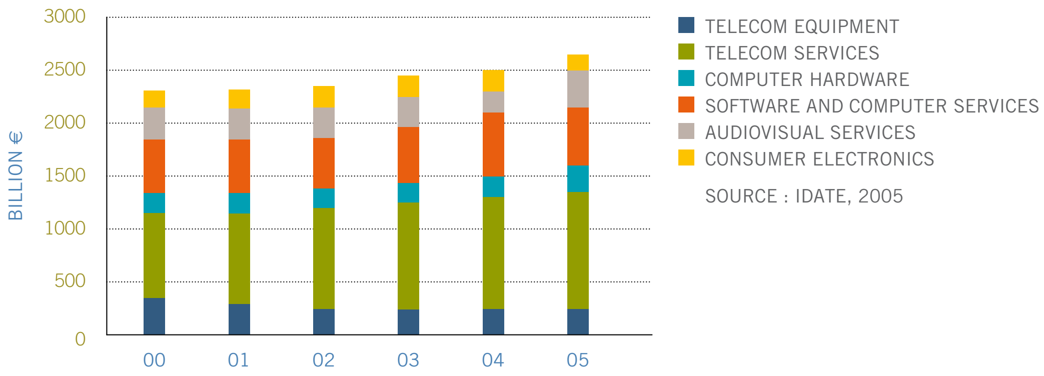
2 Governments, recognizing the structuring effect of microelectronics on the industrial and economic system of the knowledge society, have been supporting the industry around the world. This has created a certain market deficiency, which we referred to as uneven "level playing field conditions" in our 2005 report cf. [ESIA 2005]. They have accomplished this by effectively investing the complete set of political tools to take advantage of available level playing field conditions, e.g., offering property tax inducements to attract specific industries to their technology clusters, providing favourable tax incentives that bet on generating economic growth to compensate for losses in tax revenues, creating large research institutes with clear priorities, standardizing market creation and sponsoring initiatives, to name a few. cf. [Catrene White Book 2007], p.19. See also [Saunier Report], pp.27-30.

Fig. 1 - Share of ICT in Value Added



SOURCE: OECD FACTBOOK 2006

Fig. 2 - World ICT Markets by Sector



SOURCE : IDATE, 2005

Looking at ESIA's 2005 competitiveness analysis (see BOX, Fig. 3) from a 2008 perspective, it appears that the scenario that has unfolded for Europe is what we referred to as the rather gloomy, laisser-faire one that depicted a quite uncertain future and increasing challenges for Europe if it is to regain competitiveness.[3]

This, together with a semiconductor industry landscape that is increasingly shifting, creates a new environment that policy makers and key stakeholders of the industry have to face as they pursue this competitiveness.[4]

The report of the EC Directorate-General for Research summarises perfectly the situation Europe has to face. The EU represents a diminishing share of worldwide population, GDP and R&D investments, and newly emerging economies are no longer competing on the basis of low cost activities only. The EU therefore needs to respond to the challenges and make the most of the opportunities created by the new international division of labour. "The structural growth handicap of the EU and the emergence of new competitors, which are at the same time important partner countries, have created a need for decisive policy actions to address the EU's structural weaknesses and to reposition the Union in the new reality of a multi-polar world." [2]

3 cf. [ESIA 2005] p. 49
4 Other assessments confirm these perceptions. According to Ernst & Young's 2008 European attractiveness survey, Western Europe and the US/Canada fell back to third and fifth place (with 33% and 21% of votes respectively), while China has moved into first position as the most attractive business location (47% of votes). Of the six regions most attractive to potential investors, the shift of investor interest to the new economies is now evident. While Europe retains a respectable third place, more remarkable is the fall in the rating of the US to fifth place. In addition, Russia is now clearly seen as a credible competitor both to developed economies and to other high-growth economies. (cf. Ernst&Young. An open world, Ernst & Young's 2008 European attractiveness survey, 2008).

Fig. 3 - 2005 ESIA Scenario analysis

"Laisser- faire" Scenario

"The situation is left to the industry players themselves and no additional efforts are undertaken at the EU or national governmental levels to incentivise innovation and restore a level playing field. Priorities of semiconductor companies operating in Europe will focus on profitability and increasingly give preference to low-cost locations for design and engineering. They operate in a reactive and opportunistic mode. Missing public support, local R&D becoming less affordable or lacking economic incentive, the industry will take advantage of non-European opportunities for future investments and industrial deployment. As a consequence, the present state of competitiveness is likely to deteriorate further as 'no action' unavoidably means being affected by increasing comparative disadvantages."

cf. [ESIA 2005] p. 49

Persisting critical competitive dimensions for Europe

The semiconductor industry in Europe continues to be exposed to the same competitive dimensions we had highlighted in the 2005 report, with some of them putting increasing pressure on the industry.

In the following we describe what we currently see as the most relevant ones. Among the main competitive dimensions still affecting the semiconductor industry in Europe are:

- Currency disparities (competitive dimension: *Globally Effective EU Monetary Policies* or in this case global monetary policies. Here the Euro/dollar exchange rate has artificially increased the cost of European manufactured products in a market indexed in dollars)
- Timid target investment support/incentives (competitive dimension: *Target Investment Support / Incentives Levels)*
- Lagging R&D spending (competitive dimension: *R&D Spending*)
- Weak education system reinforcement (competitive dimension: *Education System Reinforcement*)
- Stringent European labour policies (competitive dimension : *European Labour Policies*)
- Legislative pressures in ESH (competitive dimension: *EU Legislative Environment*)

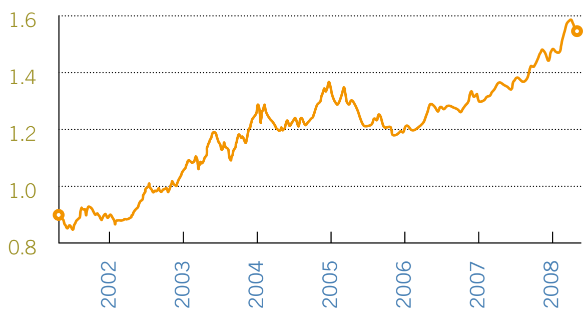
Obviously there are more dimensions, albeit not specifically related to Europe, which deserve attention in terms of competitiveness. Among those that are posing a new challenge for the semiconductor industry in particular is:

- The raising cost of energy that is rippling progressively through the entire semiconductor supply and value chain. This requires action to limit its impact.

Currency disparities

Currency disparities and fluctuations *per se* are a normal consideration for industries operating globally. However, the current successive and all-too-rapid deteriorations of the Euro/USD exchange rate over short periods of time is jeopardizing Europe's competitive position. The impact of currency fluctuations on the industry, and the extent to which fast and continuing one-directional currency fluctuations have undesirable effects on economies, cannot be underestimated. There are no significant medium-to-long-term economic or political winners in this game, no matter what region. The European semiconductor industry - among other high-tech sectors - operating in a global context and indexed on the USD, has been particularly impacted negatively over the past six years. (Fig. 4)

Fig. 4 - Evolution of the Euro vs. USD currency exchange rate 2001 - 2008



At the beginning of the current decade, the U.S. dollar and the Euro were at parity and fluctuations in the values of the two currencies were limited and unremarkable. The dollar was worth 1.0155 Euros. Eight years later, in June, 2008, the dollar had weakened to $1.6 against the Euro. Such rapid, one-directional fluctuations are likely to undermine profitability at any European-based company. But a shifting currency market over which companies have limited control is affecting more than fiscal results; it is also skewing competitiveness. It is affecting semiconductor manufacturers in particular as well as OEMs that traditionally tally their revenue in the ever-depreciating USD and their operational costs in Euros. "The region's highly export-oriented aerospace and defence, automotive, forest products and high-tech industries are most exposed, to the detriment of their profitability."[6]

The ripple effect is felt beyond Europe. Although European companies were hardest hit by the dollar's decline in the first quarter of 2008, companies in Asia also felt the squeeze. Primarily because the company's sales were denominated in U.S. dollars, margins for wafer manufacturers in Taiwan or Singapore fell during the first quarter of 2008.

> *"European companies are particularly vulnerable; whether in comparison with 2007 (e.g., using an exchange rate of $1.47/euro for 2008 first-quarter results, vs. $1.29/euro during the first quarter of 2007), or by forecasting the current year (e.g. basing 2008 forecasts on a $1.45/euro rate; while the dollar weakened further, to $1.60/euro in May). Should an exchange rate of $1.60 be sustained through the entire 2009 fiscal year, this 15 percent deterioration that is implied by such an exchange rate would lead to a reduction in EBIT of about 10 percent compared with the 2008 fiscal year. On a constant-exchange-rate basis, first quarter 2008 revenue results would have been much higher than the ones reported, and gross profit margins would have been about 3 percentage points healthier. Additionally, combined R&D and selling, general and administrative costs would have been lower."*
> *(cf. Ojo, Bolaji. The new challenge for tech companies: currency fluctuations. EEtimes Europe, 05-02-2008.)*

Unable to control the exchange rate environment beyond hedging activities, most companies are actively focusing on cost-reduction. In some cases they are renegotiating supplier contracts and transferring overhead costs and other manufacturing activities to limit their exposure. ESIA supports all types of measures that can be taken at the political level to alleviate one-directional fluctuations if they are able to make a lasting difference.

6 cf. Andreas Zsiga, Standard & Poor's, Stockholm, Sweden. In: Ojo, Bolaji. The new challenge for tech companies: currency fluctuations. EEtimes Europe, 05-02-2008.

Timid Target Investment Support/ Incentives

In 2005, ESIA strongly recommended the generalization of an R&D tax credit system for all semiconductor companies in any European geographical area. This was seen as essential for strengthening the industry's R&D capabilities in Europe and even more urgent as the trend in R&D support was evolving from a grant to a loan system.

Unfortunately, our recommendations for setting industrial policy priorities and framework conditions allowing for specific strategic sectoral interventions have not been followed. These recommendations included installing a sectoral framework for the semiconductor industry and/or adopting incentive schemes that match those offered by other regions/countries. European Member States, however, have in fact progressively adopted new tax credit systems or have improved existing ones.[7]

R&D tax credits (RTCs) are implemented to promote research and innovation in which the industry takes an active part. By reducing the real cost of companies' investment in R&D, tax credits provide focused, increased and long-term support for the industry's competitiveness in the global economy. As with many other tax incentives, the problem is that a company must have taxable profits in order for the support to have any value, making the precise value of RTC somewhat unpredictable. In recognition of this the French scheme, for example, has been designed to minimise the problem: the tax credit always remains refundable: e.g. for innovative SME's without profit, the credit allows these companies to receive a cash payment after one year, while for other companies this happens after three years.

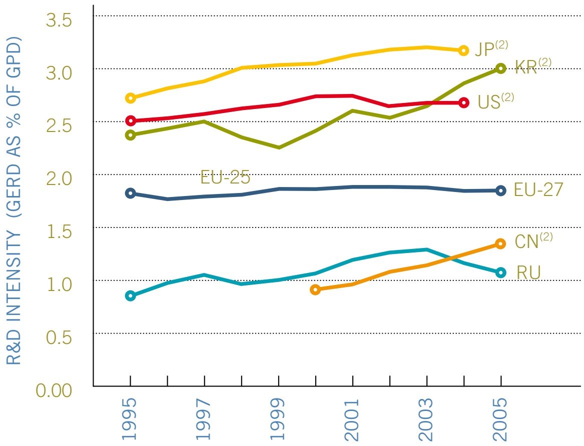
A number of initiatives have been implemented at national levels that deserve specific attention as models for the European semiconductor industry as well as for a broader level of European business activity. A summary of different types of International R&D Tax Incentives offered by select competitor-nations is shown in Appendix A1. This international comparison clearly indicates that, despite efforts made in Europe and the US, countries such as South Korea, India, Singapore and China offer substantial R&D tax advantages compared with European countries, helping to explain why foreign-based R&D spending has grown faster than that for R&D based in the EU and the US.[8]

Lagging overall R&D spending in the EU

Unleashing Europe's R&D capability was identified as a crucial priority in our 2005 competitiveness recommendations for the European semiconductor industry.[9] Not only must Europe achieve or surpass Lisbon target of 3% of European GDP allocated to R&D, all concerned European actors, Member States and industry crucially must strengthen existing future-orientated programmes such as CATRENE, ENIAC or ARTEMIS. Both actions, combined with industry's other continuing efforts, are urgently needed to close the R&D gap.

Measured against this expectation, recent data show that R&D intensity (R&D expenditure as % of GDP) in Europe has stagnated since the mid-nineties, while other regions such as Japan, China and South Korea have been able to increase substantially their R&D effort, shaping a world where knowledge is more evenly distributed than ever before.[10] (Fig.5.)

Fig. 5 - R&D intensity (GERD as a % of GDP) in the major world regions 1995 – 2005



DATA: EUROSTAT, OECD KEY FIGURES 2007
NOTES:
(1) US: BREAK IN SERIES BETWEEN 1998 AND PREVIOUS YEARS; JP: BREAK IN SERIES BETWEEN 1996 AND PREVIOUS YEARS.
(2) JP: GERD WAS ADJUSTED BY OECD FOR 1995
(3) KR: GERD DOES NOT INCLUDE R&D IN THE SOCIAL SCIENCES AND HUMANITIES
(4) US: GERD DOES NOT INCLUDE MOST OF ALL CAPITAL EXPENDITURE
(5) CN: HONG KONG IS NOT INCLUDED
SOURCE: EUROPEAN COMMISSION. DG FOR RESEARCH. TOWARDS A EUROPEAN RESEARCH AREA, SCIENCE, TECHNOLOGY AND INNOVATION. KEY FIGURES 2007. EUROPEAN COMMUNITIES, 2007.

Looking at the share of public vs. business sector in the overall R&D investment position of the EU, investment that represents about 1.2 % of GDP, expenditure in the business sector remains at a lower level than in most of the other main world regions, and in particular the US. (Fig. 6)

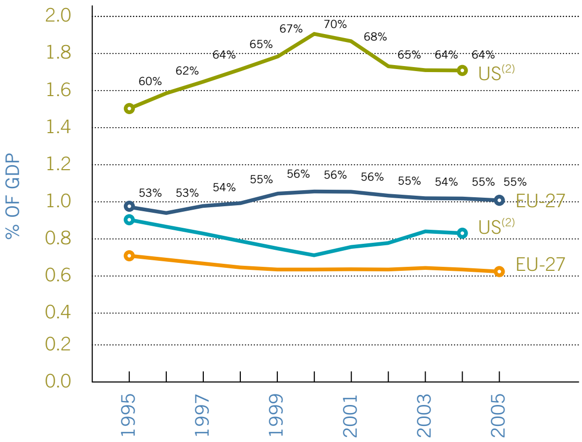
7 In a few exceptional cases, Member States have allowed for financial intervention: This was the case for France who, when seeking to foster innovation in microelectronics in the Grenoble area, agreed to provide subsidies to a new alliance between STMicroelectronics NV, IBM Corp. and the CEA. The "Nano 2012" strategic investment programme, commonly called "Crolles3", represents an investment of 3.6 billion euros ($5.65 billion) and is expected to create 650 new jobs. (see also Pele, Anne-Francoise. *France backs $5 billion program aimed at Crolles3*. EEtimes Europe, 07/09/2008). This is an example of what is possible even in Europe by combining EU, private, national and local support and priorities and actually investing in Europe's future.

8 cf. Ernst&Young. International R&D Tax Incentives offered by select competitor-nations. 2008

9 cf. [ESIA 2005] p.50 f.

10 The diagnosis is without illusion: The R&D investment deficit against the US has remained constant over recent years. In particular, the low level of business R&D, i.e. 1% on average of all sectors in the EU - contrasting with an R&D investment of approx. 20% of sales for semiconductors - remains worrying. Key Figures 2007 shows that differences in the industrial structure of the EU compared with countries such as the US are the main cause of this low level of business R&D spending, with the EU having a smaller high-tech industrial sector, a sector that usually has much higher levels of R&D spending. cf. [Key Figures 2007], p. 21 ss.

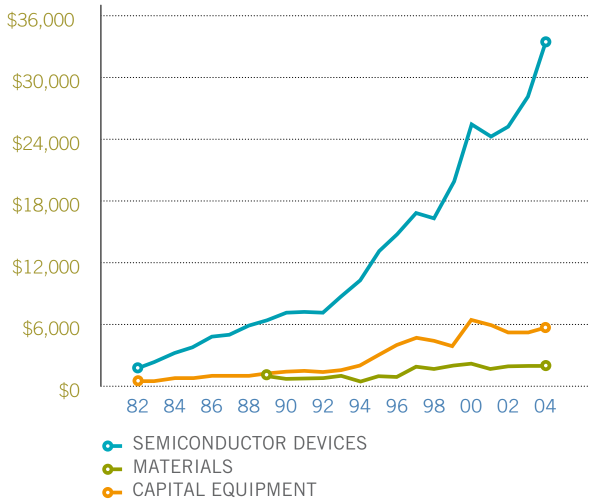
Fig. 6 - R&D financed by business enterprise and by government as % of GDP, 1995 – 2005



SOURCE: DG RESEARCH KEY FIGURES 2007
DATA: EUROSTAT, OECD
NOTES: (1) THE % ON THE GRAPH REFER TO THE SHARE OF GERD FINANCED BY BUSINESS ENTERPRISE
(2) US: GERD DOES NOT INCLUDE MOST OF ALL CAPITAL EXPENDITURE

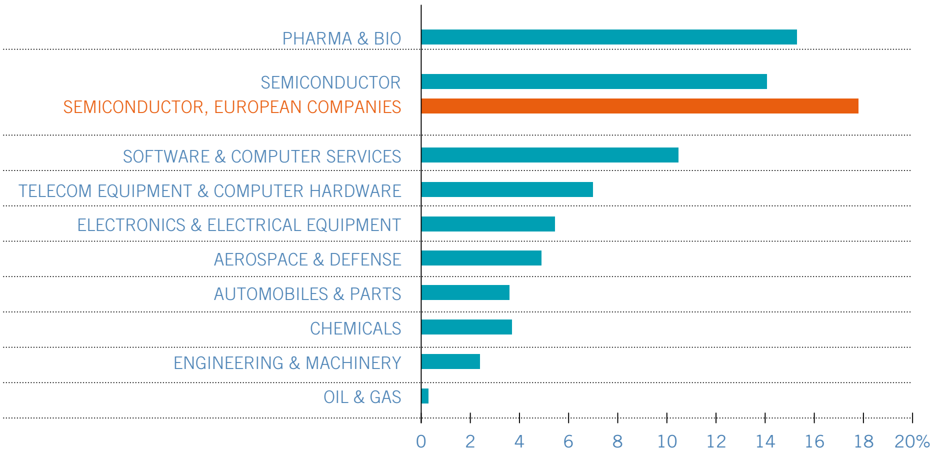
Source: European Commission. DG for Research. Towards a European Research Area, Science, Technology and Innovation. Key Figures 2007. European Communities, 2007.

Fig. 7 – Split of Nanoelectronics R&D investments 1982 – 2004 (world) (calculated on the basis of % on yearly revenues)



Sources: CATRENE 2007, S&P, SIA, SEMI, INFRASTRUCTURE Advisor

Fig. 8 - R&D spending in the EU (US$ million) - R&D to Sales ratio



Source: MEDEA+/European Commission, 2006

As stated in the *Key Figures 2007* report: "Whereas business expenditure on R&D (as % of GDP) increased in the second half of the 1990s, since 2001 the trend has been negative. The deficit in business-funded R&D explains almost 85 % of the gap between the EU and the US, and an even larger part of the gap between the EU and the two Asian countries. Conversely, business R&D is increasing at a fast pace in Asia (even though Japan's rate of growth is diminishing) while, in the US, the downward trend of 2001-2002 has come to an end and turned back into positive growth. If these trends are maintained, private R&D investment in China will have reached the same level as the EU by 2008."[11]

The extraordinary R&D investment by the semiconductor business sector (Fig.7) provides a strong contrast with the on average overall low EU public and private R&D investment levels.

Given the unique dynamics of the semiconductor industry, characterised by the need to reach the highest possible intensity of R&D coupled with the highest available intensity of capital input, maintaining leadership requires very large investments. Notwithstanding the fact that process R&D costs are rising beyond companies' financial means, forcing them to share R&D costs, European companies have invested some 20% of their annual sales revenues in R&D in recent years.

Although the share of overall ICT in hi-tech-intensive sectors overall in the EU is smaller than in the US (14% in the EU vs. 39% in the US) and smaller than Pharma in the EU (18%), it is remarkable that the portion of R&D spending by the semiconductor business in Europe surpasses even that of the European pharmaceuticals sector. The European semiconductor industry is also spending more than the semiconductor business in other areas of the world. [12] (Fig 8).

Such high levels of R&D investments by the business signals the extraordinary motor the semiconductor industry provides for innovation. Even though this compensates somewhat for the EU's relatively low overall business sector R&D intensity, it should not become an excuse for diminished public support. On the contrary, public R&D investment, whether in the context of cooperative programmes or dedicated initiatives at EU and Member State levels, are essential for sustaining and framing the technological revolution and for venturing into previously unexplored technological universes such as nano- or biotechnologies.

The semiconductor industry's R&D investment demonstrates the critical role of the business sector's involvement in future-oriented, research-driven activities along with the industry's crucial contribution to Europe's future economic growth and competitiveness.

Weak Education System Reinforcement

Education and training are essential for nurturing and sustaining a dynamic science and technology innovation system and for creating competitive market, finance and business conditions for the future. This is especially true for the semiconductor industry, where a regular influx of highly-skilled workers is paramount for maintaining the level of innovation the industry needs. In its 2005 competitiveness report, ESIA called for strengthening scientific training by opening up the educational system in Europe to new and emerging disciplines and by working to secure a constant influx of high quality researchers and employees, especially those with scientific and technical backgrounds.

"To maintain and enhance competitiveness, Europe must dramatically increase the efficiency of European research institutions, both universities and other public research entities. All levels of the educational system need to be addressed; key focus areas being the promotion of technical subjects at schools, a higher industry-focus at university level, the incorporation of technical and practical experiences into university curricula, the facilitation and increase of numbers of international student and researcher exchange, stronger collaboration between universities, and incentives able to ensure that the most talented researchers stay in Europe."[13]

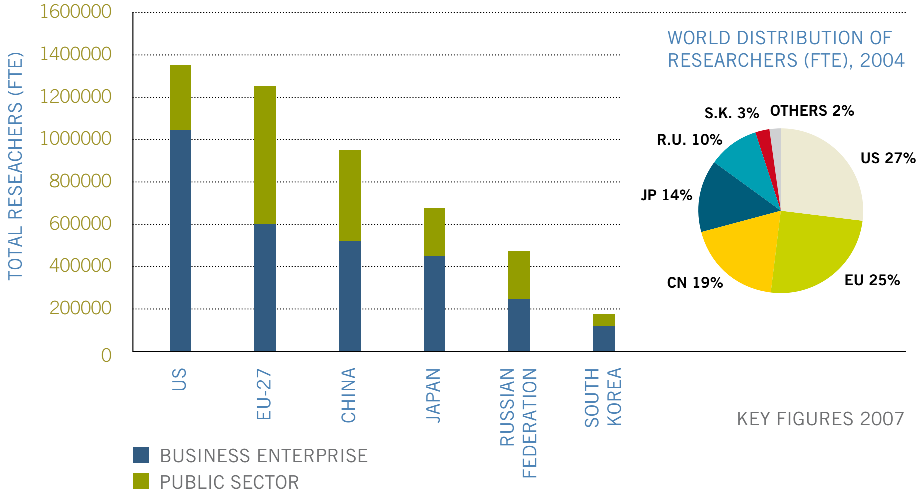
High levels of R&D investments by the business signals the extraordinary motor the semiconductor industry provides for innovation. Even though this compensates somewhat for the EU's relatively low overall business sector R&D intensity, it should not become an excuse for diminished public support.

The Green Paper of the EC DG-Research: *The European Research Area: New Perspectives 2007,*[14] resonates well with the points raised. It particularly stresses the need for action regarding the strengthening of research institutions; optimizing research programmes and priorities; and opening to international cooperation in science and technology (S&T). It is in this latter field that Europe faces major challenges to its competitiveness. Alerted by statistics indicating that the worldwide expansion of higher education degrees was stronger in the non-Science and Engineering (S&E) fields than in S&E, and that the share of degrees awarded in S&E was declining, OECD ministers have expressed concern that young people lack interest in S&E.[15]

The US and the EU still lead the world distribution of researchers. (Fig. 9) However, given the growth rate at which fresh S&E resources are required to maintain technological leadership, the domestic production of talented people, particularly in the S&T field, the US as well as the EU increasingly risk of being outperformed by countries in East Asia.

11 cf. [Key Figures 2007] p.21
12 cf. [CATRENE White Book 2008], [Key Figures 2007]
13 cf. [ESIA 2005] p.51
14 European Commission. DG for Research. The European Research Area: New Perspectives. Green Paper. European Communities, 2007.
15 cf. US National Science Foundation (2006), Science and Engineering Indicators 2006, p.4

Fig. 9 – Number of researchers (FTE) by world region, 2004



BUSINESS ENTERPRISE
PUBLIC SECTOR
(THE PRIVATE NON-PROFIT SECTOR IS INCLUDED IN PUBLIC SECTOR)

SOURCE: DG RESEARCH
DATA: EUROSTAT, OECD
NOTES: US: 2002; RU, KR: 2005

"Knowledge is a key component of competitiveness. If our businesses are to be at the leading edge in the future, they need to invest in knowledge now. And governments need to put in place the appropriate measures to help them do so."

Some of the main issues Europe is faced with concerning the future competitiveness of its knowledge base are:

- Although the output of graduates in engineering and natural sciences in the EU is still higher than in the US, gaps continue to exist regarding Europe's ability to attract foreign students in tertiary S&T education who would thereby contribute to the continuous efforts needed to maintain technological leadership. With only 3 to 4% of its students coming from outside the EU, the EU finds itself well below average in attracting and promoting international mobility. In this area both the US and countries in East Asia outperform Europe to a great degree.
- Asia – through a combination of targeted policies and attractiveness of its market – is increasingly managing to retain its S&T base.
- There is a difference between research quantity and the quality of its results. Europe lags behind the US in all scientific disciplines in terms of citation impact scores and highly-cited publications. Also, EU universities are very much underrepresented at the top of a ranking based on the bibliometric indicators of the world's largest universities.[16]
- In addition, the linkage between technology (patented inventions) and the science base is much weaker in the EU than in the US. Europe has difficulty breaking through in new high-tech industries.[173]

In conclusion, as Janez Potočnik, the European Science and Research Commissioner said: "Knowledge is a key component of competitiveness. If our businesses are to be at the leading edge in the future, they need to invest in knowledge now. And governments need to put in place the appropriate measures to help them do so."[18] Education, scientific and technological progress and innovation have always been crucial ingredients of economic activity and an important source of competitiveness. The transition to the knowledge-based economy is enhancing the level of competitiveness of our economies. The European Union is at a crossroads, where only decisive policy actions will ensure that the route towards increased long-term economic growth and prosperity is the one that is followed. Considering the difficulty of recruiting top level engineers and taking advantage of relevant research efforts for the industry in Europe, the semiconductor industry can only stand to gain from Europe taking the correct turn at this cross-road.

16 The EU is the world's largest producer of scientific output, accounting for 38 % compared with 33 % for the US, 9 % for Japan and 6 % for China. However, this EU leadership disappears when one adjusts for size and input: the US produces significantly more scientific publications per million population and per university researcher, or when comparing the respective levels of public R&D expenditure. Moreover, the EU lags behind the US in terms of citation scores and highly cited scientific publications, two proxies used to assess the impact of Europe's scientific output in the world. cf. [Key Figures 2007] p.41f.

17 The EU's relatively weak presence in fast-emerging scientific fields with high promise, and the lack of efficient science-technology linkages in the most science-intensive technologies, largely explains why the number of US patents is greater than those of the EU in high-tech areas. The EU's share of total EPO patents stood at 38 % in 2003, compared with 30 % for the US. However, the EU share of high-tech patents was only 29 % compared with 37 % for the US, even though EU inventors have a non-negligible 'home advantage' at the EPO. The US is ahead of the EU in four out of the six high-tech areas: (1) computers and automated business equipment, (2) micro-organisms and genetic engineering, (3) lasers, and (4) semiconductors. cf. [Key Figures 2007] p. 54

18 cf. EU Press Release: IP/07/790, 11/06/2007. Low business R&D a major threat to the European knowledge-based economy. Link: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/790&format=HTML&aged=0&language=EN&guiLanguage=en

Stringent European Labour Policies

As reported in our 2005 competitiveness study, the semiconductor industry often faces conditions that make it difficult for companies to adjust quickly to the pace of technology changes or to volatile market movements that are inherent in the semiconductor market. Flexibility in production, for example, requires that a fab be able to produce economically 24 hours a day.[19]

Labour costs

In 2005 we observed that the cost of a qualified workforce is much lower in Asia than in Europe and that the hourly cost projected in 2010 will be five times higher in Germany than in Singapore or ten times higher than in China. Several statistics from different sources today confirm the perception that the labour market in Europe generally continues to be less favourable in terms of cost, hours worked and regulations than in other areas, mainly Asia, where semiconductor manufacturing is strongly developing. According to these statistics, both unit labour costs and hours worked illustrate the widening gap that exists between Europe and Asia and between Europe and the US.[20]

A comparison of the long term trends (1975 – 2005) of hourly compensation costs for production workers in manufacturing in Europe, Japan, and the USA against the four newly industrialised economies of Hong Kong, the Republic of Korea, Singapore and Taiwan (grouped as “Asian NIEs”) shows Europe with the largest gap. All are – or are becoming – important semiconductor producing regions. (Fig. 10)

With regard to regulations on labour and product markets, some EU countries that have a significant semiconductor industry presence today (GY, F, NL, IT) show more restrictive regulations than do other areas. Based on OECD’s earlier assessment, Ireland is one of the most attractive EU countries from a labour standpoint, together with the UK.

Average working hours

Specifically, in terms of a global comparison of average hours actually worked, OECD figures show that in 2006 the gap is striking, especially with Korea. While it is not new that working hours are lower in Europe, the OECD figures also show that the gap is increasing – and it is this trend that is worrying for Europe. While in 1996 Europeans worked 170 hours less than their closest region (US) and 948 hours less than the Koreans, in 2006 Europeans were working 201 hours less than their closest region (Japan) and ‘only’ 774 hours less than Koreans. As a globally operating industry, the semiconductor industry cannot ignore these basic facts. They at least call for the reversal of this persistently negative industry trend. (Fig. 11)

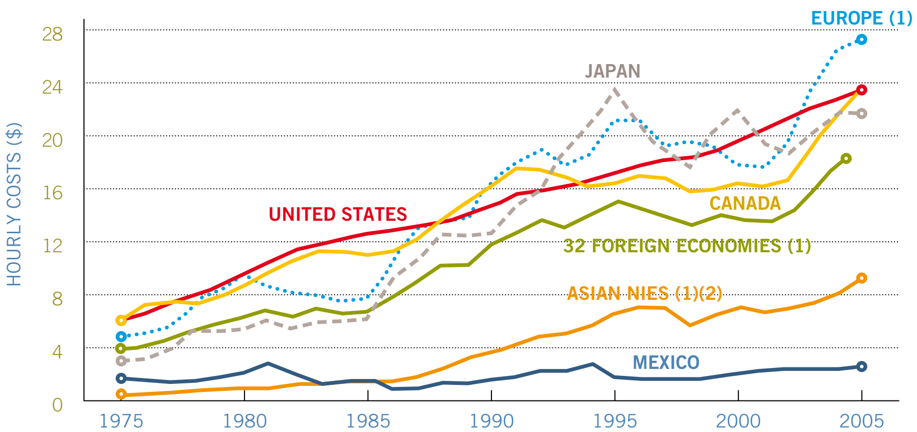
Labour productivity

OECD comparisons regarding labour productivity in terms of GDP per hour worked in different countries are a little more comforting. Europe has moved from last in rank to second, but the region still has much catching up to do to remain competitive vis-à-vis regions like Korea. Both the GDP per hour worked and the average hours worked illustrate the gap that exists between Europe and Asia / US (China is not included in this 2006 dataset). (Fig. 11)

Although labour conditions are primarily subject to national legislation, in order to be able to react quickly to a market so heavily exposed to change and global competition, companies in Europe need to dispose of tools that allow them to manage the constraints they encounter in a more flexible manner. More flexible labour conditions, in particular those facilitating a better organisational alignment of working hours - in terms both of total amount and distribution - are key to meeting the competitiveness requirements of today’s global market.

At the EU level, Europe’s answer has been the recognition that the European labour markets increasingly face the challenge of com-

Fig. 10 – Hourly compensation costs for production workers in manufacturing 1975-2005 (in USD)



1 TRADE-WEIGHTED AVERAGE
2 THE ASIAN NIES ARE HONG KONG SAR, REPUBLIC OF KOREA, SINGAPORE AND TAIWAN
SOURCE: BUREAU OF LABOR STATISTICS – US DEPARTMENT OF LABOR, 2007

More flexible labour conditions, in particular those facilitating a better organisational alignment of working hours are key to meeting the competitiveness requirements of today’s global market.

19 cf. [ESIA 2005] p. 54.
20 OECD Factbook 2008. Economic, Environmental and Social Statistics. Paris, 2008.

Fig. 11 - Average hours worked and GDP per hour worked for selected countries

AVERAGE HOURS ACTUALLY WORKED				GDP PER HOUR WORKED (ANNUAL GROWTH %)			
	1996	2000	2006		1996	2000	2006
FRANCE	1656	1592	1565	FRANCE	0.4	3.7	0.9
GERMANY	1518	1473	1436	GERMANY	2.3	2.6	2.4
IRELAND	1826	1688	1640	IRELAND	4.3	4.5	2.2
ITALY	1896	1871	1800	ITALY	-0.2	2.8	1.0
NETHERLANDS	1389	1368	1391	NETHERLANDS	-2.2	0.3	0.0
UNITED KINGDOM	1738	1708	1669	UNITED KINGDOM	1.8	3.5	2.4
JAPAN	1892	1821	1784	JAPAN	1.7	2.9	1.2
KOREA	2648	2520	2357	KOREA	5	3.3	3.4
UNITED STATES	1840	1841	1797	UNITED STATES	2.4	2.3	1.0

SOURCE: OECD FACTBOOK 2008 ECONOMIC, ENVIRONNEMENTAL AND SOCIAL STATISTICS, PARIS, 2008

bining greater flexibility with the need to maximise security for all. This has involved promoting ideas on "the role of labour law might play in advancing a 'flexicurity' agenda in support of a labour market which is fairer, more responsive and more inclusive, and which contributes to making Europe more competitive."[21] This is intended to stimulate the development of a more responsive regulatory framework that is required to support the capacity of workers to anticipate and manage change.

As highlighted in the Green Paper, in order better to respond to rapid technological progress, increased competition stemming from globalisation, changing consumer demand and significant growth of the services sector, businesses need to organise themselves on a more flexible basis. This is reflected in variations in work organisation, working hours, wages and workforce size at different stages of the production cycle and has led to the emergence of just-in-time management, the shortening of the investment horizon for companies, the spread of information and communication technologies and the increasing occurrence of demand shifts.

However, despite expanding globalisation, torn between stringent employment protection legislation and the need for increasing diversity in working arrangements, only limited progress has been achieved to date relative to enhancing Europe's competitive chances in this area. This puts even more pressure on enterprises remaining in Europe to compete in terms of product quality, innovation and responsiveness to customers' demands rather than on price and cost.

21 The EU Commission issued a Green Paper in 2006 on modernising labour law to meet the challenges of the 21st century. The paper made a number of recommendations on "the role labour law might play in advancing a "flexicurity" agenda in support of a labour market that is fairer, more responsive and more inclusive, and which contributes to making Europe more competitive." cf. European Commission. DG for Employment, Social Affairs and Equal Opportunities. Green Paper. Modernising labour law to meet the challenges of the 21st century. European Communities, 2006.

22 cf. [ESIA 2005] p. 53

Legislative pressures in environmental legislation

The unique complexities of European decision-making and legislative processes in specific sensitive domains relating to protective measures such as environmental policies are often perceived as creating incremental obstacles regarding competition with other regions. This applies to the semiconductor industry as much as to other sectors. It is primarily the bureaucratic burdens and costs, as well as the uncertainties associated with the development and implementation of such legislation rather than the intentions of the legislature that cause business to suffer.

In its 2005 report, ESIA clearly called for all legislative initiatives, even if they do not explicitly promote the competitiveness of the European industry, to avoid, at least, creating obstacles. "Finding the correct balance between advancing environmentally-beneficial policies and keeping pace with international technology developments and market demands remains a constant challenge for semiconductor innovation and production in Europe as well as for governments." [22]
Keen to anticipate compliance with regulatory constraints, industry has always taken an extremely professional approach so that governments and authorities will find in it a reliable and critically-needed partner. It should therefore be ensured that business competition criteria are taken into account at the early stages of legislation so as to allow foreseeable impacts on competitiveness to be adequately considered.

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During the past three years, despite efforts to correct problems in the way certain environmental directives and regulations were adopted (e.g. REACH, RoHS), or are being reviewed (e.g. ELV, RoHS, WEEE), legislative pressures continue to make it difficult for suppliers to respond consistently to the expectations of their end-user customers and still be in compliance. As an up-stream supplier of devices to the OEMs, strict compliance with set rules is essential to the semiconductor industry's business.

It must therefore be understood by the regulators that some materials used in semiconductor processing and in semiconductor devices are critical because of their specific functionality for achieving performance goals. Many of these goals directly relate to improving the environmental performance of end-use products and systems. Nonetheless, individual initiatives from various parties not adequately familiar with the electronics industry often make it hard for the industry to explain that the measures under consideration are either inapplicable or targeted on non-existent harm. Additionally, some of the substances targeted by the legislature are used in infinitely small quantities (e.g. lead, arsenic, PFOS, etc.), eliminating the deleterious effects that would result from using them in greater amounts. To ameliorate this situation, regulatory decisions should always be based on sound science and a thorough assessment of available alternatives, that includes determining whether or not those alternatives are feasible and environmentally superior.

Additional competitive challenges

In addition to the evolution of the competitive dimensions assessed and described above, a few others that are not specifically related to Europe will deserve particular attention in the longer term as they pose new challenges and options. One dimension to monitor with particular attention is:

The rising cost of energy

that is rippling progressively through all sectors of the economy and which will unavoidably reach the entire semiconductor supply and value chain.

The new energy landscape of the 21st century is one in which the world's economic regions are dependent on each other for ensuring energy security and stable economic conditions as well as for ensuring effective action against climate change. The dramatic oil price rises experienced in recent years, which reached an historical maximum by mid 2008, have heightened awareness of the role of hydrocarbon combustion in global environmental change and have returned energy, and petroleum in particular, to the centre of political debate.

The impact on the semiconductor industry of ever-increasing the energy costs is significant and of great concern. High energy consumption is required mainly in wafer fab infrastructure and in wafer processing. Energy is required to power the entire infrastructure needed to operate cleanrooms, including the HVAC (air conditioning), water deionisation (to manufacture high purity water), generation of high purity nitrogen, generation of compressed air and facility lighting. It is also required for processing silicon wafers in the tool itself, as well as for to powering the tool during idle times. Additionally, individual components of processing tools require energy, such as vacuum pumps or motors.

It follows that for the semiconductor industry the overwhelming part of energy consumption is determined by the equipment and affects both facility management equipment (clean-room maintenance) and the equipment consumption itself. In Europe electricity makes up 80 to 85% of the consumption by the industry. It is worthwhile noticing that, while energy consumption is determined by technical requirements of processes and products, and its reduction potential is limited according to the technology roadmaps - the industry is an key enabler for energy efficient solutions and systems. This is worth doing so as the main energy consumption of end-products occurs in the use stage and not in the manufacturing.

Studies of semiconductor facilities by ISMI (International SEMATECH) from 1997 and 2007 show that process equipment/tool energy continues to represent a significant portion (40–50%) of total energy requirements in semiconductor facilities. Concerted efforts continue to be made with semiconductor equipment manufacturers to deliver tools to the semiconductor device manufacturers that are increasingly energy efficient. As a result, energy efficiency and energy productivity of semiconductor manufacturing is continuously improving.[23]

The industry is focused on constantly delivering products that provide increased functionality alongside improved energy performance. The semiconductor industry is a key enabler for energy reduction across other industrial sectors of production.

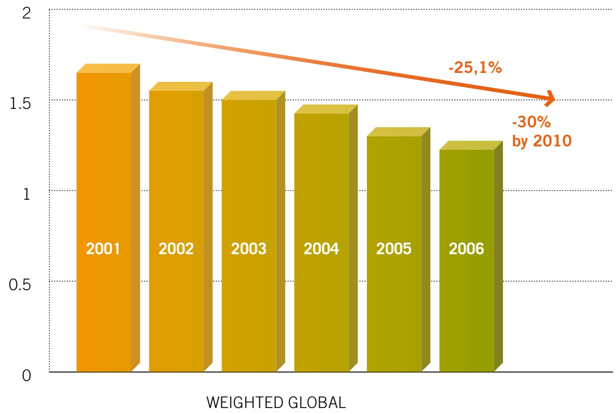
The industry is focused on constantly delivering products that provide increased functionality alongside improved energy performance. The semiconductor industry is a key enabler for energy reduction across other industrial sectors of production. Semiconductor industry devices have the ability to reduce significantly the energy needs of other industries as noted by the American Council for Energy-Efficient Economy – 'For every 1Kwh of ICT energy used -10kwh were saved in US economy'. [24](Fig. 12)

ESIA fully supports the voluntary approaches taken within the industry and is of the opinion that no legislation is needed to improve the energy efficiency of semiconductor manufacturing further. Actions that the EU Commission should focus on are: research in energy-efficient technologies and building

23 The actions undertaken by the World Semiconductor Council (WSC), of which the European Semiconductor Industry Association (ESIA) is a member, to reduce the consumption of electricity underscore the relevance of this issue. WSC is a global association of six regional semiconductor associations whose reach spans three continents and represents the vast majority of global semiconductor processing capacity. Member companies cover more than 95% of WW production. In the field of energy, WSC
- cooperates on energy savings and resource conservation programmes;
- cooperates and has a dialogue with equipment suppliers to ensure continued improvements in the energy efficiency of tools; has a common global metric for a global data collection on the parameters of electricity normalised on the basis of cm2 of silicon;
- has agreed to a common definition of expectation levels for the reduction of electricity use in the semiconductor production process on a global scale. The expectation level for WSC normalised electricity reduction 2001 –2010 is 30%.

24 For the semiconductor industry contribution to energy reduction in general, see also ESIA. Consultation Paper of Semiconductor Manufacturing for the European Commission, DG INFSO, Unit H4 "ICT for Sustainable Growth", on Information and Communication Technologies enabling Energy Efficiency. Brussels, 2008.

Fig.12 - Energy Efficiency Trend of Global Semiconductor Manufacturers – Electricity Consumption as reported to WSC, from 2001 through 2006.



SOURCE: WORLD SEMICONDUCTOR COUNCIL (WSC), 2007

awareness of those technologies, together with supporting best practices. Governments and/or utilities can significantly help expand awareness, e.g., by actively supporting sector and cross-sector voluntary measures; partnerships with measurable deliverables; involvement of regional and local authorities in the process; incentives such as energy utility rebate programmes for manufacturers that develop or use products meeting high standards of energy efficiency.

2.2. CURRENT STATE OF THE SEMICONDUCTOR INDUSTRY

This section describes the current situation of the semiconductor industry in Europe.

The semiconductor ecosystem

Following the invention of the transistor in 1948, semiconductors rapidly evolved into a key enabler for providing solutions to societal, business and consumer needs in the second half of the last century. That role continues today and will do so in the foreseeable future. Every hour of the day, people everywhere in the world benefit from a broad range of semiconductors, whether they are using their PC, listening to music, using transportation or going to the doctors. Semiconductors have become indispensable for modern day life and stand at the forefront of the development of the information society. The sector is seen as a strategic 'must' by an ever increasing number of regions, with the central importance and role of semiconductors also historically being compared to that of grain and iron and steel in previous centuries. By enabling functionality and form factors previously unimagined, semiconductors continue to make modern day life possible, constantly improving the quality of life while at the same time contributing to deal with issues such as global warming and other global environmental concerns.

As of today, the semiconductor market has reached a value of 256 billion USD globally on an annual basis. (Fig. 1) This amount has a multiplier effect of approximately 25 times that amount in terms of equipment and services ranging from television sets to IT, or in other words it provides the knowledge and technologies that generate some 10% of global GDP.

For Europe the picture looks similar (Fig. 2). The pyramid also illustrates the fact that the electronic manufacturing industry is less strong than in other regions.

Because of their enabling role, semiconductors continue to enjoy higher than average growth, as illustrated in figure 3. This figure shows the long term development of global semiconductors markets, electronic equipment production and global GDP.

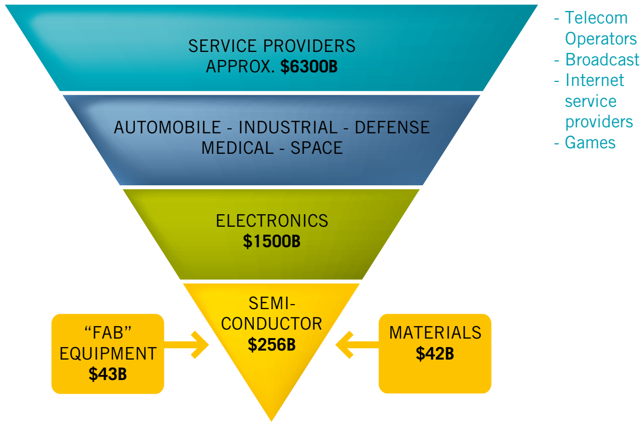
As can be observed from this graph - and highlighted in figure 4 - semiconductor markets have not only grown rapidly but also have been highly volatile. By the end of the last century, semiconductor markets have reached a more mature phase. Whereas until the end of the last century, the average annual growth rate was in the order of 15%, average annual growth is now in a single digit range comparable to the growth of electronic equipment production. Such a deceleration is normal for maturing markets.

1 See ESIA 2005 ; p. 14

2 See e.g. The Semiconductor Industry Contribution to Saving Energy & Protecting the Global Environment. May 2008 WSC presentation, under: http://www.eeca.eu/index.php/esh_about/en/

Fig. 1 - Impact of semiconductors on key downstream sectors worldwide - 2007

SEMICONDUCTOR AS "ENABLING" INDUSTRY

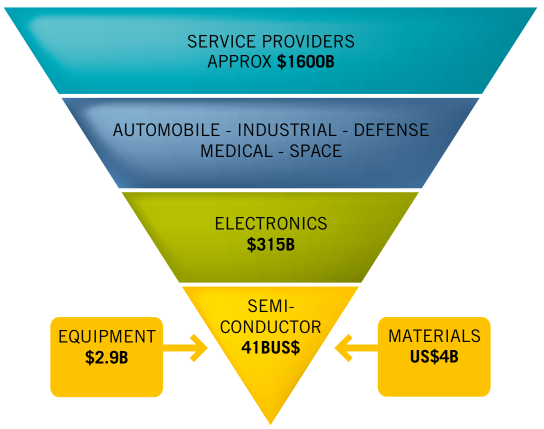


SOURCE: IMF, ESIA, WSTS, DECISION

Note: World GDP (based PPP): = US$ 65200B

Fig. 2 - Impact of semiconductors on downstream industries for Europe

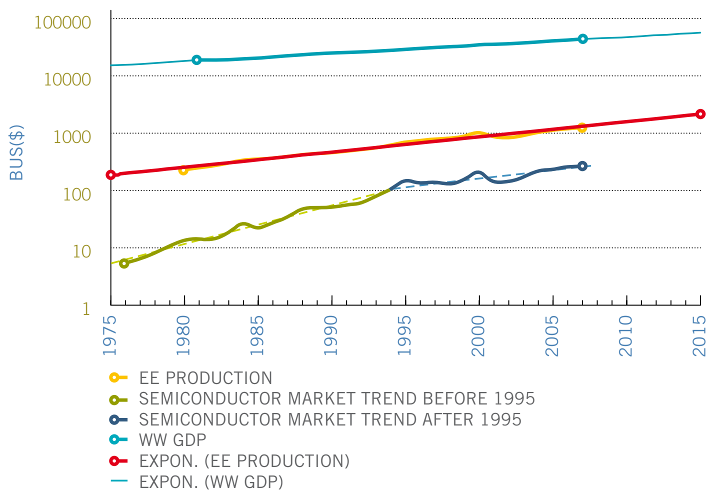
EUROPEAN DATA



SOURCE: IMF, ESIA, WSTS, DECISION

Note: EU GDP (based PPP): = US$14800B

Fig. 3 - Long term development of WW GDP, Electronic Equipment production and the Semiconductor Market



SOURCE: WSTS, IC INSIGHTS

Fig. 4 - Semiconductors – Continuing growth, volatile markets

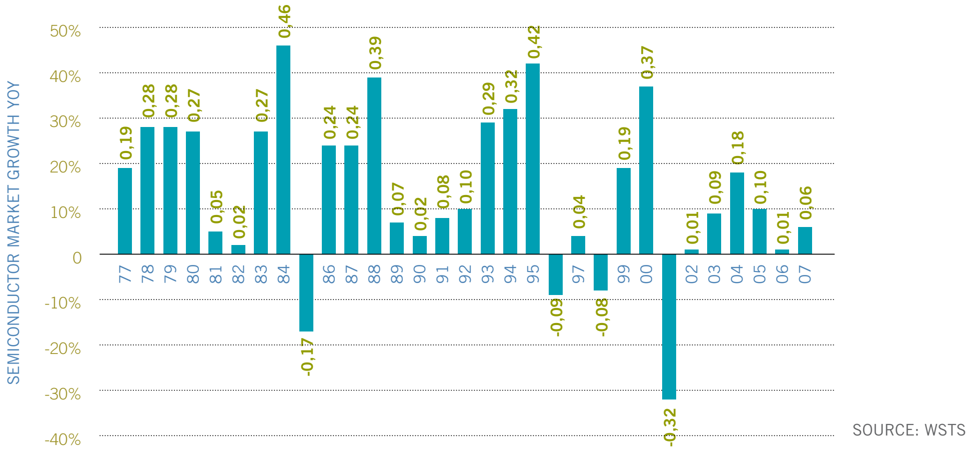
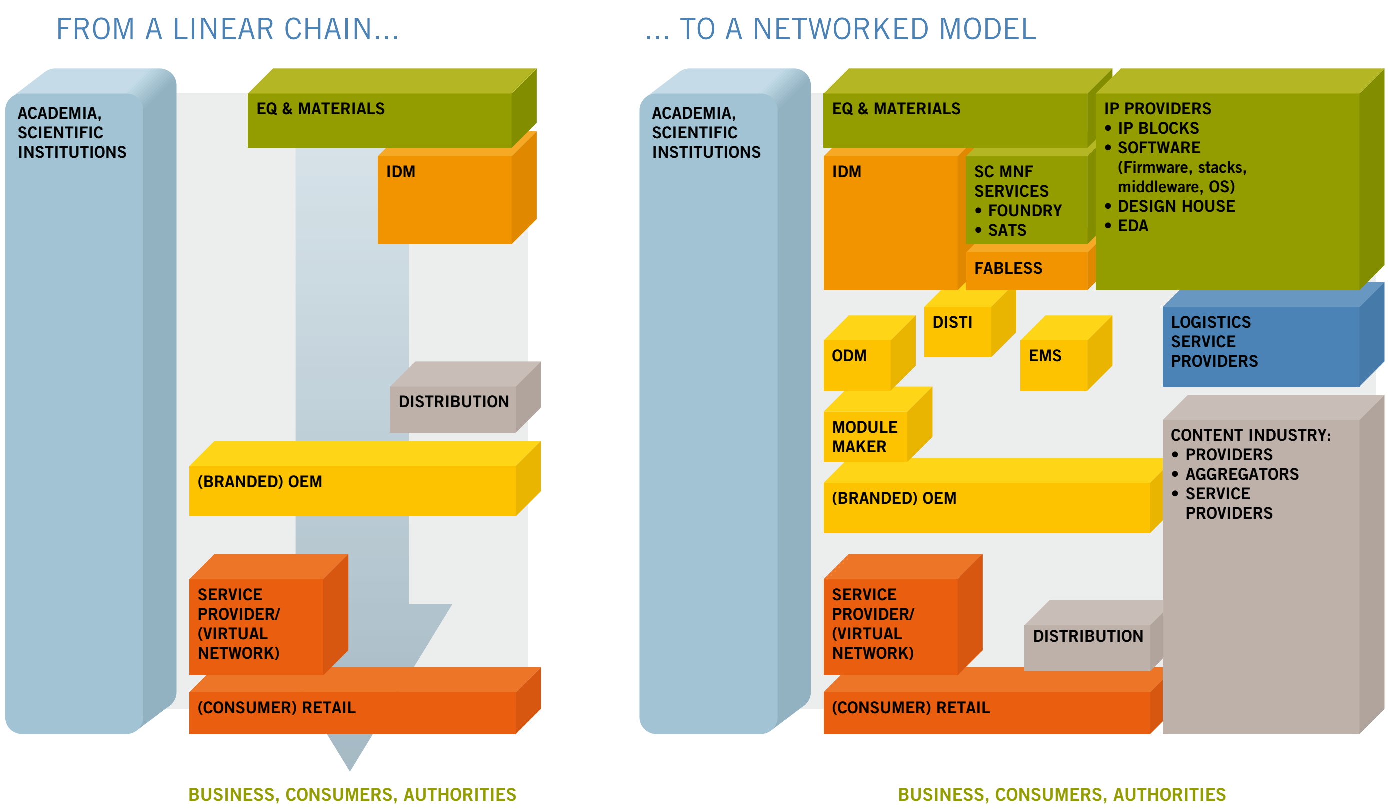


Fig. 5 - The evolving semiconductor landscape



SOURCE: ESIA

The semiconductor ecosystem has become increasingly complex, especially in terms of relationships with customers and suppliers. Over time, semiconductors have migrated from a classical linear and largely vertically-integrated supply chain (Fig. 5) to a network structure offering opportunities for specialized players. The consequence is that the semiconductor industry remains dynamic, hyper-competitive and highly innovative.

Because of this and given the complexities and opportunities of the manufacturing processes, semiconductors are also a truly global industry, constantly aiming at and operating within a zero tariff trading environment. There are currently hundreds of companies worldwide involved in the design and marketing of semiconductor devices, with large differences in terms of size and manufacturing capability. The combined market share of European companies has hovered around 11.5% for the past six years. In 2007, European head-quartered semiconductor companies held a combined market share of 11.7%. European head-quartered companies continue to compete at the highest industry levels. Looking at the top 15 in 2007, 3 EU companies held positions in that group. Five years earlier there were three European companies in the top 10. (Fig. 6).

Not only is the semiconductor industry as a whole truly globalized but so is the entire semiconductor supply chain. By the time semiconductor products are delivered to the final customer, they typically have travelled across the globe at least once, because wafer processing, testing and assembly in general all taking place in different locations. The semiconductor manufacturing sequence is highly complex and is composed of hundreds of processing steps with a cycle time that may take several months to complete.[3]

The European semiconductor market

The European semiconductor market attained a value of approximately Euro 30 bn (41 billion USD) in 2007, representing 16% of the worldwide total.

Figure 7 illustrates the rapid increase in the importance of the Asia Pacific region since 2001 as a market for semiconductors, initially at the cost of the Americas and Japan, but increasingly also at the expense of Europe. By the beginning of 2008, the share of Europe had only slowly declined to 16% of the worldwide semiconductor market, whereas Asia-Pac APAC - where the market is growing the fastest - had increased to almost 50%. WSTS currently forecasts the market share of Asia-Pacific 50% to increase further.

The stability of Europe relative to the decline of Japan and the US may be explained due to the strong presence of key original equipment manufacturers (OEMs) in Europe, that has so far ensured the continued importance of Europe as a manufacturing base for electronic applications and hence as a market for semiconductors. However, this manufacturing reality is undergoing rapid changes, as will be outlined in the trends of the next section.

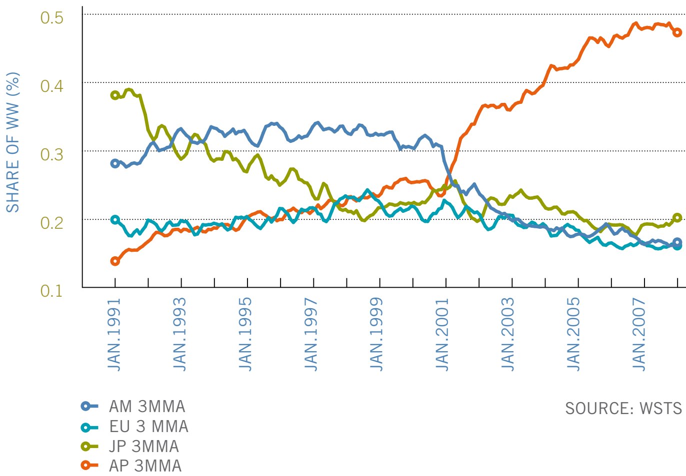
From an application perspective there are some very positive areas of activity in Europe for the semiconductor industry. The 2007 WSTS data clearly show strength in Europe of automotive and industrial customers, where Europe represents 40% resp. 27% of worldwide markets, and a good European position in communications, with Europe representing 16% of the worldwide market. However, consumer electronics and computing are underrepresented in the region.

Fig. 6 - Company rankings

	1990 SALES RANKING	2002 SALES RANKING	2007 SALES RANKING
1	JAPAN	USA	USA
2	JAPAN	KOREA	KOREA
3	USA	JAPAN	USA
4	JAPAN	EUROPE	JAPAN
5	USA	USA	EUROPE
6	JAPAN	JAPAN	KOREA
7	USA	EUROPE	JAPAN
8	JAPAN	USA	JAPAN
9	EUROPE	EUROPE	EUROPE
10	USA	JAPAN	USA

SOURCE: ISUPPLI

Fig. 7 - Semiconductor shares of the total market



3 The basic production process is executed at two types of manufacturing facilities: front-end manufacturing takes place in so-called wafer fabs, and back-end processing in test and assembly plants. The process is composed of two main cycles, the diffusion/pre-test cycle with a cycle time that may take several months, and the assembly/final test cycle with a typical cycle time of a few weeks. The diffusion process may take place in one or more wafer processing fabs in different localities around the world. Assembly and test are typically done in the Far East, after which the product is 'shipped' to the final end customer.

Fig. 8 - Semiconductor markets – Europe and the world, 2007

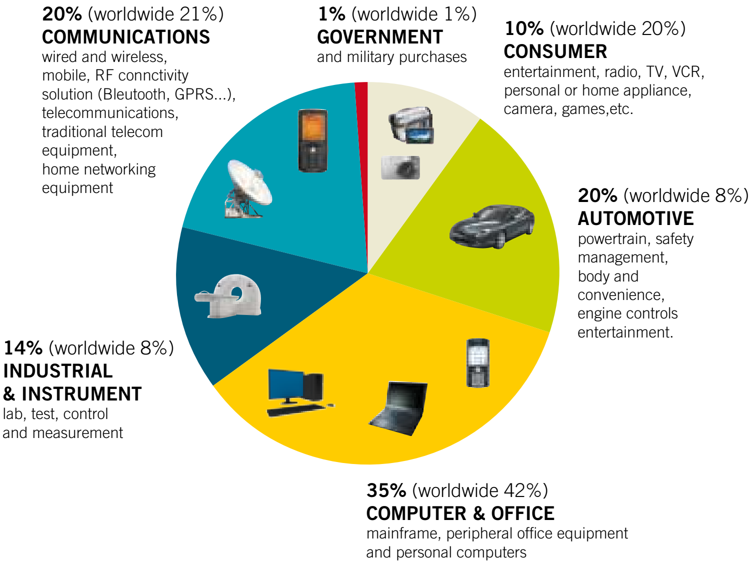


Fig. 9 – Semiconductor sales by application area (US$ million)

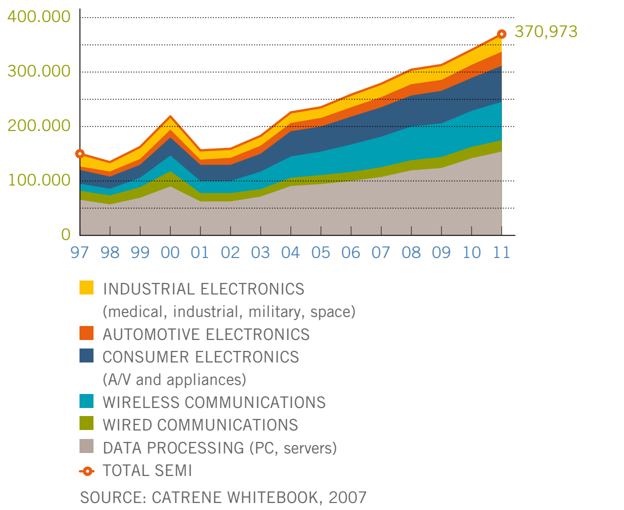


Fig. 10 - Electronics system OEM rankings

AUTOMOTIVE REGION OF HQ	INDUSTRIAL REGION OF HQ	MEDICAL REGION OF HQ	POWER REGION OF HQ	WIRELESS COMMUNICATIONS REGION OF HQ
1 EUROPE	1 EUROPE	1 USA	1 EUROPE	1 EUROPE
2 JAPAN	2 USA	2 EUROPE	2 USA	2 USA
3 USA	3 EUROPE	3 EUROPE	3 EUROPE	3 KOREA
4 EUROPE	4 EUROPE	4 USA	4 EUROPE	4 EUROPE
5 USA	5 USA	5 JAPAN	5 USA	5 EUROPE
6 EUROPE	6 USA	6 JAPAN	6 TAIWAN	6 KOREA
7 USA	7 USA	7 USA	7 TAIWAN	7 JAPAN
8 EUROPE	8 JAPAN	8 JAPAN	8 JAPAN	8 EUROPE
9 EUROPE	9 USA	9 JAPAN	9 USA	9 JAPAN
10 USA	10 USA	10 USA	10 USA	10 CHINA

SOURCE: ISUPPLI 2008

Fig. 11 - Major semiconductor spending by application top OEMS in 2007 est.

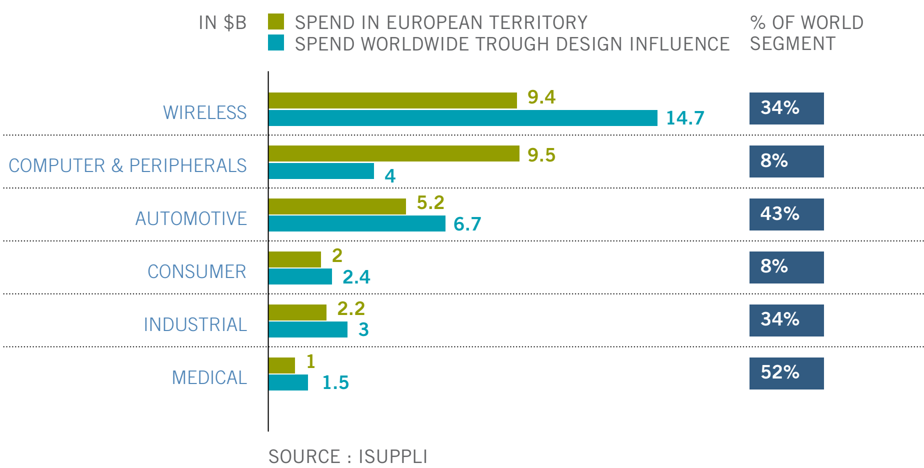


Figure 8 illustrates the different semiconductor market mix in Europe compared with the rest of the world for 2007, while figure 9 shows the past and anticipated market trends by application segment of semiconductor sales.

According to figure 10, European players hold key positions in the automotive, industrial, medical, power and wireless communication markets, measured by electronic systems revenue. This is a substantial source of competitive strength for the semiconductor industry in Europe.

The strength of Europe is furthermore illustrated when looking at the design influence of top OEMs in major application segments, in some of which European companies represent worldwide leadership. (Fig. 11).

Reflecting the European strength in these areas there are typically also one or two European semiconductor companies in the top 10 of each of these major application segments, particularly in automotive and industrial applications - which by and large includes medical and power as well - there is a high number of European semiconductor players represented overall (Fig. 12).

The numbers also reflect areas of strength of European Semiconductor industry. While typically there are one or two European semiconductor companies in the top 10 of each of the major application segments, in particular in automotive and industrial applications, there is a high number of European semiconductor players represented.

The semiconductor industry in Europe

The distribution of capacity worldwide and its evolution over time shows that, although Europe represents approximately 16% of the semiconductor market, it holds only around 11% of the worldwide wafer processing capacity (2007).This implies that Europe is a net importer of semiconductors.

Looking at the overall geographic location of wafer fab capacity (Fig.13), the biggest share is in the Asia Pacific region (i.e. South Korea, Taiwan, South East Asia and China), accounting for almost half of worldwide production in 2007.

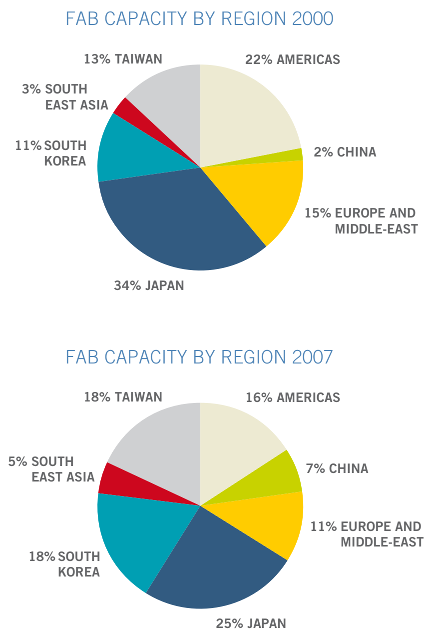
The picture looks even more impressive if trends are assessed over time (Fig.14, 15). Such an assessment shows that the semiconductor production centre of gravity has moved towards Asia Pacific and that this has been accompagnied with a strong reduction in Japanese production share and a more gradual reduction of share in Europe (EMEA) and the US. This trend has several underlying causes, including the migration of semiconductor markets to Asia Pacific and also the reduced financial return of manufacturing facilities in Europe (and the US as well) as compared with Asia. Prior studies by EU and US industry groups have indicated that, driven primarily by incentive packages, the return from a state-of-the-art manufacturing facility in Asia over a 10-year period can be around 1 billion USD higher than in the EU or the US.

Fig. 12: Companies in the top 10 of each major application segments

AUTOMOTIVE S/C RANKING 2007		INDUSTRIAL S/C RANKING 2007		WIRELESS S/C RANKING 2007	
RANK	REGION OF S/C COMPANY HQ	RANK	REGION OF S/C COMPANY HQ	RANK	REGION OF S/C COMPANY HQ
1	USA	1	EU	1	USA
2	EU	2	USA	2	USA
3	EU	3	USA	3	EU
4	JAPAN	4	EU	4	USA
5	JAPAN	5	JAPAN	5	JAPAN
6	EU	6	JAPAN	6	EU
7	EU	7	USA	7	USA
8	US	8	USA	8	JAPAN
9	JAPAN	9	EU	9	EU
10	JAPAN	10	USA	10	KOREA

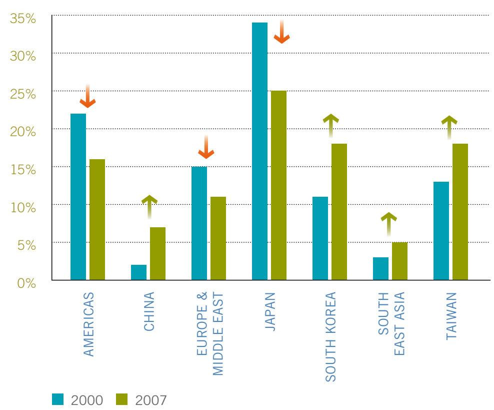
SOURCE: ISUPPLI

Fig. 13 - Fab capacity by region 2000-2007



SOURCE : SEMI

Fig. 14 - Fab capacity by region 2000-2007 – trends



SOURCE : FAB CAPACITY REPORT

Fig. 15 - Growth of Industry Capacity by Region

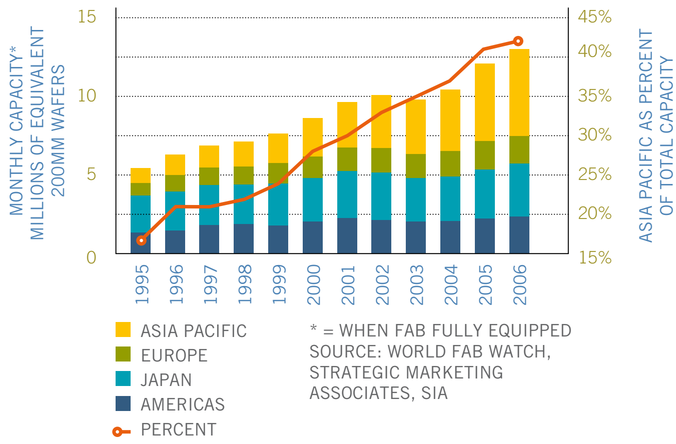


Fig. 16 - 300 mm Capacity by Regions

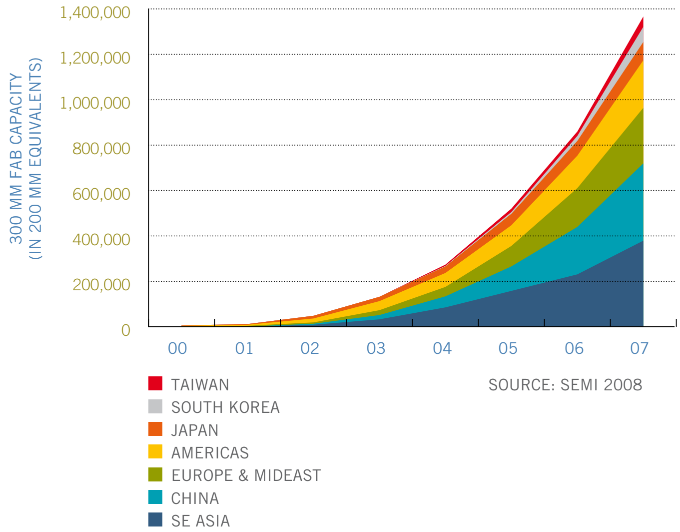


Fig. 17 - European semiconductor CAPEX as % of sales

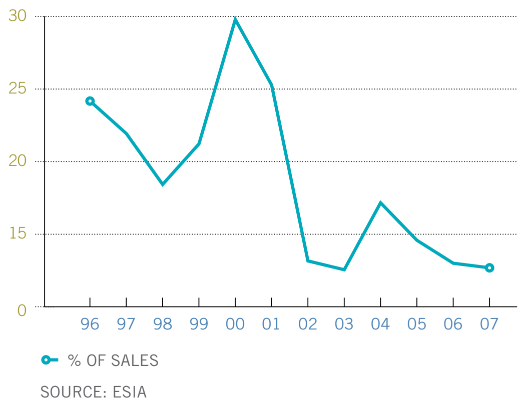


Fig. 18 - SEMI 2007 Equipment Markets Year over Year

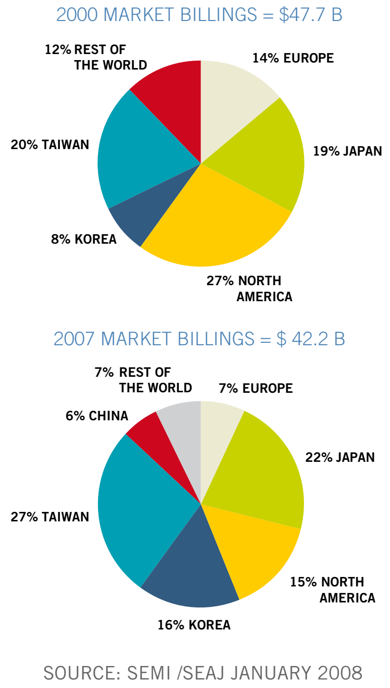
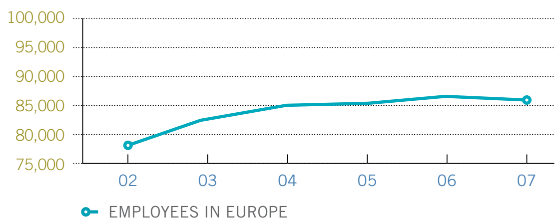


Fig. 19 – Direct employees numbers of ESIA company Members



This development affects both older and leading-edge technology. A striking example concerns 300 mm fabs (Fig.16): in 2000, only Japan and Europe had 300 mm fabs in production, while by the end of 2007 Taiwan and Korea have become the leaders in 300mm production capacity. Moreover, in all regions the growth of 300mm capacity exceeds that of Europe, foreshadowing a further decrease in Europe's share of future semiconductor production. Compounding this trend, the high investment required to build newer-generation fabs tends over time to reduce the number of semiconductor players that can afford wholly-owned, state-of-the-art wafer processing facilities.

Front-end manufacturing in Europe

Before taking a closer look at the location of semiconductor manufacturing in Europe, some general concepts need to be explained.

The basic chip production process is executed at two types of manufacturing facilities: front-end manufacturing takes place in so-called wafer fabs, while back-end processing in test-and-assembly plants. The process is composed of two main cycles: the diffusion/pre-test cycle, with a cycle time that may be several months, and the assembly/final test cycle, with a typical cycle time of a few weeks. The diffusion process may take place in one or more wafer processing fabs in different locations around the world. Assembly and testing are typically done in the Far East, after which the product is 'shipped' to the end user customer.

The set-up cost for a fab has increased substantially over time. According to Moore's second law, costs for a leading edge fab double between two chip generations. Today the cost of setting up a new 300mm fab amounts to Euro 3-4 billion, and roughly 20% of the industry's annual revenues are spent on capital expenditures.

Even after a fab has been built, rapid technological advance will make it likely that it will need to be upgraded several times during its productive life. Hence the most important cost factor in wafer production is the depreciation of equipment, fab buildings and facilities. This can reach as high as half of the total initial cost. Given high fixed capital costs and relatively moderate variable costs in semiconductor production, unit costs per semiconductor produced decrease as more semiconductors are produced in a fab. This is because the fixed capital costs can be spread over greater unit production. Increased output is reached due to learning effects and improved technological efficiencies that result in an increasing absolute number of chips on a wafer and in relative yield increases, and hence a fall in unit costs. It is generally observed that unit costs of production for semiconductors decrease by 30 percent if cumulative output doubles.

Europe has traditionally been a good place to invest in front-end facilities (fabs), as shown by the emergence of European-headquartered companies and their growth on the global market, but also by the number of non-European-headquartered companies that have decided to have facilities in Europe in the past years (especially in the '90s). This may not be the case in the future.

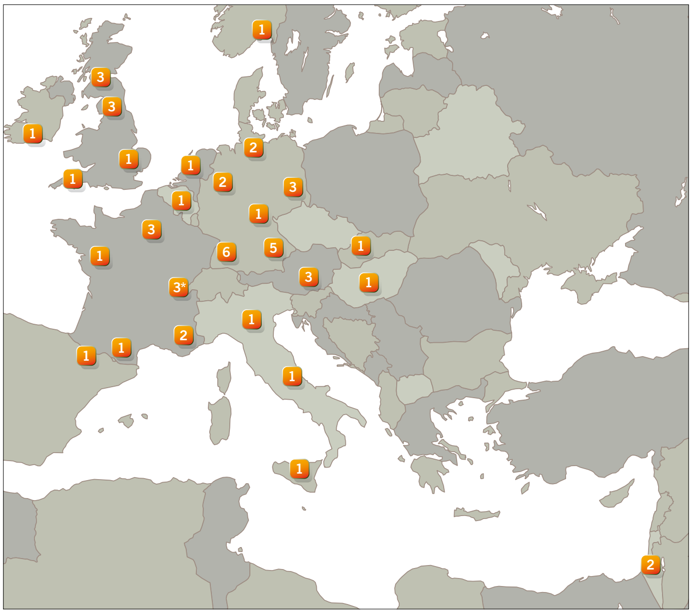
In the past, integrated device manufacturers (IDM) have been the main model in the region. However, the scale of investments needed to remain in advanced CMOS manufacturing is now driving many IDM players toward the so-called 'fab-lite' model, in which a major part of wafer manufacturing is outsourced to foundries. This is resulting in a structural decrease in capital expenditures by European companies. (Fig. 17)

Where semiconductor companies have historically invested more than 20% of their annual sales in manufacturing facilities and equipment, this percentage has dropped to approximately 13% for the past 5 years. Then there is the fact that there is a limited foundry activity in Europe contrasted with an increasing number of fabless companies. As a result, investments in new production equipment in Europe continue to lag. While in 2000 Europe still constituted 14% of the worldwide market for semiconductor manufacturing equipment, this percentage had dropped to only 7% by the end of 2007. (Fig. 18)

Despite this trend, direct semiconductor industry employment has increased over the past five years and now numbers almost 90 000 people in Europe[4], typically in high-skilled jobs. (Fig. 19)

As of 2005, although leading edge capacity was concentrated in a limited number of countries, wafer processing in general had a widespread presence throughout Western Europe, with major manufacturing activities in Germany (mainly in Baden-Wurttemberg, Bavaria and Saxony), France (Paris area, Grenoble and Provence), Italy (grouped around the three cities of Agrate, Avezzano and Catania), The Netherlands (Nijmegen), the UK (with an important – although recently declining - presence in Scotland), Ireland and Austria. (Fig. 20)

Fig. 20 - Total Front End Locations in Europe by number of companies, status 2005. (Total = 52 company manufacturing sites.[5])



SOURCE: ESIA MEMBERS; PUBLICLY AVAILABLE INFORMATION

4 This calculation is based on EECA-ESIA direct Members. The addition of further companies represented via the National Associations adds to this. The total direct employment of semiconductor manufacturers in Europe is therefore estimated at up to 115 000.

5 SEMI has calculated a total of 278 "production and R&D Fabs in Europe" and "'Seven 12' wafer fabs and 11 sub-90nm fabs". SEMI January 2007

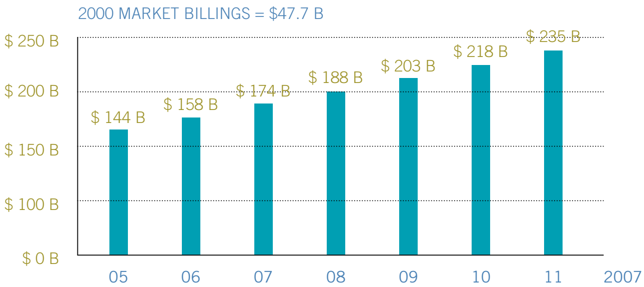
Fig. 21 - Back-end locations – ESIA Members status 2005

SOURCE: ESIA MEMBERS; PUBLICLY AVAILABLE INFORMATION

Fig. 26 - Semiconductor R&D locations in Europe

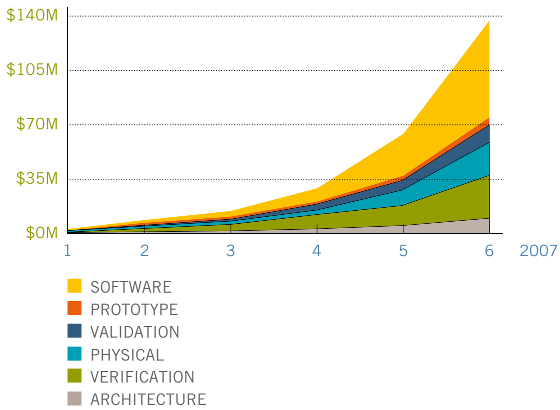
SOURCE: EECA - ESIA

Fig. 22 - Market for software



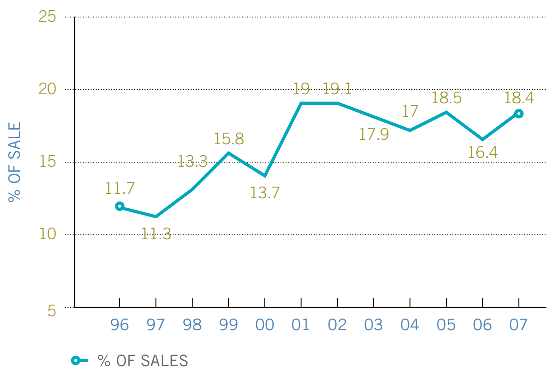
SOURCE: GARTNER

Fig. 23 - The escalating cost of design



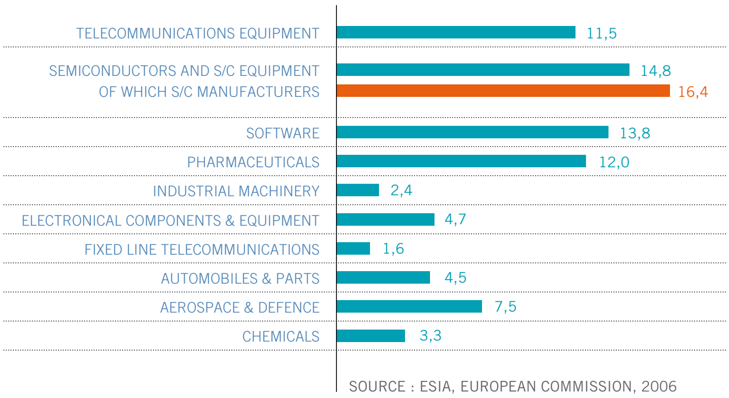
SOURCE: SYNOPSYS

Fig. 24 - Semiconductor R&D as % of sales



SOURCE: ESIA MEMBERS; PUBLICLY AVAILABLE INFORMATION

Fig. 25 - R&D intensity



SOURCE : ESIA, EUROPEAN COMMISSION, 2006

Back-end manufacturing

As stated above, back-end activities (assembly) normally take place in other geographies (namely South-East Asia) since they are more labour-intensive production processes. Measured by number of employees, approximately 85% of SATS services are located in APAC, compared with less than 2% in Europe.

Nevertheless, a small but important number of back-end facilities are present in Europe, employing between 20 and 4000 employees per facility. (Fig.21) In most cases they are directly connected to front end fabs, pilot lines or R&D assembly facilities. The number of pure back-ends is therefore quite limited, and only locations like Malta, Casablanca, Porto or Cegled can be considered large facilities.

Semiconductor centres of excellence: R&D and the phenomenon of clustering

With the commoditization of mainstream manufacturing (because of the high level of investment required), increasing functionality of products and exploding complexity of designs, the importance of software in electronics products continues to increase, as illustrated by the continuing growth of the market for software. (Fig. 22)

This is also reflected in the escalating costs of chip design. In figure 23 we have taken line width as a placeholder for design complexity. The graph clearly shows the exploding cost associated with complex designs and the high proportion on these costs represented by software and design verification. This contributes to the high R&D intensity of the semiconductor industry and of European innovation.

Semiconductors have been and remain highly R&D intensive. Semiconductor companies on average spend on the order of 18% of their sales revenues on R&D (Fig. 24).

This makes semiconductors one of the most R&D-intensive industry sectors (Fig. 25), even more so than software and pharmaceuticals, and a driver for innovation in Europe because of the widespread presence of R&D locations (Fig. 26) and the network of knowledge-based clusters in which these activities are embedded. These installations are a significant part of Europe's strength.

Semiconductor clusters in Europe

There are several factors which influence a company's choice of location, ranging from considerations such as the availability of highly-skilled personnel, good infrastructure, favourable financial conditions (tax schemes, incentives), the location of its headquarters, the proximity to customers, suppliers and the presence of R&D centres. These last conditions can be found all together in a technology cluster. (Fig. 27)

The proximity of research, design centres and manufacturing facilities benefits technology transfer because it minimises delays. Where research and manufacturing meet, effective networks between companies and research institutes emerge, attracting engineers, researchers and academics to share knowledge and experience, thus stimulating and accelerating the innovation process in a particular geographic area.

Examples of such clusters can be found in the Grenoble area, the ETNA Valley (Catania), the Nijmegen-Eindhoven-Leuven axis and in Dresden. Similar structures can be observed in the Dublin area.

Fig. 27 - Main technology in Europe

2.3. CONCLUSIONS

The picture of the competitive environment the semiconductor industry is facing today in Europe as well as in the global playing field shows the complexity of the challenges it must deal with. In comparison with our observations in 2005, the competitive constellations that have emerged in the global scene from both an industry and a geo-political perspective have taken a more precise shape. Obviously, today's visible structural changes in the world economy have taken more than a generation to produce such shifts in the center of gravity, impacting on the competitive race for ICT in general and for the semiconductor industry in particular.

Our analysis of the 2008 competitiveness pressures in section 2.1., along with the semiconductor landscape described in section 2.2., shows the emergence of a few overarching patterns that form the background against which the longer term future semiconductor industry environment must be viewed. Here we can sketch only the most striking traits:

- *De-verticalisation of the semiconductor value chain* causing the entry of new players.
- *Attraction of significant FDI in Asia Pacific countries* as a consequence of aggressive industrial policy-setting in ICT.
- *Delocalisation of manufacturing processes* to low cost countries, mainly Asia Pacific.
- *Consolidation of global clusters of know-how* in ICT becoming new, world-leading, large- scale ecosystems fuelling strong advances in R&D.
- *Amplification of Asian academic brainpower* in high-technology disciplines at a much higher rate than in the US and Europe.

When analysing the trends that shape the landscape of the industry in more detail in the next section, it must be remembered that it is also against these patterns at the world level that strengths and weaknesses, opportunities and threats need to be assessed.

APPENDIX A1:
International R&D Tax Incentives offered by select competitor-nations

The following is a summary of R&D tax incentives offered by select competitor-nations (Ernst & Young, 2008)*

Country	R&D Tax Incentive	Comment
Australia	- Allows a 125% deduction for R&D expenses. - Plus a 175% premium tax deduction for R&D expenditures exceeding the prior 3-year average spending. - Effective from 2008, foreign-owned R&D activities undertaken in Australia may also attract a 175% premium tax deduction.	The 125% deduction is the equivalent of 7.5 cents in the dollar after tax benefit. The premium 175% amount equates to 22.5 cents in the dollar after tax benefit. In discussing its R&D-friendly environment, the Australian government's website (investaustralia.com) concludes that with the 125% tax deduction, 175% premium tax deduction for foreign-owned R&D, "It's little surprise then, that many companies from around the world are choosing to locate their R&D facilities in Australia." The government also points out that "50% of the most innovative companies in Australia are foreign-based."
Canada	- Offers a permanent 20% flat (i.e., first dollar) R&D tax credit. - Also many provincial governments offer various incentives (e.g., refundable credits) for R&D activities conducted in their provinces.	In 2003, U.S. subsidiaries spent $2.5 billion on R&D in Canada, which has mounted an aggressive marketing campaign, including television and print advertisements, to lure more U.S. companies to locate R&D operations north of the border. Ontario print ad discusses "R&D tax credits, among the most generous in the industrialized world" and "a cost structure which KPMG confirms as lower than the U.S. and Europe"; the ad concludes, "you'll see why R&D in Ontario is clearly worth investigating."
China	- A R&D center qualified as a State-encouraged high and new technology enterprise can enjoy a 15% reduced tax rate, instead of the 25% corporate income tax rate, and potentially a tax holiday of "2-year tax exemption and 3-year 50% deduction" if located in the prescribed areas. - A 50% "super deduction" is allowed in addition to the actual expense deduction for R&D expenses that are not required to be capitalized as intangible assets. - In addition, there are indirect tax incentives to the R&D center for example, business tax exemption and duty-free importation of equipment and spare parts, etc.	On 3/16/07, China adopted a new Enterprise Income Tax Law that eliminated many of the incentives applicable exclusively to foreign-investment enterprises. The new law was adopted in part out of a desire for equal taxation of all enterprises and to remove incentives applicable only to foreign investment. Still, the new law includes incentives to encourage activity that stimulates economic growth, such as research and development. (Fundamental Enterprise Income Tax Reform in China: Motivations and Major Changes, Jinyan Li, Comparative Research in Law and Political Economy paper 33/2007).

* URL: http://www.investinamericasfuture.org/PDFs/Coaliiton_Interntl_RD_tax_5-18-07.pdf

Country	R&D Tax Incentive	Comment
France	- A 30% credit for qualifying R&D expenses for the year of up to €100M. - The 30% rate is raised up to 50% and 40% for the first and second years, respectively, following a five year period during which the enterprise has not benefited from the R&D Tax Credit mechanism. - The total amount of the R&D Tax Credit is not capped anymore.	As part of the French Finance Act for 2008, approved 12/18/2007, the R&D limitation of roughly US$23 million was eliminated and the previous two-pronged credit consisting of a variation and volume component was abandoned in favor of 30% volume component. "Practically, all taxpayers engaged in R&D should benefit from these changes, with a proportionally bigger tax benefit for taxpayers incurring stable or declining R&D expenses." (International Tax Review, February 2008)
India	- A 15-year phased income tax holiday and a complete exemption from indirect tax implications for export of services (including R&D) from a Special Economic Zone. The complete exemption may continue indefinitely as long as certain requirements are met. - Deduction for scientific expenditure or in-house R&D equal to 1.5 times the expenses so incurred. The deduction is restricted to entities approved by the Department of Scientific and Industrial Research (DSIR) and is limited to selected industries (e.g. biotechnology, electronic equipment, etc.). - Special other benefits such as accelerated tax deductions, allowability of prior period expenses and weighted deductions are also available, depending upon the facts.	"More than 100 global companies … have established R&D centers in India in the past 5 years, and more are coming. … As I see it from my perch in India's science and technology leadership, if India plays its cards right, it can become by 2020 the world's number-one knowledge production center." Raghunath Mashelkar, Director General, Council for Scientific & Industrial Research, India, in Science Magazine.
Ireland	- Offers a 20% R&D tax credit on incremental expenditures calculated with reference to base year of 2003. This in addition to any existing deduction or tax depreciation. This results in an effective benefit of up to 32.5% based on Ireland's low 12.5% corporate income tax rate. - Capital expenditure on scientific research may also qualify for a separate 100% initial allowance.	According to IDA Ireland, the government agency with responsibility for the promotion of direct investment by foreign companies into Ireland, "Many leading global companies have found Ireland to be an excellent location for knowledge-based activities. … Nearly half of all IDA supported companies now have some expenditure on R&D and 7,300 people are engaged in this activity."
Japan	- A corporation my claim two credits, generally equal to 5% of certain incremental R&D expenditures in a year and 8% to 10% of total R&D expenditures in a year, subject to a limitation of 20% of the corporate tax due for the year. The excess can be carried forward only for 1 year. A 5% credit is a sunset provision and is not available for tax years beginning on or after April 1, 2008. - The 2008 tax reform is currently pending. A proposal to change the rule to the following has been made, however, the Diet has not passed the reform yet: (1) 8% to 10% of total R&D expenditures in a year, up to 20% of the corporate tax due; (2) Either (a) or (b) (elective) (a) 5% of incremental R&D expenditures, up to 10% of the corporate tax due; (b) If the current R&D expenditures exceed 10% of the average sales, a certain % of such excess amount, up to 10% of the corporate tax due (The % is computed by the following formula: (current R&D expenses / average sales x 10%) x 0.2%)	Japanese Finance Minister Fukushiro Nukaga said in January 2008 that reforms acted upon in 2008 would focus on R&D among other issues, in an effort to provide a sustained economic recovery in the face of rising oil prices, troubled foreign economies, and an aging population (Bureau of National Affairs).

Country	R&D Tax Incentive	Comment
Japan	The total of (1) and (2) can be claimed as a credit. Note that the 10% limitation under (2) is separate from (1) and therefore, the total credit can be up to 30% of the corporate tax due.	
South Korea	- A 100% deduction for R&D expenses is allowed. - Tax credit would be 40% of incremental R&D expenses for the current year exceeding the average of the R&D expenses incurred during the previous 4 years. - For Small and Medium Enterprise (SME), more benefit may be available.	South Korea has moved aggressively to attract foreign R&D center, offering income tax exemption for foreign companies locating their R&D center in Foreign Investment Zones ("FIZs") or in Free Economic Zones ("FEZs"). i) FIZs: A 100% exemption for first 5 years and a 50% for 2 years – minimum 2 million investment ii) FEZs: A 100% exemption for first 3 years and a 50% for 2 years – minimum 1 million into FEZ + 10 full time research staff
Singapore	- "R&D and Intellectual Property Management Hub Scheme" offers U.S. companies a 5-year tax holidays for foreign sourced royalty or interest income earned with respect to Singapore-based R&D. - The 2008 Budget proposed that companies that carry out R&D activities in Singapore will qualify for a tax deduction of 150% of the amount of R&D expenses incurred in the tax year ending in 2008 to 2012. There is no need for the R&D activities to be connected to the Singapore entity's current trade or business to get the deduction. This proposal is expected to be enacted in late 2008. - Another 2008 Budget proposal is for companies with chargeable income (i.e., taxable income after depreciation allowances and applicable tax exemption) to be granted on R&D tax allowance for each year from tax year ending in 2008 to 2012, at a prescribed rate of up to 50% of the first $300,000 (approx. US$218,000 as of April 3, 2008) of the company's chargeable income. Likewise, this proposal is expected to be enacted in late 2008.	According to Singapore's Economic Development Board website, "Singapore does not just welcome business ideas; it actively seeks and nurtures them. We play host to any shape and size of enterprise and innovation – startups with little more than the germ of an idea; global corporations with large R&D teams and complex production operations."
United Kingdom	- Allows a 125% deduction for R&D expenditures incurred by large companies prior to April 1, 2008, and 130% for expenditures incurred after April 1, 2008.	The UK leads the world in attracting R&D investment by U.S. affiliates – U.S. subsidiaries spent more than $4 billion on UK-based R&D in 2003. The 130% deduction alone is equivalent of a flat 8.4% R&D tax credit.
United States	- Allows a maximum 10% incremental credit (a nominal 20% credit) for qualified R&D expenditures in excess of a calculated base amount. - The Alternative Simplified Credit ("ASC") provides companies with a credit of 12% of R&D expenditures that exceed 50% of average R&D expenditures over the prior three years. - An Alternative Incremental Research Credit formula is also available. The AIRC computation combines a three tiered fixed-base percentage with a reduced three-tiered credit percentage. - The business deduction for R&D expenses must be reduced by the amount of any R&D credit.	The U.S. R&D credit expired on December 31, 2007. In 2006, Congress enacted into law a seamless extension of the R&D tax credit from January 1, 2006, through December 31, 2007. Included in the law was language to strengthen the credit with a new credit formula called the Alternative Simplified Credit that became effective January 1, 2007 through December 31, 2007.

TRENDS SHAPING THE FUTURE SEMICONDUCTORLANDSCAPE 3

The purpose of this section is to undertake a systematic review of what we regard as twelve of the most important current critical trends that are reshaping the global semiconductor industry today. This consists first of all of a brief analysis of each of the trends in terms of their impact on the semiconductor industry both globally and in Europe. Next there is an assessment of whether each semiconductor industry trend, and the opportunities and/or threats it represents, converges with Europe's perceived interest in having a globally-competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries.

Based on the analysis of the individual trends, a short synthesis highlights competitive opportunities, i.e. areas where the combination of industry and societal interests in Europe may provide a basis for making policy recommendations.

Based on an iterative selection procedure the finally retained semiconductor trends have been classified into the following three groups: (Fig.1)

D = Device Trends:	*From Components to Systems Solutions*
R = R&D Trends:	*R&D, Process Technology, Manufacturing*
V = Value Chain Trends:	*The Differentiating Semiconductor Value Chain*

FIG. 1 - TRENDS SHAPING THE SEMICONDUCTOR LANDSCAPE

	TRENDS
DEVICE	FOR COMPONENTS TO SYSTEM SOLUTIONS
D1	Increasing importance of systems architecture and design
D2	Increasing importance of software in semiconductors
D3	Increasing importance of testing and simulation
D4	Increasing importance of multilayer, multichip solutions
R&D	R&D, PROCESS TECHNOLOGY, MANUFACTURING
R1	Increasing specialization towards application-driven R&D
R2	More clustering of innovation and IP generation along the supply chain
R3	Further consolidation of R&D on advanced CMOS* platform development
R4	Increasingly differentiating semiconductor manufacturing models
VALUE CHAIN	THE DIFFERENTIATING SEMICONDUCTOR VALUE CHAIN
V1	Blurring boundaries between semiconductor players and OEMs
V2	Shifting business models of integrated circuit (IC) suppliers and foundries
V3	Shifting revenue stream of semiconductor equipment and material suppliers
V4	Increasing role of IP and fabless IC providers

Our Approach

Trends shaping the future semiconductor landscape

- *What are key trends shaping the current industry landscape?*
  - *What are the main characteristics of these trends?*
- *What is the impact of each of these trends on the semiconductor landscape*
  - *Impact on the global semiconductor industry?*
  - *Impact on the semiconductor industry in Europe?*
- *Trend Assessment*
  - *Does each individual trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology, and supporting innovation for end-use industries?*
- *Competitive opportunity*
  - *What opportunities exist for Europe based on these trends?*

3.1 FROM COMPONENTS TO SYSTEMS SOLUTIONS

D 1 The increasing importance of system architecture and skills in dedicated design techniques

The increasing complexity of solutions driven by the creation in many areas of new industry and end-user applications requires an increasingly modular design approach, developing more innovative building blocks and flexible system architectures with higher integration capabilities. (Fig.2)

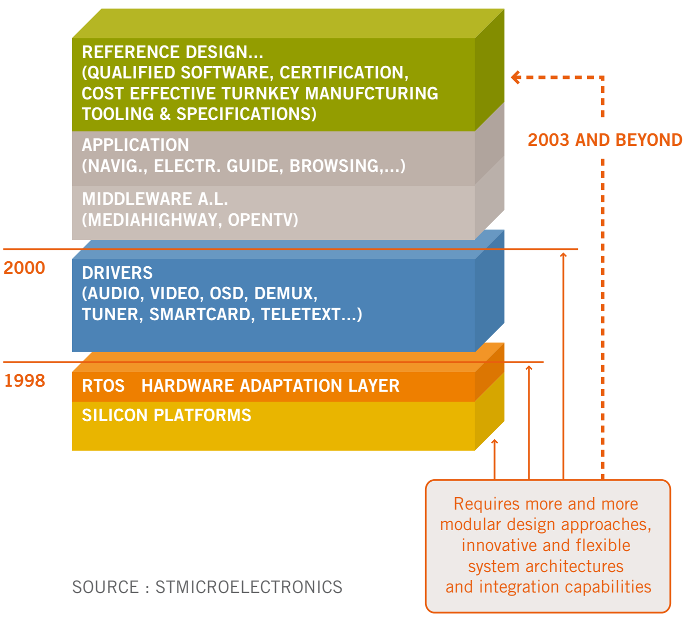
1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- The semiconductor value chain is becoming more differentiated and traditional players are moving forward along the entire chain to provide systems solutions as required by the market. The trend includes moving from components to solutions, e.g. in radio frequency (RF); from modules to fully-integrated solutions; from components business to systems business (e.g. camera systems with sensors, mechanics, lenses; telecom systems; architectural systems)

- The need for compatible approaches drives new types of industry collaborations and the forming of industry consortia establishing common user platforms and/or standards (e.g. Flexray in automotive; user platforms for wireless handsets; etc.)

Fig. 2 – Increasing importance of systems architecture



SOURCE : STMICROELECTRONICS

- The increasingly complex structure and broad application areas of semiconductors drive the importance of electronic design automation (EDA) both for the semiconductor industry and its customers. As applications themselves become more specialised and sophisticated, (e.g. for automotive, industrial production, communication, security, energy, etc.) requiring further system integration and ever-higher quality standards, the semiconductor industry increasingly responds to such specific needs by offering designer skills and differentiated design tools to develop these complex systems on the chip.

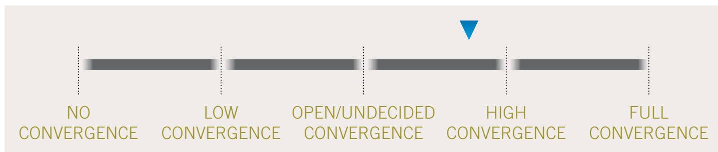
2. Impact on the Semiconductor Industry in Europe

- Whereas in the US digital systems are dominant, Europe has strength in the analog/mixed-signal space where customised tool boxes for multi-chip architectures, including verification and simulation, are required. As more and more semiconductor companies go fablite or fabless, the European value added will further shift towards design and tool flow within the semiconductor value chain.

- However, the situation regarding the availability of analog designers in Europe appears to be worsening: the number of engineers graduating from European universities in this discipline is decreasing, so a shortage of electronics engineers in general, and analog design engineers in particular, needs to be anticipated.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



High convergence. The interests between the semiconductor industry and Europe mainly converge in areas of specialised applications where competency and experience in modular design approaches, innovative and flexible system architectures and integration capabilities are the key success factors. With Europe's global leadership in industry segments such as wireless communications, consumer and automotive, the semiconductor industry finds itself very well positioned to add value.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

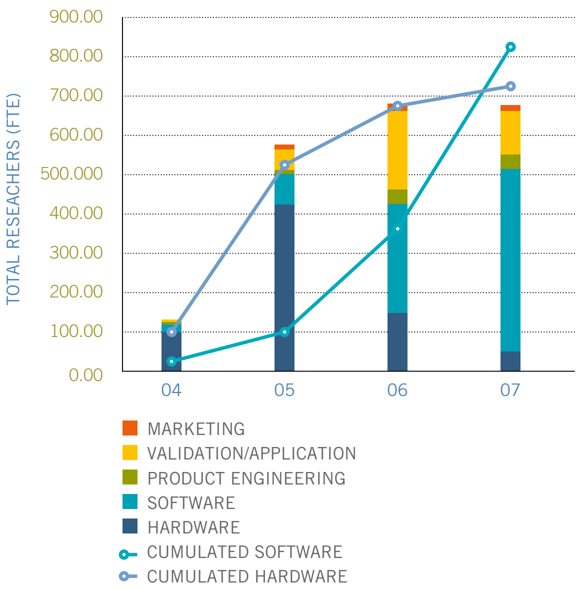
Europe's leadership position in industries such as wireless communications, consumer and automotive offers significant opportunities for the semiconductor industry in specialised application areas. Europe has strength in the analog/mixed-signal space where customised tool boxes for multi-chip architectures, including verification and simulation, are required. The industry should be able to leverage the competency and experience that exists in modular design approaches, innovative and flexible system architectures and integration capabilities.

It is crucial that European universities, along with public authorities and key industry players, undertake actions to prevent a shortage of electronics engineers and a further decrease in the number of analog and systems design engineers graduating in this discipline.

D 2 The increasing importance of software in semiconductors

The know-how of dedicated semiconductor applications is increasingly implemented in software. Despite the portable nature of software, the close interaction between software and hardware in embedded control is still essential for effective implementation. Quick and reliable solutions can only be realised within a software ecosystem. For this reason, knitting a dense network of hardware and software development entities within and/or outside companies with local presence is critical. (Fig.3)

Fig. 3 - Increasing role of SW development overtaking HW design



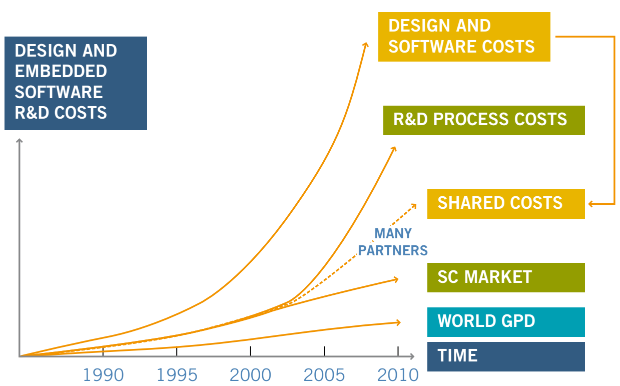
SOURCE: ST MICROELECTRONICS

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- Any complex semiconductor device embeds electronic parts and related software. There is a clear correlation between the attractiveness of the product and the total amount of electronics it embeds (hardware and software). The software controls the user-visible part and determines the price point and margin of the product. The software part is often used to create differentiation among products with similar dedicated hardware.
- The increasing complexity and focus of semiconductor applications on dedicated solutions and systems integration - implying sophisticated software and human interface functionalities -, requires increasingly specialised software capabilities that only providers with a critical mass of skills and service resources are able to offer.
- Semiconductor vendors are required to provide the software ecosystem. Therefore software providers increasingly offer full integration and services packages.
- The semiconductor industry is also required to provide more and more reference design and platforms. This means that the semiconductor industry provides not only ICs but also the systems software on top of which the OEMs can customise their products, including hardware and system software. The implementation of a complex platform already requires more software designers than hardware designers.
- As the variety of applications is broadening, the development of more advanced SW tools and packages is becoming increasingly sophisticated. (See Box next page)
- In information processing the trend is toward multiple cores. This will likely push design challenges even more towards SW.
- In summary, as a consequence of the increasing role of SW development by the semiconductor industry, design and embedded software R&D costs are rising faster than any other costs. (Fig.4)

Fig. 4 - Design and embedded software R&D costs rise faster than anything else



SOURCE: ST MICROELECTRONICS

Software is the carrier for applications know-how

Software is becoming the carrier for applications know-how, making up a significant portion of the end-user product, so the distinction between "product" and "software" is increasingly difficult to make. For example: when manufacturing gearboxes, the know-how about the friction in clutches is captured in software programmes. In the gearbox that is sold, where essentially an electronics module controls the clutches and the gears, the value of the software is part of the product and cannot be separated from the hardware. Also, for this reason among others, it is not easy to measure the value of software accurately.

Following are examples of different application areas where SW is becoming a critical success factor and competitive differentiator.

- *In automotive, consortia such as AUTOSAR are being established in order to develop dedicated SW packages for the automotive industry at all stages of solution development, from engineering to implementation and testing.*
- *In wireless communication, a complex platform such as in mobile telephony now easily requires thousands of designers, out of which more than 50% are SW designers. In addition, a variety of standards have to be observed for global access to communication networks. This implies complex and expensive chip architectures, along with multi-antenna design, which engenders a high probability of bugs.*
- *In consumer, applications such as pay-TV, e-passports or e-banking rely on encryption technologies to be safeguarded against copying or falsification. Here the combination of HW and SW security is the solution; this is a classical example of where HW and SW development have to be coincident. New applications such as trusted computing will broaden the scope of software-based security solutions in the semiconductor industry.*
- *Software is a carrier for services as well. Certain functions or services are performed in software and the value of the software is reflected in the value of the service. For example: a phone call is routed through a number of software layers. A web inquiry is performed by software and its result is paid for by the user through different direct or indirect means of payment.*

2. Impact on the Semiconductor Industry in Europe

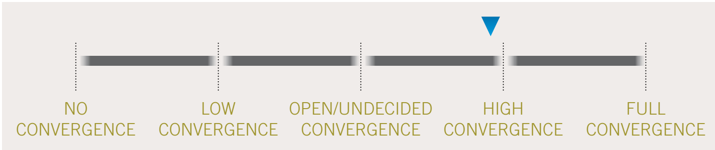
- The semiconductor industry in Europe has key players in the consumer, automotive and telecommunications sectors with deep experience in providing system solutions combining HW and SW.

- Software development in Europe is a well established, still affordable and an increasingly specialised and differentiated, highly competitive business.

- A number of European OEMs are leading providers to the global market for goods and products in which the embedded semiconductors provide the SW based intelligence, in particular for the automotive and wireless communication industry. The alignment of semiconductor manufacturers in Europe with these OEMs represents a major competitive opportunity and a solid ground for the development of new applications in growing markets such as energy saving, environmental protection, security and health.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



High convergence overall. Europe has an interest in mastering software development and maintaining an ecosystem of its products. Some of Europe's global industry leaders in wireless, automotive and industrial goods increasingly require software driven semiconductor applications and value added.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

The opportunity for Europe is to build a rich ecosystem around software for semiconductor products for support and services. Fostering and extending these skills is crucial to the success of the semiconductor industry in Europe. However, as software systems are often complex agglomerates originating from different providers, the challenge for every company is to keep control over the sections of code that implement their unique product know-how in software.

In order to overcome these obstacles, the EU should encourage collaborative programmes that are oriented towards final customer applications and include all actors along the value chain, including, e.g., companies in biotechnology, MEMS, sensors and actuators, etc., as well as end-use customers.

In order to nurture the engineering talent pipeline starting at an early age, educational systems should promote a comprehensive understanding of the technology eco-system from hardware to software to human capital in order to encourage interest in engineering careers.

D 3 The increasing importance of testing and simulation

As integrated solutions in dedicated application areas become more complex, simulation and testing will play an increasingly business-critical role. Testability of complete solutions based on advanced securing and documenting of engineering, validation, quality control and certification will become a challenge in the future.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- Given the ongoing decoupling of front-end (IC creation) and back-end manufacturing (assembly and packaging) testing and simulation as a key activity in the back-end process of manufacturing has almost entirely migrated to Asia.

- Testing is becoming increasingly critical to product/application success. Key test development activities include test specifications/test bench conception and diagnostic; test programme development (test vector conversion/test programme synthesis); test programme debug and optimization (test characterization/optimization); test pattern generation.

- There is also an increased emphasis on solutions testing, verifying how they work rather than just providing technical data. The issue becomes how to test a complete system, e.g. in field tests or in assessing interoperability.

- Testing strategies are expected to become increasingly platform-based. Driven by an applications market, they are becoming more local and more supported by dedicated application engineers. As a consequence, the development and implementation of such test platform systems requires increased flexibility and ease of access globally. The flexibility of platforms will allow their being more widely used in probe, final test or engineering environments.

- Testing cost has increased due to the higher number of testers and the complexity of testing, which cause an increased board usage; the impact of maintenance activities is thus becoming more critical. Increased tester efficiency improves productivity and delivery to customer with higher overall customer satisfaction. Better tester performance also means increased productivity in the sense of improved MTBF (Mean Time between Failures), i.e. lower board usage or tester failure, hence reduced maintenance resources to be devoted. Better tester performance will also reduce rejection: this will improve tester utility, hence lesser waste of material, tester required, and energy consumption.

2. Impact on the Semiconductor Industry in Europe

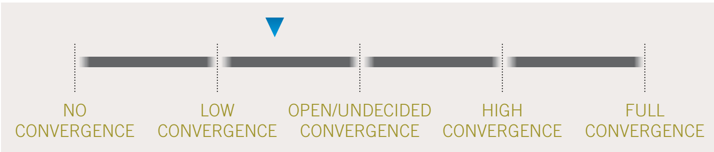
- In Europe, the presence of manufacturing test services addressing both device and packaging is low and could become a challenge for IC critical product development.

- The quality requirements in the automotive market and the certification issues in security markets are good examples of the growing influence of in-house test activities in the semiconductor value chain. The same applies for wireless or medical devices.

- Tester complexity is becoming increasingly demanding for maintenance teams who have to continuously improve their specific maintenance skills. This requires an ongoing investment in skills development for tool analysis and problem solving.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



Low to undecided convergence. Traditionally, operational testing is concentrated outside Europe and there is no indication that this trend will change. However, as the development of local testing capabilities gains in importance and becomes more sophisticated, companies tend to seek more control over it. This may correct the negative convergence to some extent.

4. Competitive opportunity What opportunities exist for Europe based on this trend?

Despite starting from what presently looks as an unfavourable convergence of interests between the semiconductor industry and Europe, the trend could become quite favourable. The industry in Europe may capture the opportunity of developing specialised knowledge and methodologies in testing, since this is becoming more important not only in areas where quality requirements are stringent, such as automotive and medical applications, but also in areas where adequate testing must forestall significant downstream economic damage, e.g. in the case of large volumes of complex products.

D 4 The increasing importance of multilayer, multichip solutions

Suppliers are increasingly using a multichip-module approach. Multichip modules provide the highest integration level along with the higher performance and full functionality of complete chipsets while fulfilling requirements for minimizing space usage.
They are expected to lead to shorter time-to-market, less overall cost and an improved price-performance ratio for the end-user by lowering sourcing, logistics, and assembly costs.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

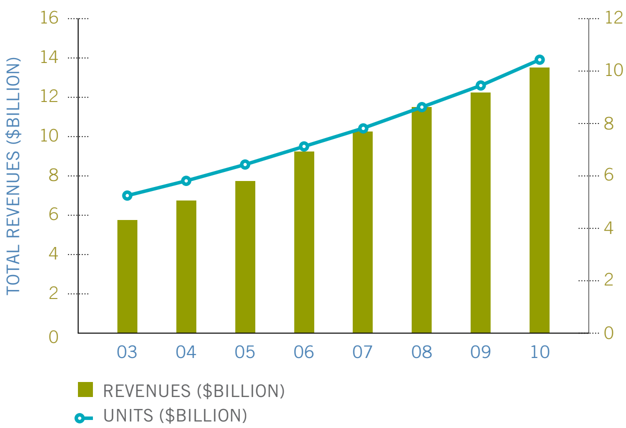
- Electronic systems incorporate more functionality into a smaller volume. This is the major driver for the microelectronics industry. Bulky printed circuits boards are increasingly being replaced by multichip modules and system-in-package solutions. This trend is the key enabler for many application areas (mobile communication, portable appliances, healthcare, security, automotive, etc.).

- The need for ever-higher performance while using less space drives an accelerating demand for multichip ICs that combine two or more chips within the same package. These provide the enabling technology for the production and future development of products such as mobile phones, DVDs, MP3s, camcorders and all types of multimedia products possible.

- Multichip devices are equally becoming critical e.g. in sensors for car dashboards; camera modules where a multimillion pixel sensor together with lenses and signal processing are all accommodated onto a few cubic mm; in memory chips or power management.

- Data for multi-chip and multi-component integrated circuits (MCPs and MCOs) including integrated passive discretes (IPDs), are shown under systems-in-a-package (SIP)and comprise different families of integrated circuits. (Fig. 5)

Fig. 5 – Total System-in-Package Market: Unit shipment and revenue forecast (world), 2003-2010



2. Impact on the Semiconductor Industry in Europe

- In 2007, worldwide MCP (multichip integrated circuits) revenues of European-based semiconductor companies already exceeded the €2bn mark. MCPs form an increasingly important part of company portfolios and account for an overall average of around 10% of total revenues. While this figure refers to European-based companies, it reflects the fact that MCPs are already a significant part of a worldwide semiconductor market today. Market analysts speak of of a potential compound annual growth rate of 25%, underlining the importance of this segment for the semiconductor industry.

- As a key supplier to major European-based wireless communication, automotive, industrial and medical equipment OEMs, the semiconductor industry in Europe has specific strengths and competences in design, heterogeneous integration and manufacturing innovative multichip solutions.

System In Package Market Data

Total System-in-Package Market: Percent of Unit Shiments by Application (World), 2003-2010

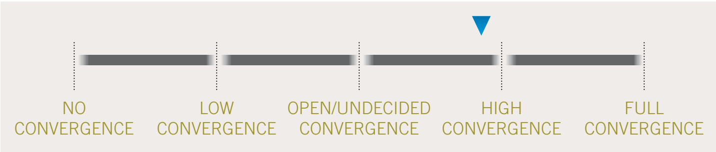
Year	RF Cellular (%)	Digital (%)	WLAN (%)	Power Supply (%)	Auto-motive (%)	Image/ Display (%)	Opto (%)	Others (%)
2003	35.1	5.3	4.7	13.9	5.9	5.7	6.6	22.8
2004	35.1	7.7	6.3	13.4	6.9	5.7	6.2	18.7
2005	35.2	10.2	8.4	12.0	7.7	5.7	5.8	14.0
2006	35.2	12.2	10.5	12.6	8.4	5.8	5.3	10.0
2007	35.3	14.1	13.1	12.2	9.1	5.8	4.9	5.5
2008	35.3	14.5	14.0	11.6	9.5	5.8	4.5	4.8
2009	35.2	14.9	14.7	11.2	9.9	5.9	4.2	4.0
2010	35.0	15.5	15.5	10.9	10.3	5.9	3.6	3.2

Key: RF = Radio Frequency
WLAN = Wireless Local Area Network
Others include medical and military applications

SOURCE: Frost & Sullivan

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



High converging interests. Given their specific application focus on automotive, wireless, industrial and medical, semiconductor players in Europe are well-positioned in the accelerating trend towards multichip ICs.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

This represents an opportunity to supply the global market with systems that are more cost efficient. The semiconductor industry in Europe can exploit its experience, competences and specific strengths in heterogeneous integration: in the design and manufacturing of innovative multi-chip solutions that are in growing demand for most OEMs, including major European-based OEMs providing wireless communication, automotive, industrial and medical equipment.

Europe is in a strong position to capture this trend. This implies that it must help ensure that semiconductors - and in this case the relatively new development of multichip solutions - can trade freely in the global market. It therefore remains vital that Europe provide strong support for an expansion of the 2006 MCP Agreement[1], as well as offering further support to ensure that trading regimes worldwide keep pace with technological developments in this direction.

1 Cf. European Commision. Press Release: IP/06/391 Brussels, 28 March 2006: Commission welcomes international agreement to boost trade in new generation of semiconductors. The European Commission has today welcomed the signing of an international agreement which will make it easier to trade in semi-conductors, a key component in many popular goods such as mobile phones, MP3-players, electronic devices in cars and personal organisers. The MCP Agreement will eliminate customs duties and other charges on multi-chip integrated circuits among the main semiconductor trading nations and territories. Over the last year, the European Commission had assumed a leading role in the negotiations towards the conclusion of this Agreement.
See also: EECA-ESIA press release 28-03-2006. Link: http://www.eeca.eu/data/File/ESIA%20PR/060328%20multichip_ic_press_statement.pdf

3.2. R&D, PROCESS TECHNOLOGY, MANUFACTURING TRENDS

R 1 The increasing specialization and pace of differentiation of devices by product and/or market type

In response to the consolidation towards common design and process platforms and their relative commoditization, competitive pressure is increasing for semiconductor companies to focus their R&D on accelerating the differentiation of their devices, for example basing them on new, proprietary features and incremental performance. This trend impacts the strategic priorities given to types of products and application segments. Choices concerning research investments made in-house or outsourced under collaborative funding schemes in order to optimise the use of dedicated process technologies and design activities are thus also affected.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- This trend applies primarily to sizeable integrated semiconductor manufacturers (IDMs) keen to differentiate their product portfolio and to offer specific sets of products in order to maintain differentiating competitive advantages, for example based on product performance and features or on 'wholly'-owned intellectual property. Products falling in this category may include memories, analog, sensors and actuators, power, RF, MEMS, etc. One of the main challenges is achieving this cost-effectively by using common platforms while retaining key differentiators.
- Marketwise, semiconductors are more than ever becoming the key enablers for forward-looking innovations in areas such as environmental controls, energy management and bio-medical applications. These new opportunities will accelerate and amplify dedicated R&D and engineering efforts to achieve more differentiated knowledge on a very large scale.
- This trend also appears increasingly to create opportunities for spin-offs, mergers or joint ventures based on innovative technologies and targeted to specific market segments.
- The opportunities for semiconductor product providing dedicated functions and technologies focused on specific application areas are closely linked to end-user industries. Semiconductor companies may benefit strongly from access to, and proximity of, end-user industries.
- Product differentiation is a key trend, but because of the increasing cost of development this may only be achieved in a cost-effective way by basing development and design on commonly standardised and reusable process and devices.
- In such a context it is becoming more difficult for pre-competitive research programmes to address the request for the increasingly differentiated needs of the industry for advanced R&D. These programmes may not prove to be sustainable ei-

ther in terms of competitive leverage or return on investment.

- There is growing pressure for greater engagement of publicly-funded R&D in competitive fields. This would require that public or semi-public labs focus on R&D programmes addressing advanced differentiating process technologies in public-private partnerships.

2. Impact on the Semiconductor Industry in Europe

- Based on Europe's global leadership in market segments offering strong electronic content leverage (automotive, wireless, industrial) and the strength of European-based companies in these segments, the semiconductor industry in Europe is in a favourable position to (re-) focus R&D towards leading application areas and take advantage of the geographical proximity of end-user companies, both in terms of knowledge and decision-making presence.

- The policy context established by the EU in favour of energy saving, transportation, environmental control, and health care represent incentives and opportunities to focus R&D initiatives on related emerging application domains.

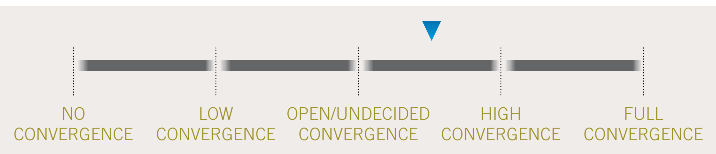
- An increased focus on dedicated R&D initiatives and opportunities may trigger spin-offs or joint ventures along with increased company support for entrepreneurial activities. Newly-formed entities in Europe may benefit from the existing ecosystem that was built up prior to diversification and associate all actors along the value chain.

- Expected progress in innovation can no longer be achieved solely in the domain of publicly-funded R&D as is the predominant practice under the EU Framework Programmes and under the national / regional programmes. More pro-active R&D directions involving partners from the industry together with research organizations such as CEA-LETI, Fraunhofer and IMEC in Europe will have to be sought. Public authorities should also encourage a stronger refocusing of collaborative programmes such as MEDEA+/CATRENE, ARTEMIS, ENIAC, EURIPIDES, etc.

- There is a potential threat regarding a lack of skills in Europe, as the number of students engaging in curricula for engineering and technology is decreasing (see also section 2.1. p. 8 ff.)

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



Medium-to-high convergence of interests. Driven by a strong demand for new applications, and in response to the ever-rising electronics content of products, there is a high potential for semiconductor companies to differentiate their product portfolio to aim at strong end-user market players in Europe in established as well as in new market segments.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

For the semiconductor industry there is a high potential for attractive opportunities in Europe to leverage the presence of strong end-user market players in Europe and the ever-increasing demand for new applications. For semiconductor companies this represents an opportunity to differentiate their product portfolio by each exploiting their respective competitive advantage and engaging in emerging market segments.

In support of these opportunities, specific multidisciplinary private-public R&D programmes that would encourage a more dedicated focus and specialization of semiconductor suppliers on new applications would send a strong message. Such programmes should align with the stated EU objectives and policy agenda, e.g. in environmental controls, energy management or health care.

In this context, a close connection could be sought between researchers from specialised institutes, industry, and academia across Member States based on common topical themes. Such innovation clusters (see also trend R2) could take the form of networks organised within the framework of new programmes such as e.g.CATRENE.

R 2 The increasing engagement of semiconductor innovation in "clusters" or centres of excellence to enable market access and generate IP

In order continuously to gain access to knowledge and new markets, semiconductor-led R&D and innovation is a key enabler in clusters that include suppliers and end-users and that focus on new applications and solutions. Forming such centres of excellence or poles of competitiveness based on common interests and capabilities enables IP generation while ensuring competitive differentiation and capturing new market opportunities through standardization.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- The trend toward making new IP operational by grouping suppliers and end-users under clusters, centres of excellence and/or consortia has become an important condition for gaining access to new markets. The semiconductor industry has taken the lead in promoting critical innovative areas such as nanotechnology, bio-medical and health care, security, environmental control, wireless media applications, etc.

- Building long-term strategic partnerships around proprietary R&D programmes challenges major semiconductor companies to locate their specialised design centres according to the needs of their customers and close to these customers' centres of expertise in order to be able to make use of the proximity opportunity. There is a virtuous cycle that amplifies the uniqueness of the R&D capability due to the attractiveness of the installed base and the available infrastructure, as well as of an accessible scientific community and academic learning grounds.

- Along with a growing automotive and communication industry in Asia, more and more science and industrial parks, including R&D clusters, are emerging in China, Taiwan, Korea, or India. Semiconductor companies with design centres located near these potential customers will be able to exploit the proximity advantage by having sustained interaction with them.

- In order to participate in these efforts, governments worldwide strive to achieve vertically-integrated R&D frameworks, programmes or projects, e.g. on energy efficiency and generation, telecom standards or automotive application requirements, where semiconductor companies co-operate with OEMs, Tier1 and Tier2 from the very beginning. This approach may foster increased standardization, orient a more market driven approach and reduce overall cost of development.

- The success of innovation clusters is increasingly becoming a favoured policy of local authorities focusing on supporting global champions. Whereas previously the clustering primarily was initiated by large companies in a given region, the driving force in forming these centres of excellence or poles of competitiveness increasingly appears to be led by national and local authorities seeking to attract global players through local investment and tax incentives while providing the right infrastructures and ecosystem. More and more local authorities are targeting the opportunity for creating jobs, attracting skills, and maximizing IP generation and return.

2. Impact on the Semiconductor Industry in Europe

- The worldwide strength of major European end-user industries in automotive, wireless communication, industrial, medical equipment and environmental applications makes Europe a place of choice for creating vertically oriented clusters or centres of excellence for R&D, engineering and SW development, and IP generation.

- The strong presence of advanced design centres of the semiconductor industry in Europe such as e.g. for automotive in the Munich area, or for RF and communication in Southern France, Munich and the Nordics, for power in Toulouse, Graz, etc. play a critical role in facilitating the creation of centres of expertise jointly with the concerned end-user industry segments.

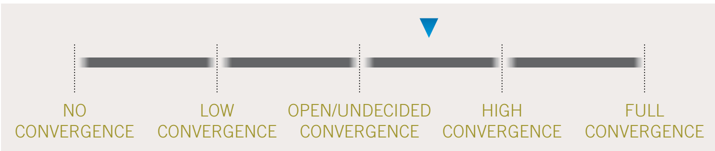
- The close collaboration between European based research institutes and the industry has led to the creation of some advanced research poles in Europe such as the CEA-LETI pole in Grenoble, the Fraunhofer Centre for Nanotechnology in the Dresden area and the industry research co-located in the IMEC research centre in Belgium. These are building blocks of a pan-European research infrastructure able to leverage critical mass of resources by forming clusters of innovation in advanced research areas.

- Public-private research partnerships in the semiconductor arena such as the Joint Technology Initiatives ARTEMIS and ENIAC or the Eureka cluster MEDEA+/CATRENE are all embracing a collaborative approach.

- R&D policies of several EU member states (e.g. France, Germany, UK, Spain) continue to encourage the creation of innovation clusters by co-locating industries and skills sharing common innovation interests. Such poles of competitiveness are intended to spearhead emerging technologies and applications.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in a globally-competitive semiconductor industry that contibutes to GDP growth, generates employment, enables access to advanced technology, and supports innovation for end-use industries?



Medium-to-high convergence of interests. The presence of strong end-user industries in automotive, wireless communication, industrial, medical equipment and environmental applications makes Europe a place of choice for creating centres of excellence based on R&D, engineering, SW development and IP generation. There remains, however, a risk of too broad a dispersion of efforts caused by uncoordinated national priorities across the EU and hence a lack of critical mass.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

The opportunity for the semiconductor industry in Europe to leverage its talent and know-how derives from a leading customer base in automotive, wireless communication, industrial, medical equipment and environmental applications. The global strength of these end-user industries based in Europe continues to require talent, skills and know-how as well as the experience available in the semiconductor industry in semiconductor-related R&D, engineering, SW development and IP generation. The geographic as well as cultural proximity to this semiconductor industry customer base in Europe is an invaluable asset for exploiting this opportunity.

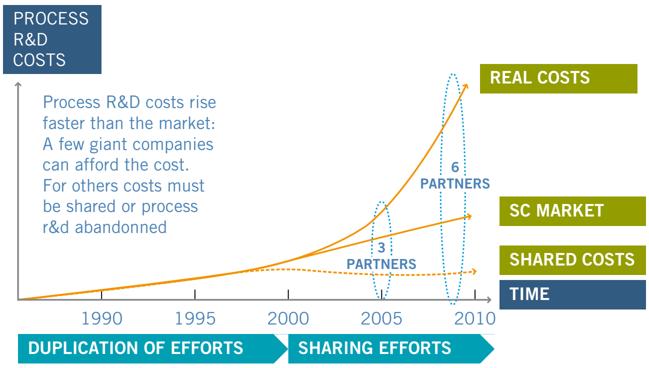
Encouraging strategic clustering in such areas of expertise, for example in the framework of application-focused centres of excellence supported by strategic European R&D programmes e.g. under the evolving European Technology Platforms (ETP) or

EUREKA clusters such as CATRENE, would help avoid the dispersion of efforts while ensuring critical mass and strength of mindshare.

R 3 The continued consolidation and concentration of R&D investments in advanced CMOS platforms worldwide

The development of future CMOS technology platforms at 32nm and below geometries for next generation semiconductors requires an ever increasing level of financial and specialised human resources dedicated to basic CMOS R&D. This will result in a steady consolidation and concentration of advanced CMOS R&D capabilities under a few global consortia in order to achieve critical mass and economies of scale. (Fig. 6)

Fig. 6 - Process R&D costs are rising above companies' financial means, pushing them to share R&D costs



SOURCE: STMICROELECTRONICS, CATRENE 2008

1. Impact on the Global Semiconductor Industry

What are main characteristics of this trend?

- With the cost of developing a next-generation CMOS technology platform increasing faster than the revenues of the semiconductor industry, companies need to optimise their R&D investments in order to maintain competitive advantage and to ensure time-to-market, while at the same time ensuring full access to advanced technologies.

- For logic products on the one hand, representing a large part of semiconductor devices with product cycles continuing to shorten, CMOS technology platforms are increasingly becoming commodity products. Sharing R&D investments to ensure early access remains a necessity for leading edge semiconductor players. For memories, on the other hand, MPU, and FPGA, CMOS-based platforms are the products that require very focused and continuous in-house development. For companies leading in this segment the differentiating value is derived from their early adoption.

- In order to get access to advanced CMOS technology platforms at affordable costs, companies seek collaboration as a means of leveraging available resources both in terms of time and money and knowledge. They are doing this by moving from in-house development of technology platforms towards a model where returns on R&D investments are maximised by joining consortia with other companies for the development of next generation mainstream CMOS technology platforms (LP CMOS, High Performance SOI)

- Developing a next-generation CMOS technology platform requires significant and increasing levels of investment, both in R&D and manufacturing. Hence there is growing competition between leading CMOS technology R&D consortia trying to capture the necessary resources. Semiconductor manufacturers aim at staying in the race for global competition by joining consortia that have critical mass and are able to maximise resources – private and public – at a higher level than the competition. As a consequence, consolidation and concentration of R&D platforms and foundries as has been seen recently (see also Section 2.2, p. 33) are likely to continue.

- By cooperating in the development of advanced CMOS technology platforms, companies can optimise their R&D investment by redirecting some of their R&D investments with the aim of competing on performance and features and/or on wholly-owned intellectual property. In doing so, companies would adopt a wide range of variations in the mix of sharing and contracting, from R&D partnering to seeking competitive differentiation. Therefore, various types of cost sharing on pre-competitive R&D may free up funding for the development of new business differentiators.

2. Impact on the Semiconductor Industry in Europe

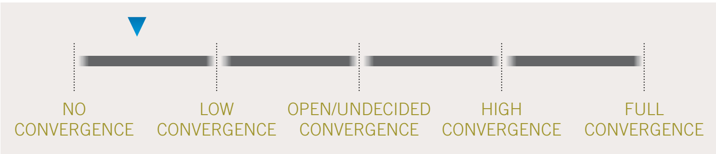
- Large-scale, consolidated R&D in basic advanced CMOS platforms is being outsourced to consortia outside Europe as a consequence of the economies of scale required, the size of companies in Europe and the lack of major manufacturing lines in Europe.

- Despite successful collaborative efforts in the past to establish leading edge CMOS technology platforms in Europe (e.g. the Crolles2 Alliance 2002-2007 between ST, NXP, and Freescale), the number of players and hence the available levels of investment needed to stay in the race for the development of next-generation mainstream CMOS technology platforms falls short of what globally consolidated consortia can offer.

- There are specific pre-competitive R&D programmes/projects in Europe supporting the development of next-generation processes, however on a much smaller scale, in highly specialised domains and hence with limited scope. Some are partly funded at the European and/or national levels; some are set up in collaboration with European research institutes (CEA-LETI, IMEC, Fraunhofer institutes). The complexity of the different funding schemes (EU Framework Programme, Joint Undertakings, EUREKA clusters, national and regional programmes) along with a lack of coordinated focus overall minimises their potential contribution. If advanced CMOS manufacturing were to disappear from Europe, the risk exists that the pre-competitive advanced CMOS R&D programmes still in existence may not survive.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



No to low convergence. The increasing consolidation and concentration of R&D investments in advanced CMOS platforms worldwide appears to exclude Europe as a geographical basis for developing next generation CMOS technology platforms. European companies are joining relevant consortia based outside of Europe.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

Given the required critical mass for developing next-generation advanced CMOS technology platforms in terms of resources and investments, it is in the interest of semiconductor companies in Europe to embrace a global R&D strategy and participate in global consortia that ensure access to--and compatibility with--advanced CMOS technology platforms as required. Companies need constantly to adopt a dual strategy to ensure competitive advantages derived from the value-chain, application and product knowledge that exists in Europe while maintaining adequate levels of R&D investments, including advanced CMOS technology platforms.

There are still opportunities - although small compared on a global scale - for Europe to engage in advanced CMOS R&D programmes jointly with established research institutes that are funded both at European or national and company levels in a number of countries (including France, Germany and Benelux). However, the complexity of each of the different funding schemes and the limited public funding of approximately one-third of the total R&D effort appears to restrict their overall impact.

R 4 The increasing cost of investments for new, advanced CMOS manufacturing plants drives the distinction between different manufacturing models

Semiconductor manufacturing faces the challenge of ever-increasing capital investment needs in order to achieve most advanced CMOS production capability. Increasing investment and efficiency requirements drive the distinction between the three manufacturing models based on emerging technology trends, market characteristics and companies' strategic choices.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- The set-up costs for a fabrication line increase substantially over time. The steadily growing cost of investments in new, advanced CMOS manufacturing plants based on the most advanced process technologies is likely to continue. Historically, up to 20-25% of the industry's annual revenues are spent on capital expenditures.

- Costs for a leading-edge manufacturing line double between two CMOS technology generations. Today the cost of setting up a new 300mm fabrication line amounts to €3-4 billion. Even after a fabrication line has been built, rapid technological advance makes it likely that it will need to be upgraded several times during its productive life. Hence the most important cost factor in wafer production is the depreciation of equipment, buildings and facilities.

- In view of the high investment levels associated with new, advanced CMOS manufacturing facilities, the presence of appropriate incentive schemes is an important consideration when companies decide on new manufacturing line locations. This is one of the reasons why new investments are concentrated in countries in the Asia-Pacific region, including in China

- As it becomes increasingly difficult - if not impossible for any single company - to bear the cost of advanced production facilities and to balance both increasing investment and ROI requirements, companies pool such production resources to achieve economies of scale.

- This gives rise to increased specialization along three distinct manufacturing models based on emerging technology trends, market characteristics and companies' strategic choices:[2]

  - **Fabrication lines for memories and standard products,** characterised by very high volume products such as microprocessors. "Here one or two similar processes run with very few mask sets. These fabrication lines are maintained fully loaded, and the product cost is just a function of manufacturing efficiency, including investment cost and cost of capital, manpower, overhead and taxes, and size."

2 Cf. CATRENE Whitebook Part A, Upcoming Manufacturing Scenarios, p. 30, for the definitions of the 3 models.

- **Fabrication lines for logic products made using standard CMOS processes.** "Here a few processes run with a high number of products (mask sets). These fabrication lines are maintained fully loaded thanks to the aggregation of worldwide market demand. In this foundry model, key cost parameters are: investment cost and cost of capital; manpower, overhead and taxes; size; flexibility on product mix within few processes; and cycle time."

- **Fabrication lines for dedicated products with differentiated processes.** "These fabrication lines run different processes in parallel with a high number of products. The processes are largely tuned to each product and this is where the design and device interaction is maximal." Key cost parameters are: cost of capital; manpower, overheads and taxes; flexibility on product mix within a large number of processes; cycle time; and design and control of a large number of different process routes. The investment cost is less an issue in niche markets like MEMS where the standard is still 6-inch wafers on fully amortised equipment.

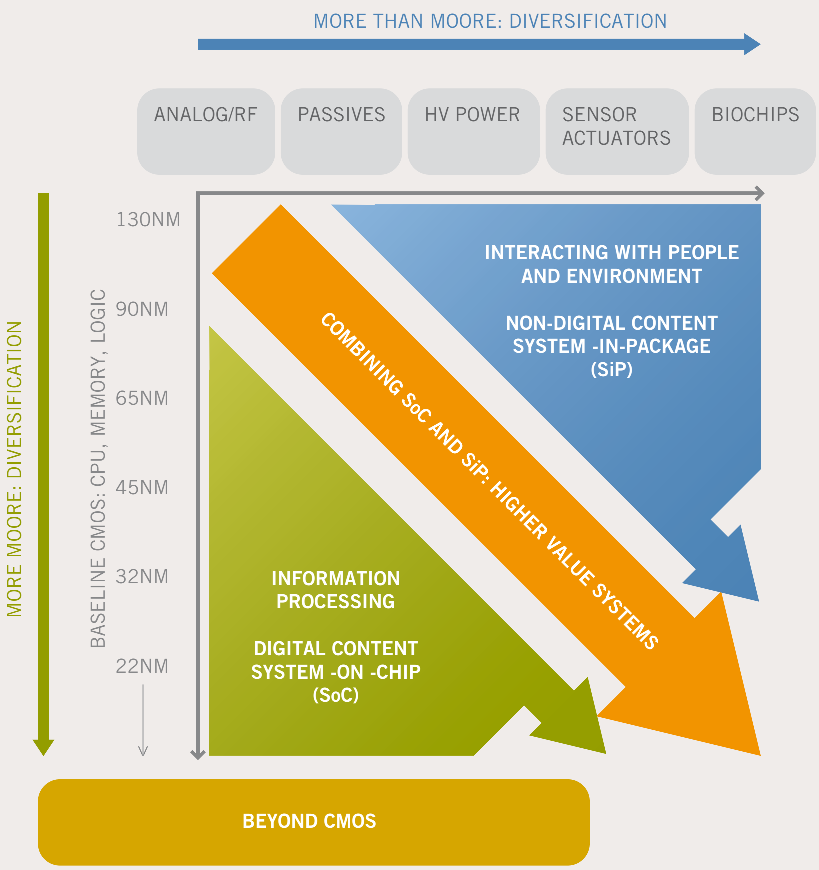
These three models align with the the distinction between "More Moore" and "More-than-Moore" as proposed by the international technology roadmap for semiconductors (ITRS) .

International Technology Roadmap for Semiconductors (ITRS).

Semiconductor technology trends

"In the late 1960s, Intel co-founder Gordon Moore predicted the number of transistors on a chip would double every 18 months; an observation now referred to as 'Moore's law'. Referred to as 'More Moore' this trend continues, particularly for memories and microprocessors, which depend on size and power reduction for introduction of ever increasing complexity. (Fig. 7) At the same time, a greater variety of semiconductor devices can be combined on the same chip in SoCs or in the same package using SiPs. This concept, known as 'More than Moore', adds a lot of other devices on top of the pure CMOS process – such as analog/RF, passive, high voltage (HV) power, sensor/actuator, biochip and MEMS components – that are processed and embedded in the chip/package instead of being added at systems level. This improves system integration by an order of magnitude and opens new application fields." cf. [CATRENE White Book 2007] Part A, p. 13-14

Fig. 7 - Semiconductors technology trends



SOURCE: INTL. TECH. ROADMAP FOR SEMICONDUCTORS ITRS, 2007)

2. Impact on the Semiconductor Industry in Europe

- It appears that – with possibly very few exceptions – there will be no large-scale advanced CMOS manufacturing facilities in Europe. The current fabrication lines in Europe are likely to focus on extending the life of their activities and/or consolidating as in the case of manufacturing lines in memories, standard products or microprocessors. To revitalise the European manufacturing base it would be vital to address new application domains requiring new process technologies.

- For memories and standard products, only a few players, mainly in the microprocessor business, will be able to afford their own advanced CMOS manufacturing facilities and operate as stand-alone companies by maintaining and/or extending their lifetime; others in this group, mainly in the memory business, are likely to consolidate/merge and/or spin off their activities.

- For logic products using standard CMOS processes, the trend of moving to a fablite – or even fabless - approach will continue. The bulk of advanced CMOS logic manufacturing will be outsourced to foundries. Foundries are expected to focus increasingly on R&D at the intersection of process and design, thereby indirectly lowering the barriers of entry for new entrants into the semiconductor market via a fabless approach.

- The trend towards product differentiation based on process differentiation, also referred to as "More-than-Moore", is key for products providing specific functionality using dedicated technologies (e.g. Sensors, RF, Power, Analog, etc.), including those in emerging (nano-) technologies (e.g. biochips) and/or integration processes on SoC and SiP (e.g. for MEMS). Through this trend, specialised manufacturers may continue to compete as long as the added functionalities do not require mastering the whole flow of advanced CMOS processes. (Fig. 7)

- Opportunities for such products are closely correlated with specific end-user industries. Semiconductor manufacturers and end-user industries may benefit strongly from the close interaction that may result from regional proximity, enabling the development of differentiated and advanced systems for the applications of tomorrow.

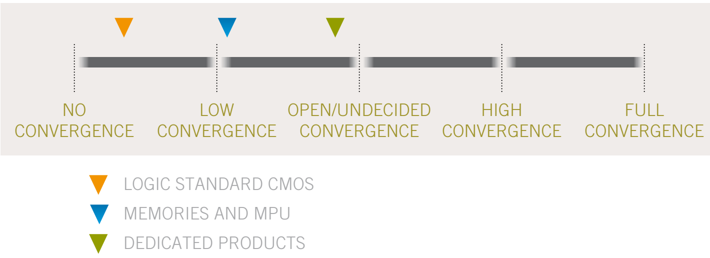
3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?

- For standard CMOS Logic products:
  No convergence. As companies profit from generous incentives elsewhere, and as Europe appears to be unable/unwilling to compete at this level, there is a low level of matching interests between the industry and Europe. Furthermore, Europe is hindered by unsynchronised or contradictory aims concerning state aid as well as by an EU policy focusing more on favouring internal market competition than on building up an international level playing field. As a result, Europe remains a net importer of semiconductors and no additional new fabrication lines are being planned.

- For Memories and MPU:
  Low convergence. While these products currently still feed major manufacturing activity in Europe, current investment trends are moving toward new advanced CMOS fabrication lines outside of Europe. The Memories industry continues to go through different phases of consolidation and rationalization, depending on the memory segment (DRAM, NAND flash, NOR Non-Volatile Memory (NVM) flash). The outlook for the future, therefore, is unlikely to offer more room for convergence.

  For dedicated products:
  Potential convergence. Non-standard CMOS manufacturing technologies can still benefit from opportunities in dedicated products based on differentiated processes. Products such as sensors, RF, power, analog, etc., may still meet end-user opportunities for high volume production, as may chips in specific application areas in the wireless or consumer markets as well as for specialised SoC and SiP (e.g. for MEMS) integration process foundries and niche manufacturers



4. Competitive opportunity

What opportunities exist for Europe based on this trend?

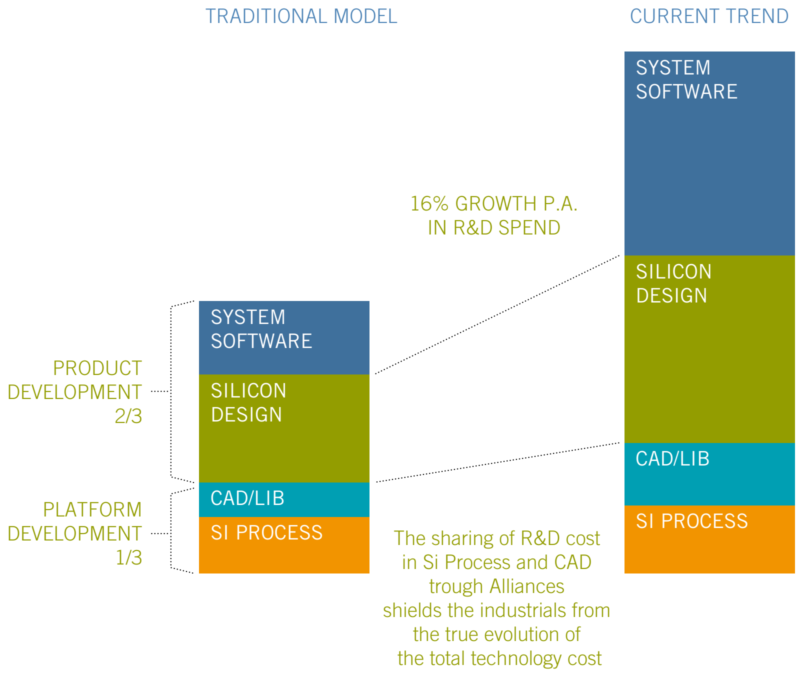
The opportunities for the semiconductor industry in Europe vary depending on the manufacturing models.

With advanced CMOS no longer being the primary competitive differentiator for semiconductor manufacturers and, as described in trend R 3, with the development of related process technologies taking place in larger consortia, European-based semiconductor manufacturers increasingly adopt asset-light strategies. As a consequence, advanced CMOS technology skills may no longer be anchored in Europe, and the *'fab-is-the-lab'* principle for process R&D will become less home-based.

The dependence on IC foundries, typically located in Asia, is likely to increase. Here Europe should ask itself whether this generates any strategic risks that should be addressed by trying, for example, to attract some of the leading global foundries to invest in manufacturing in Europe.

For memories, the manufacturing technology is the product; for microprocessors, technology is a key differentiator; and for consumer ASICs, application-specific standard products (ASSPs) and more globally dedicated products, things are changing. Product development is becoming a larger and larger part of total R&D for such products. Therefore, for dedicated products, in parallel with what is happening on a global scale, a considerable scope of interest may still exist in, along with a potential for, establishing smaller, more specialised local foundry opportunities in Europe. (Fig. 8)

Fig. 8 - Value chain change for dedicated products



SOURCE: CATRENE 2007

3.3. THE DIFFERENTIATING SEMI-CONDUCTOR VALUE CHAIN

Global value chain evolution

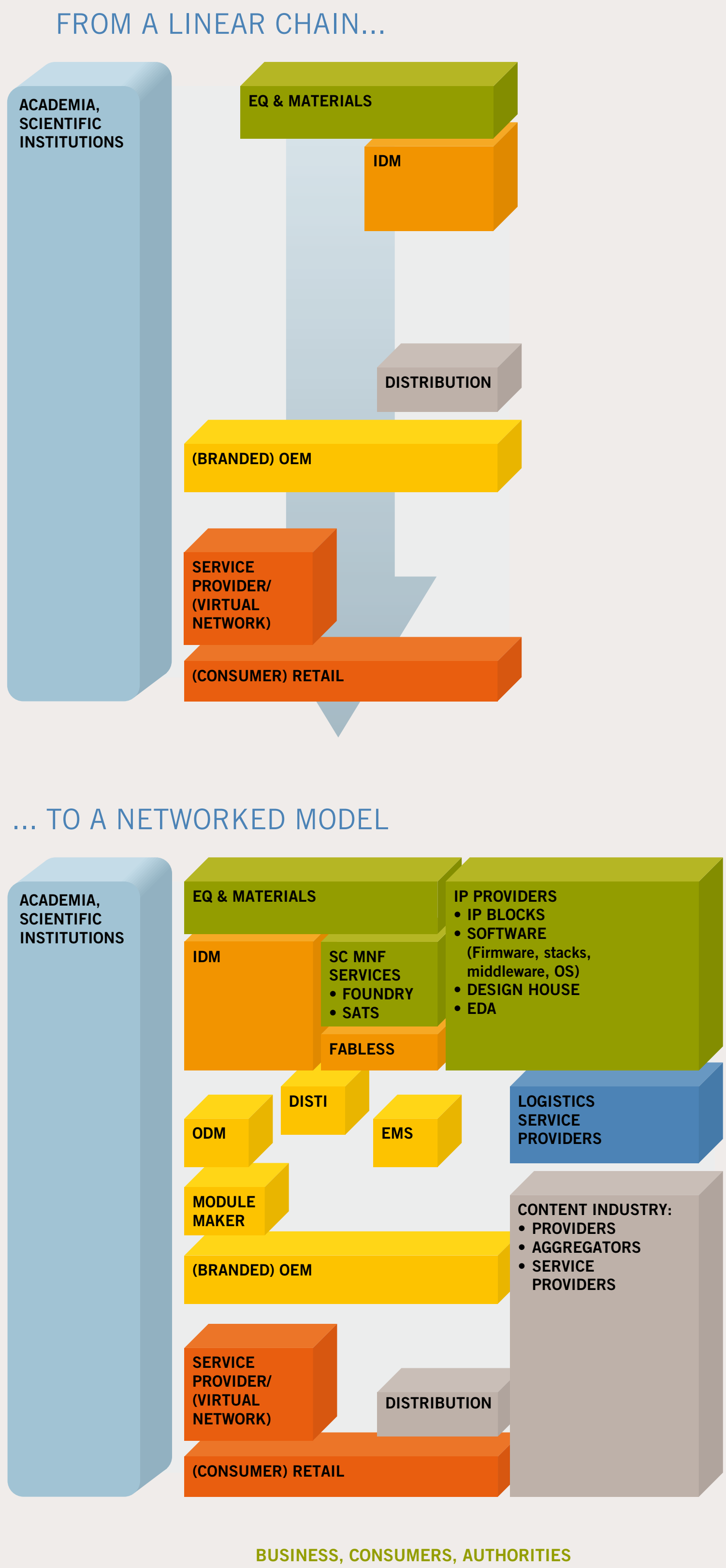
"The growing complexity of nanoelectronics technology and electronic products and services in general has strongly affected the landscape of the high-tech industry. Increasing complexity results in exponential increases in capital spending and critical know-how. In the early days of semiconductors, Independent Device Makers (IDMs) could handle the entire value chain, sometimes even extending their business into manufacturing equipment and materials at one end and electronic products and services at the other. Due to extensive de-verticalisation in the industry, that model has now changed. Today, IDMs typically outsource shareable tasks to more recently established businesses such as Original Design Manufacturers (ODMs), Electronics Manufacturing Services (EMS) and Design Houses. Many successful fabless companies (semiconductor companies relying totally on third-party foundries for manufacturing) have emerged. For cost reasons, many IDMs have also entered into industrial alliances in order to jointly develop common processes.

Continuing disparity between life-cycles for technology innovation (as much as 3 years) and application innovation (as low as 6 months), increasing market demand for first-time-right and zero-defect products, and the need for semiconductor companies to provide complete hardware/software reference designs, have drastically changed the position of IDMs. No longer 'arms-length' suppliers to their customers, semiconductor companies are now at the very heart of the innovation process in System Houses and Original Equipment Manufacturers (OEMs).

As a result, the formerly linear high-tech supply chain has expanded into a series of multiple interconnected ecosystems, all of which have the semiconductor industry as an essential common element. In this multi-dimensional design environment where many different players are involved, it is no longer evident that an IDM's R&D and manufacturing will, can or even should be on a single site. Where and with whom a company performs the R&D related to a specific part of the value creation process is predominantly influenced by vicinity to appropriate partners (including suppliers and customers) and availability of know-how, followed by state support conditions. An early market of sufficient scale offers the potential for a higher return on investment and consequently a reduced risk. Proximity and local requirements are key factors for many of these markets and partnerships and therefore influence the choice of R&D and business location."

cf. [ENIAC SRA 2007] p. 7s.

Fig. 9 - The evolving semiconductor industry landscape



V 1 The blurring boundaries between semiconductor players and OEMs

As specialised semiconductor applications increasingly provide full-systems solutions to end-user customers, there is a tendency for OEM systems design to migrate to semiconductor suppliers, opening up new collaborative opportunities for providing full R&D development and engineering for such solutions. This means that more systems knowledge is being integrated into semiconductor products. Often this move means branding the solution as well.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

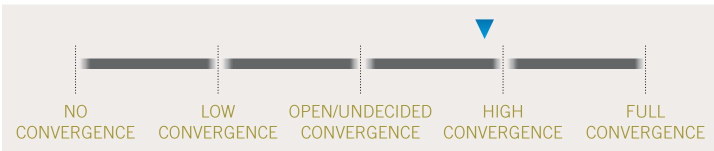
- Given the value-added and unique knowledge base semiconductors represent in their products, an increasing number of OEMs are moving part of their systems R&D, design and engineering resources to semiconductor manufacturers, both for hardware and for software.
- For the semiconductor industry, this means that it will have to sustain higher R&D expenses. In order to do so, it anticipates achieving a considerable market share in the system when developing a new solution.
- Development of such advanced platform/system solutions represents significant investment levels, reaching in the order of hundreds of millions of Euro. In view of this, industry leaders will strive for strong positions in the value chain based on intellectual property, thereby increasing the competition in IPs.
- At the same time the requirement from OEMs to have fully tested platforms supporting main operating systems increases the pressure on the designers of microelectronics suppliers to provide faster more and more complex products to the market. Complete control over system hardware and software is now a standard request from the OEM to the semiconductor supplier that has to provide partly tested platforms with the implementation of the hardware-sensitive software blocs already integrated for the main operating systems. This further motivates closer collaboration between the OEM and semiconductor design teams.
- The migration from OEMs to semiconductor providers may also occur in the reverse direction. Some OEMs may consider taking control of more activities that were initially held by semiconductor companies: e.g., branding or financing.
- At the same time, customer expectations from semiconductor suppliers are increasingly shifting toward platforms, systems integration and services. (Fig. 10)

2. Impact on the Semiconductor Industry in Europe

- The shifting of traditional boundaries between semiconductor players and customers along the value chain should be seen as an opportunity for the whole of the European semiconductor industry and should reinforce its position in the global market place. This shift opens new opportunities for focusing resources on added value activities and for becoming a reference for new standards, advanced platforms, etc, worldwide.
- European Technology Platforms such as ARTEMIS and ENIAC have underscored this trend toward shifting boundaries between semiconductor players and OEMs.
- Managing an advanced IP portfolio as well as access to the global market are essential to being a player in this new space of shifting boundaries.

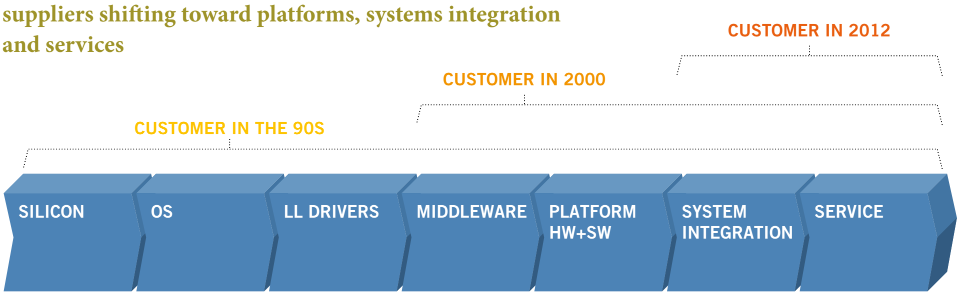
3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



High convergence of interests. The proximity of semiconductor players and end-user OEMs, and the long established relationships between them, reflect interests that are strongly-shared by the semiconductor industry and the European economy..

Fig. 10 - Customer expectations from semiconductor suppliers shifting toward platforms, systems integration and services



4. Competitive opportunity

What opportunities exist for Europe based on this trend?

The trend toward 'crossing boundaries' between the semiconductor industry in Europe and its customers along the value chain represents an opportunity for the entire industry and is reinforcing its position in the global market place. This shift is opening new opportunities for engaging in a wider range of added value activities and for becoming a reference for new standards, advanced platforms, etc., worldwide.

V 2 The shifting business models of IC suppliers and foundries

The traditional business model of a semiconductor company as an Integrated Design Manufacturer (IDM) is shifting towards a model that increasingly seeks to optimise the combination of in-house manufacturing and service activities with outsourced ones.
This dynamic is contributing to reshaping the semiconductor landscape, moving progressively away from an integrated company model and allowing foundries and services providers such as ODMs and EMSs to extend their portfolio of offerings. Fablite and fabless are the business models emerging from this trend.

1. Impact on the Global Semiconductor Industry

What are the main characteristics of this trend?

- The trend of Integrated Design Manufacturers (IDMs) taking full command of their manufacturing to outsource some activities to foundries using so-called fablite approaches is a growing reality.

- The investment in new wafer fabrication lines using the most modern CMOS technologies is becoming too expensive for most IDM's, as it exceeds the return on investment that can be expected. Stand-alone global foundries are therefore likely to become increasingly important, especially in terms of capacity availability and in providing a portfolio of manufacturing services.

- In addition to supplying modules and meeting the manufacturing needs of IDMs and fablite companies, the foundry provider is being asked to offer a growing list of services that make it possible for fabless companies to develop and manufacture their own products/applications. These services can be performed in-house or through partnerships. Key service activities are: Physical design services (from a Netlist to a GDS2); test development; prototyping; failure analysis and yield ramp up; and logistic support.

- With the progress of this trend, the need for specific foundry services such as low-volume production, unique process, customization options or developing technology research is likely to increase. The trend towards an increasingly fablite/fabless-foundry model for IDMs in Europe and in the US is therefore enabling the potential emergence of new competitors. At the same time, the trend is lowering the entry threshold for new companies into the semiconductor market.

- As the established foundries in Asia-Pacific expand their activities beyond contract manufacturing and are venturing into manufacturing services, foundries such as TSMC, Chartered or UMC are expanding their services to R&D and technology development for generic processes. The trend is likely to go beyond generic processes to produce variations and process derivatives because increased specialization represents new business opportunities for foundries.

- As a consequence, there may also be a trend towards setting up more specialty fabrication lines for specific applications requiring non-advanced CMOS technologies.

- On the OEM side, companies are evolving from managing vertically-integrated activities, i.e. from IC specification through end product marketing and sales, to doing more outsourcing. In this way OEMs have begun to farm out various electronic design and manufacturing roles to ODMs and EMSs. In turn these ODMs, while offering design and manufacturing to different OEM brands, are becoming potential targets for outsourcing IP design and semiconductor products sourcing as well.

2. Impact on the Semiconductor Industry in Europe

- Except for microprocessors and memories, semiconductor companies with CMOS manufacturing activities in Europe have started working according to a fablite operating model mixing in-house proprietary processes and with outsourced manufacturing, thus balancing investments in fabrication lines, R&D, CMOS technology platforms with the cost of operations.

- With European companies increasingly including fablite elements, or in some cases even going fabless over time, European players are likely to redirect their R&D effort to align them better with emerging market opportunities. They also may evolve towards specific technologies and services offered by new specialised manufacturing lines or may transform some of their existing European foundries (e.g. MEMS).

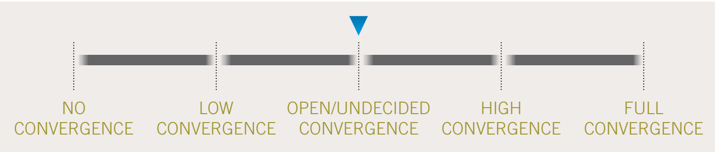
- Today, among the 1300 fabless companies worldwide, only 12% are located in Europe, while 4% are located in Israel, 46 % in North America and 38% in Asia. However, the top 10 major fabless companies represent 57% of total revenue. (see also trend V4).

- Specialised foundries have emerged in Europe (X-FAB, Altis), and the 'freeing-up' of fabrication lines in Europe may be transformed into foundry capacity. This seems to materialise.

- In order to allow fabless companies to engage effectively in the market, foundry services must be matched seamlessly with a range of other services such as design support, testing, etc. In the absence of a full spectrum of manufacturing services offered by European companies, fabless companies will have to address their manufacturing needs to the Far East, where foundries able to provide these services are located.

3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



Medium convergence. As long as a globally competitive foundry industry able to capture new opportunities does not exist in Europe, the outlook for this trend is rather undecided for the European semiconductor industry. At the same time, SAT (semiconductor assembly and testing) and the software industry are consolidating outside of Europe, SAT in the Far East and software in India.

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

There are opportunities for Europe in fablite and fabless companies based on innovation, possibly complemented by smaller, specialised non-advanced CMOS niche manufacturing for dedicated products in Europe, which could extend the economic life of the existing manufacturing base. European companies are making use of models of integration that are increasingly differentiating, adding fablite elements to their supply chain models.

As mentioned in trends D 3 and R 4, an ecosystem of large-scale foundry and large-scale semiconductor assembly and testing service providers is absent in Europe.

V 3 The shifting revenue stream of s/c equipment and material suppliers

The revenue stream for equipment & material suppliers that originally was generated by semiconductor manufacturing is gradually diversifying geographically and by type of new manufacturing areas such as LCD panels, photovoltaic, etc. Specific know-how, customization and short innovation cycles do not make large-scale delocalization as attractive as for semiconductor device manufacturers. However, global competition among equipment & material suppliers is rising as new players emerge in Asia.

1. Impact on the Global Semiconductor Industry

What are main characteristics of this trend?

- Semiconductor equipment and material suppliers have not followed the semiconductor manufacturing delocalization trends outside of their home base at large, although there are a few individual attempts which were more or less successful. However, there is growing concern that the knowledge base and to a certain extent the advantages of customer proximity/ intimacy in the home base will be weakened as semiconductor device manufacturing continues to delocalise.

- Given the world leading market position and size of some of these materials & equipment companies enjoy, there is a significant governmental interest in, and impact at stake, regarding strategic moves these companies may decide on.

- The increasing product complexity asks for early and mutual development / cooperation between semiconductor equipment and device manufacturing, the cost of development of a new tool increasing with the complexity of the product.

2. Impact on the Semiconductor Industry in Europe

- Historically the world market size for semiconductor equipment and materials has demonstrated double digit growth rates and will reach approximately US$ 80.0 billion including US$ 6.2 billion in Europe in 2008. Whereas most of the these suppliers are located in the US or Japan, a few like ASML, ASMI, Oerlikon, Aixtron, Siltronic, Wacker, SOITEC, Air Liquide, Linde, and more have their home base in Europe. (Fig.11)

- The European-based equipment and material producers - with a worldwide ranking among the top five in their specific fields of activity -, make most of their revenue outside Europe. Back-end equipment has already reached 80% of export. Without device manufacturing in Europe this trend will continue.

- With the delocalizing of the device makers to Asia, increasing portions of their sourcing are to be relocated outside Europe. Investments are being directed to the regions where the semiconductor device manufacturing develops fastest.

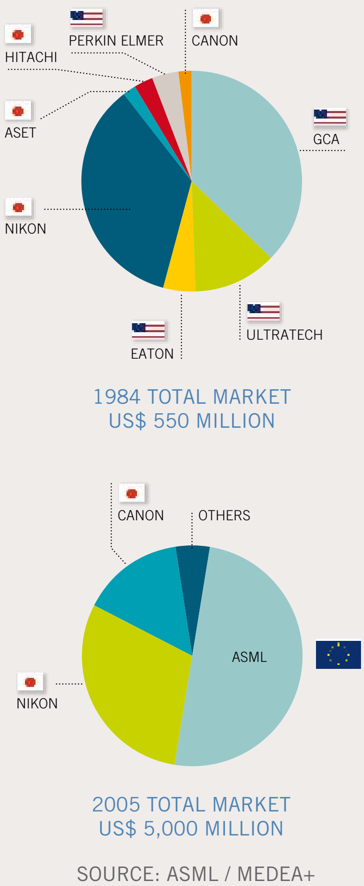
- As the semiconductor business is already shrinking some companies already diversified into related technology such as photovoltaics. While solar technology offers great opportunities in the next couple of years, the technology used to make solar cells is not state of the art. This means that those companies will lose their capabilities to develop and produce leading edge technology.

- As semiconductor technology is enabling most of the key European industry sectors such as telecommunication, automotive, automation, medical, office automation etc. Europe would risk losing its competitiveness with great damage for jobs and GDP.

Semiconductor equipment and materials

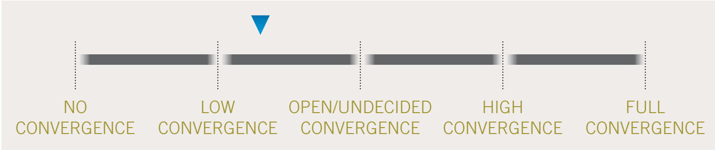
Some European material and equipment suppliers have established themselves as world leaders, for example in the crucial strategic lithography sector or in the advanced silicon-on-insulator (SOI) and engineered substrates. (Fig. 11)

Fig. 11– European leadership in lithography, 1984 and 2005.



3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?



Low to medium convergence. The convergence of interests of the industry and Europe remain undecided, or may potentially converge. Despite the slowing semiconductor driven revenue generation there potentially is a favourable alignment between the semiconductor materials & equipment companies and new, closely related areas of production in Europe (e.g. for LCD panels, photovoltaics, etc).

4. Competitive opportunity

What opportunities exist for Europe based on this trend?

In view of the lack of new, advanced CMOS wafer processing plants in Europe, or a full foundry and semiconductor assembly and testing ecosystem, the opportunity for equipment suppliers to maintain their revenue stream from European semiconductor industry is reducing.

V 4 The increased roles of IP and fabless IC providers

Design complexity and time-to-market requirements lead to increased differentiation of providers offering IP blocks, specialised designs and market functional blocks that are incorporated in integrated circuits (ICs). Semiconductor companies will increasingly contract related IC design services and /or acquire IP blocks from external suppliers who are not considered critical from a competitive differentiation point of view on the open market.

1. Impact on the Global Semiconductor Industry

What are main characteristics of this trend?

- Semiconductor companies face growing costs in keeping up with the ever-increasing complexity of IC design and with the related creation of IP blocks and manufacturing processes integrated under one roof. This provides opportunities for spinning off specialised activities in these areas or for new companies to propose their services, both resulting in further differentiation in the semiconductor value chain.

- Today, among the 1300 worldwide fabless companies only 12% are located in Europe, 4% in Israel, 46% in North America and 38% in Asia. However, the top 10 major fabless companies represent 57% of total revenue. (Fig.12, 13)

- The rising role of fabless design and IP providers is driven by the requirement to apply efficiently the most advanced product engineering and packaging as well as to optimise the integration of IC design know-how /skills at the same time as reducing the overall cost of the final product.

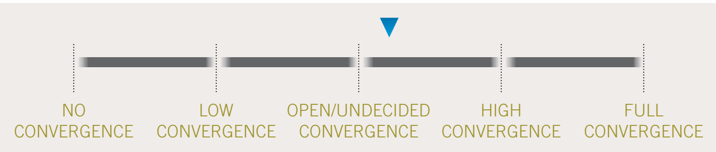
- Contracting with design houses and IP providers tends to allow semiconductor companies to focus on their strategic competitive advantage while outsourcing non-core IP/design activities.

- In this context, IP creation and IP protection play highly strategic roles for both fabless design and IP providers as well as for the semiconductor companies.

2. Impact on the Semiconductor Industry in Europe

- This trend impacts Europe particularly in contracting with, or outsourcing to, design houses and IP providers because of the diversified product portfolios of European semiconductor suppliers.

- A stronger fabless IC European base may respond to growing specific IP development requirements.



3. Trend Assessment

Does this trend converge with Europe's perceived interest in having a globally competitive semiconductor industry contributing to GDP growth, generating employment, enabling access to advanced technology and supporting innovation for end-use industries?

Medium convergence. There is potentially a favourable match of this trend with the interests of Europe if we consider a few European success stories that have successfully captured this trend.

4. Competitive opportunity

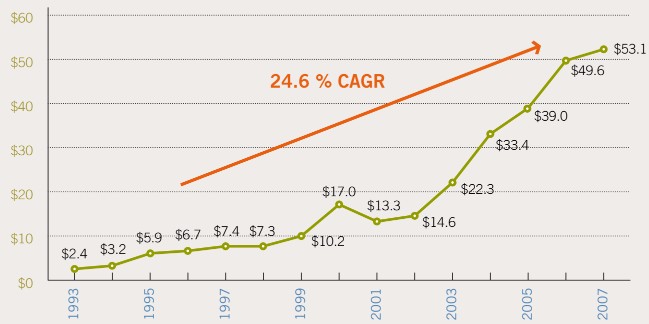
What opportunities exist for Europe based on this trend?

Having a diversified portfolio requires that European semiconductor companies have access to a wide range of IP blocks. This represents an opportunity for European IP suppliers to be a part of ecosystems for specific application areas, stimulating the emergence and success of European IP.

The fabless semiconductor segment

The fabless semiconductor segment is estimated to have generated $53 billion in 2007, an increase of 7% over 2006, and representing 20% of the total $256 billion in semiconductor sales.

Fig. 12 – Total public fabless revenue by year ($B)



SOURCE: GSA: REFLECTS UPDATED DATA. MAY DIFFER FROM THE MOST RECENT GLOBAL SEMICONDUCTOR FINANCIAL REPORT.

Fig. 13 - Top 10 Fabless Companies by CY 2007 Revenue (Source: GSA)

	COMPANY	CY 2007 Revenue ($bn)
1	QUALCOMM (QCT Division)	$5,6
2	NVIDIA	$4,1
3	SanDisk	$3,9
4	Broadcom	$3,8
5	Marvell Technology Group	$2,9
6	LSI	$2,6
7	MediaTek	$2,5
8	Xilinx	$1,8
9	Avago Technologies	$1,5
10	Altera	$1,3

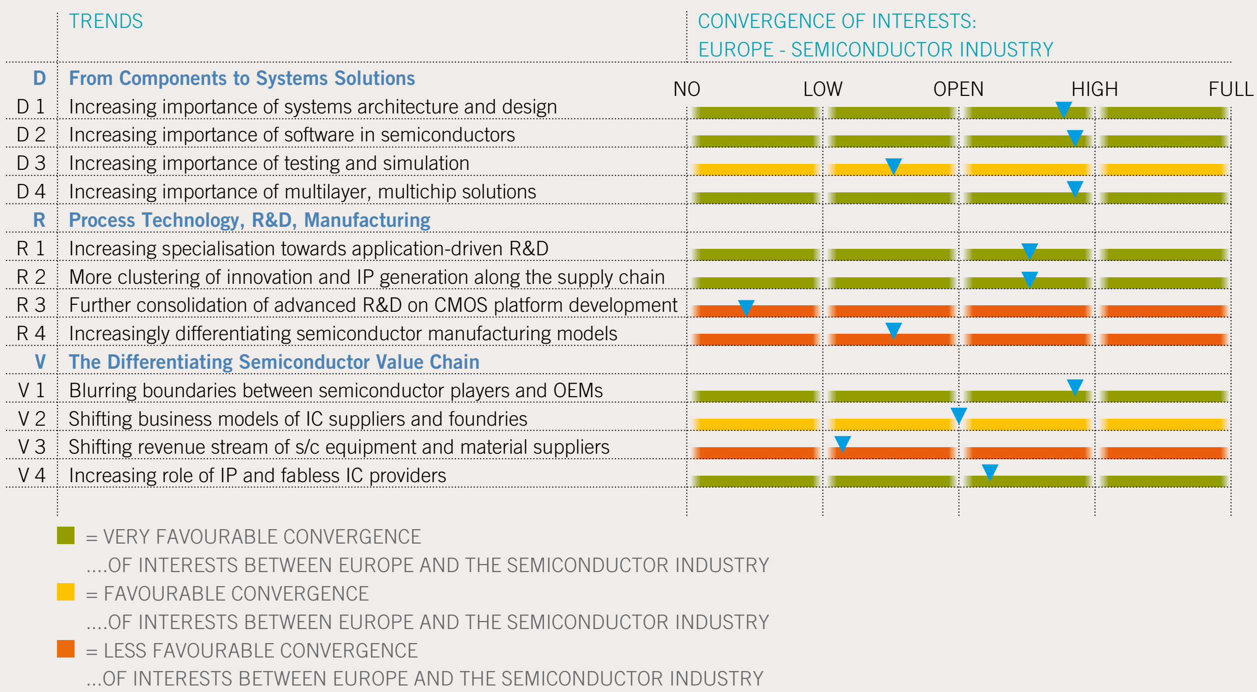
- *Growth of fabless companies: 1999: 500; 2007: 1300 and growing*
- *Geographic Dispersion of Fabless Companies (2007): NA=600, EU=150, Asia=500, Israel=50*

3.4. CONCLUSIONS

As mentioned in the introduction to this section, the review and assessment of twelve of what we regard as the most important critical trends reshaping the global semiconductor landscape show the current dynamics at work in the semiconductor industry. The structural shifts they are causing may be projected over the next 2 to 5 years. Moreover, not all of the trends evolve at the same pace, and many of them will possibly combine one with the other to create interdependencies and new dynamic constellations that involve more than just one individual trend.

In conclusion, therefore it is important to note that beyond the semiconductor landscape reviewed in this report there are some fundamental trends in the technology that have emerged. There are longer-term technological developments in the semiconductor and nanotechnology fields that will represent major shifts in the industrial context worldwide beyond 2015 and these will fundamentally impact the driving forces in the global competition. ENIAC's 2007 Strategic Research Agenda or CATRENE's 2007 White Book highlight these perspectives and the EU's Information Society Technologies Programme Advisory Group (ISTAG) is working specifically on future and emerging technologies (FET) with the mission to provide strategic advice and orientation on long term foundational research in ICT. More details are shown in Appendix A2.

Fig. 14 - Summary of Trends and Convergence of Interests



APPENDIX A 2 : New Technology Frontiers

In addition to the trends reviewed in this report there are significant technological developments in the semiconductor and nanotechnology fields that will represent major shifts beyond 2015 in the industry context worldwide and which will again fundamentally impact on driving forces in global competition.

According to the ITRS roadmap, macromolecular scale devices are now on the horizon. The current roadmap predicts that the minimum feature size of silicon CMOS technology will approach 20 nm as early as 2010. As silicon CMOS technology scales beyond these dimensions, new device structures and computational paradigms will be required to replace and augment standard CMOS devices for ultra large scale integration (ULSI) circuits. These possible emerging technologies span the realm from transistors made from silicon nanowires to devices made from nanoscale molecules. Most of these devices will require significant breakthroughs in the development of new nanomaterials and associated fabrication processes.[3]

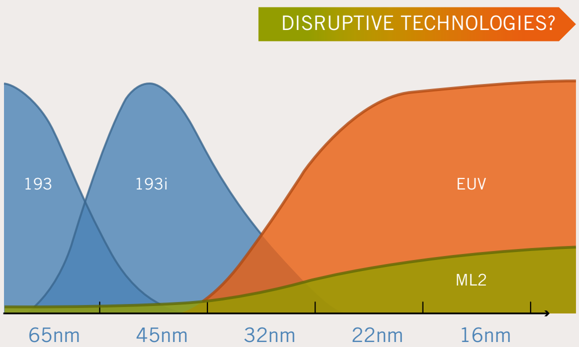
Following are a few perspectives on new technology frontiers for the semiconductor industry.

Optical lithography

As reported in the ENIAC Strategic Research Agenda: "New materials and shrinking device dimensions will pose challenges for Europe's equipment makers in all aspects of semiconductor processing, from lithography and mask making through metrology and device processing to assembly and test. In parallel to 'classic' optical and EUV lithography, new mask-less lithographic techniques are emerging, such as nano-imprint and multi-beam. But despite demographic shifts in semiconductor manufacturing, Europe continues to have a strong supplier base."[4]

Optical lithography has been the engine of continuous scaling in nanoelectronics probably reaching their limit at the 22-nm node, and in the near future will be extended to Extreme Ultra-Violet Lithography (EUVL) to reach 13-nm or 8-nm nodes which may be the key for high volume miniaturisation - the last optical technology currently foreseen - but it involves very expensive tools and masks. (Fig.1)

Fig. 1 - Lithography Roadmap



SOURCE: ENIAC SRA, 2007

450mm Wafer Size

Developing 450mm wafers poses a significant technological and economic challenge to both the semiconductor manufacturers and the equipment and material suppliers. At a research level, all groups from device manufacturers, equipment and materials suppliers to research institutes need to collaborate if they want to align the characteristics of their products and to cope efficiently with the rapid pace of change that the next generation of technologies will require. Given a development cycle of more than eight years from preliminary research to volume production on a new wafer size, the extremely high capital investment and the need for availability of a broad range of resources, it appears that such a path will only be possible under conditions of global consortia among different semiconductor industry players. For this reason, many companies have not yet made a decision to migrate their manufacturing. This is even more challenging, since at the same time all the challenges resulting from the new materials and shrinking device dimensions need to be considered when moving to a new wafer size production.

Future Emerging Technologies

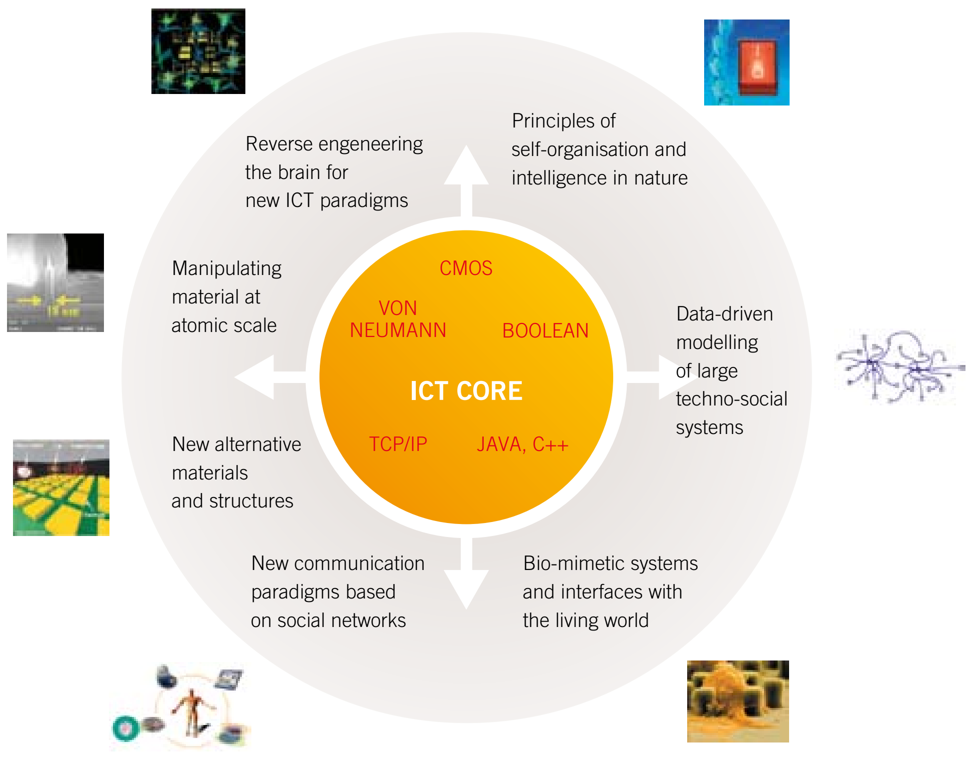
The EU Information Society Technologies Programme Advisory Group (ISTAG) is working specifically on future and emerging technologies (FET) with the mission to provide strategic advice and orientations on long term foundational research in ICTs, with a view to strengthening and broadening effectively the science and technology basis of future ICTs. In its proactive consultation process it addresses topics ranging from human-computer confluence to massive ICT systems; quantum information processing and communication; entanglement-enabled quantum technologies; overlay computing and communication; molecular-scale information systems; as well as alternative bio-inspired ICTs. (Fig. 2)

3 See also ISTAG Working Group on FET, Work Programme 2009-2010, EU DG IST, 2008

4 c.f. (ENIAC SRA 2007) p6, and also: 53 s.

5 cf. LaPedus, Mark. Sematech: 450-mm is progressing. EEtimes Europe, 07/10/2008. "Currently, the chip-making consortium International Sematech (Austin, Texas) continues to move ahead with its 450-mm programs, but the question is whether the industry can meet its goals in building 450-mm fabs by 2012. The consortium is up and running with its "factory integration test bed" facility for the development of 450-mm fab tools. Sematech is also testing silicon wafers based on 450-mm technology. And the group also claims it has made progress on its so-called ''Next Generation Factory" (NGF) program. The program is geared to bring lower costs and reduced cycle times in 300-mm wafer manufacturing.
There is widespread support among the fab-tool community for 300mmPrime, which looks to boost the efficiency of existing 300-mm fabs, thereby pushing out the need for 450-mm plants. The newer, more controversial ISMI 450mm program, announced last year at Semicon West, calls for some chip makers to make a more direct transition from 300-mm to the larger 450-mm wafer size. Many fab-tool vendors are reluctant to endorse the next-generation wafer size or devise 450-mm tools, saying that it is simply too expensive. Many vendors claim that 300-mm fabs are suitable for most applications and the real goal for the industry is to improve the productivity of current plants.
However, the mood is somewhat beginning to change, especially when Intel, Samsung and TSMC in May reached an agreement on the need for industry collaboration for 450-mm wafers starting in 2012. Intel, Samsung and TSMC indicate that the semiconductor industry can improve its return on investment and reduce 450-mm research and development costs by applying aligned standards, rationalizing changes from 300-mm infrastructure and automation, and working toward a common timeline. (..)
The bottleneck remains in moving the wafer lots from one tool to another. The goal is to process wafers without any delays, according to Sematech. "

Fig. 2 – Trends towards future ICT's



SOURCE: FET- Proactive Future ans Emerging Technologies and Work Programme 2009/2010, EU DG ISI, 2008.

In the framework of the EU's FP7 Fet Proactive Initiatives launched or to be launched for 2009-2010 cover a wide spectrum of emerging technologies in future ICTs, e.g.

- Science of Complex Systems for Socially Intelligent ICT
- Embodied Intelligence
- ICT forever yours
- Massive ICT Systems
- Human Computer Confluence
- Quantum Information Processing & Communications (QIPC) and other quantum technologies
- Proposals under negotiation online on the home page of each initiative
- Nano-scale ICT devices and systems
- Pervasive-Adaptation
- Bio-ICT convergence.

In addition to the initiatives defined for 2009, the list of future candidates has become longer as a result of an ongoing consultation process regarding "Future Proactive Initiatives". The topics or new challenges include future ICT areas of exploration covering, e.g., overlay computing and communication; synthetic living ICT; zero power ICT; creativity; bio-ICT (cell level); embodied ICT (system level); neuro-ICT; future computing technologies (incl. zero power); modeling and simulation for large scale systems; social-ICT.

Of particular importance for the future of the semiconductor industry is the development of nanotechnologies. The ISTAG working group is conducting a detailed analysis of very far reaching roadmap implications the emerging technology represents.

COMPETITIVE OPPORTUNITIES FOR THE SEMICONDUCTOR INDUSTRY IN EUROPE 4

The trends described in Section 3 show the current dynamics at work in the semiconductor industry. The structural shifts they are causing in the industry landscape may be projected over the next 2 to 5 years, depending on an overall economic and political environment that will accelerate or slow down some of these trends. Moreover, not all of the trends are evolving at the same pace and many of them may possibly combine with one another, creating interdependencies and new dynamic constellations that involve more than one individual trend.

This section takes a more integrated look at the opportunities and challenges for the semiconductor industry in Europe within this context. It highlights the matching potentials that can be derived from the interests of the semiconductor industry combined with the broad scope of those of Europe.

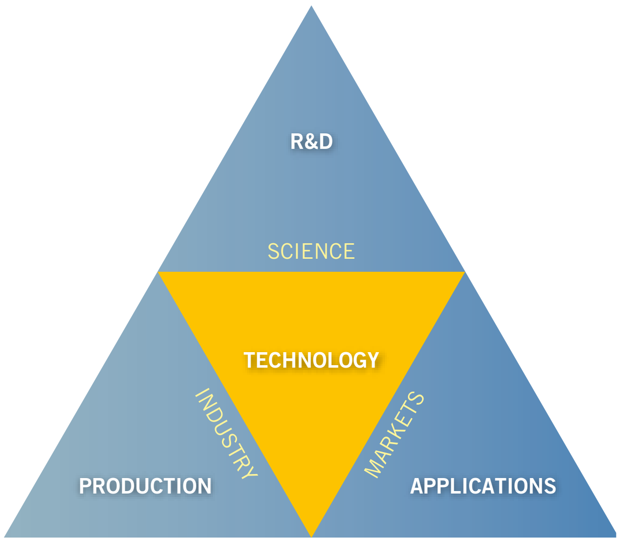
By mapping opportunities and challenges onto the shifting semiconductor landscape, our purpose is to offer a way forward for Europe, indicating directions for best capturing these trends and making them work both in and for Europe. For us, taking advantage of these opportunities means mastering the innovation Europe needs in order to leverage its competitive position in the race for the coming micro- and nano-electronic future. Whether a better understanding of the main areas of action translate into new initiatives and measures, and whether the opportunities described will materialise or not, depends in large measure on the combined actions of all concerned decision makers.

Our purpose is to offer a way forward for Europe, indicating directions for best capturing these trends and making them work both in and for Europe

Three focal areas of opportunities

A closer look at the opportunities the trends provide reveals three distinct categories, each highlighting an area of focus for the industry. Figure 1 below visualises the three opportunity areas while stressing the key driving role that technology development plays in the semiconductor industry (Fig.1).

Fig. 1 - Visualizing three opportunity areas for the semiconductor industry



These are:

- *R&D-centred opportunities* where the industry, drawing on advances in science and technology, is able to leverage its skills, know-how and competency
- *Applications-driven opportunities* where the industry is able to stimulate a strong "market pull" for new markets by providing technology-led solutions in domains demanded by emerging societal needs
- *Production-focused opportunities* where the industry is able to take advantage of a globally shifting manufacturing environment by developing and engineering new devices based on an evolving industrial ecosystem.

4.1 R&D-CENTRED OPPORTUNITIES

For the semiconductor industry in Europe, the value-added based on R&D continues to represent one of its major assets. Despite manufacturing delocalization, the R&D-driven strength of the semiconductor industry in Europe, seen in terms of its R&D-to-sales ratio, has remained intact. Thanks to its continuous efforts in engineering and designing products and applications for Europe's world-leading companies in wireless communications, automotive and industrial equipment, it has been at the core of the success of these industries. Today, as the complexity of semiconductor devices increases dramatically, the challenge for the industry in Europe is to stay ahead of the competition.

For the semiconductor industry in Europe, the value-added based on R&D continues to represent one of its major assets.

As shown in the trend analysis (see mainly trends D1: systems architecture and design; D2: importance of software; D3: testing and simulation; D4: multichip solutions; V4: role of fabless providers) Europe is in a strong position to capture the opportunities associated with these trends. The technical challenges and R&D efforts these opportunities represent for the semiconductor industry are being addressed in detail and on an ongoing basis by the International Technology Roadmap for Semiconductors (ITRS)[1]. For Europe, the reports of both the ENIAC SRA and CATRENE provide a much more detailed and extensive picture of R&D priorities.[2] (See also Appendix 3).

Below we summarise those critical priorities that align with our identified trends. The prerequisite for a semiconductor industry-led R&D effort able to take advantage of the research-driven opportunities in this area is a continued focus on:

- Refining *systems specification and validation, as well as complex architectures* able to meet the specifications while integrating increasingly functional solutions into a single chip. This requires the application of sophisticated modular design methods and tools to assist system architects and designers in the hardware/software partitioning and to ensure that each individual system approach follows established standards. (Trend D1: systems architechture & design)

- Seeking significant improvements in *software-driven system design*, enabling further integration of software and hardware while exploring methodologies for solving problems concerning, for example, the impact of hardware-dependent software development on current design costs.[3](Trend D2: importance of sofftware)

- Further developing in-house (or in close collaboration with electronic design automation (EDA) houses) *tools and methods* to close the so-called 'design gap'; i.e. the difference between what can theoretically be integrated into a chip and what can be practically implemented given design tool constraints. This requires tools that are able to address *verification, validating and testing* issues.[4](Trend D3: testing and simulation)

- Developing - beyond *multi-chip /multi-component packaging* and handling the complexity of extreme Systems-on-Chip (SoC) - multi-functional solutions or advanced Systems-in-Package (SiP) able to integrate semiconductor devices and devices based on other technologies into packages with integrated circuits (ICs).[5] (Trend D4: multichip solutions)

- Ensuring the crucial development of very advanced algorithms for embedded systems and for access to a wide range of IP blocks by specialised design houses and fabless companies participating through their R&D activities in ecosystems for specific application areas.[6] (Trend V4: role of fabless providers)

These are all critical innovation domains that Europe must master if it wants to leverage its know-how and stay ahead. The list is far from exhaustive. However, focus on the afore-mentioned R&D priorities in Europe is essential if the current end-user customer base is to maintain its leadership position. This is even more urgent because the unique constellation of advanced systems and software R&D in Europe corresponds to the needs of globally-competitive industry segments. Europe now has an opportunity to participate fully in the extremely rapid development of newly emerging application domains. These are addressed in following section on 'applications-driven opportunities'.

Focus on the afore-mentioned R&D priorities in Europe is essential if the current end-user customer base is to maintain its leadership position

1 cf. http://www.itrs.net/
2 cf. [CATRENE White Book 2007], [ENIAC SRA 2007]
3 Hardware-dependent software (HdS), i.e. the layer on top of which the operating system (OS) is built, should allow development of the OS and higher software layers independ¬ently of the hardware, thus enabling portability and reuse of the upper software layers.
4 cf. It also requires tools that are able to take into account process technol¬ogy and manufacturability, and to deal with heteroge¬neous systems, including mechanical, thermal, optical and chemical aspects. Quality management and reliability qualification testing methods are becoming even more important: test procedures, so test requirements must be considered during the design phase and integrated into the production flow.
5 The capability of designing heterogeneous systems that combine digital and non-digital functions, nanoscale module and 3D integration, interconnection, packaging and assembly are essential for paving the way for nanotechnologies to exploit improved material properties.
6 This is a response to the eroding boundaries between semiconductor devices, packaging and system technologies. Research and implementation of new algorithms will be required mostly in image processing, but also in digital signal processing that cannot support real time in software.

4.2 APPLICATIONS-DRIVEN OPPORTUNITIES

The semiconductor industry in Europe has demonstrated that a strong and highly-innovative industry contributes positively to the competitiveness of the overall economy, while at the same time a dynamic economic environment is likely to encourage the industry to benefit from the competitive advantage and value-added that advanced technologies provide. Such a virtuous circle can be seen at work in the industry's global leadership position in major application segments such as wireless communication, automotive electronics, industrial and medical equipment and consumer electronics.

Europe is in a favourable position to capture the opportunities associated with trends that stress the market side of the industry.

As shown in the trend analysis (see mainly trends R1: applications-driven R&D; R2: innovation clusters; V1: blurring boundaries s/c-OEM; V4:role of fabless providers), Europe is in a favourable position to capture the opportunities associated with trends that stress the market side of the industry. The focus observed in the trends highlights a shift in the industry from steadily bringing new products and enhanced features to the market, the so-called "market push", to a much more refined alignment of the possibilities technology offers with the demand to find solutions to the needs observed in the market, i.e. "market pull".

In other words, with the EU and Member States having increasingly addressed emerging societal challenges in the current legislature (e.g., smarter management of safety and emissions in transport, energy conservation and the development of renewable resources, increased efficiency of and access to health systems, ubiquitous networking and information processing), the "agenda making" position of the EU has now rapidly shifted to the industrial players, thus creating new opportunities to assert global leadership in some of these new markets.

Again, the broad potential for applications based on the innovative power semiconductor technologies bring to the market has been extensively described in a number of recent reports involving ESIA member companies.[7] (Fig. 2) (See also Appendix 4)

Based on our trend assessment, in order to leverage European strengths, pursue new opportunities and increase competitiveness in chosen application segments, the industry must be able to respond to the following new market dynamics:

- The competitive pressure for semiconductor companies is increasingly focused on *accelerating the differentiation of their devices and specializing in specific applications* based on new strategic priorities given to targeted types of products and application segments. (Trend R1: applications driven R&D) The sought differentiation goes well beyond renewing the current product portfolio, protecting proprietary features and ensuring incremental performance. It addresses new markets that benefit from technological innovation and are best able to lead the final development of products and services that respond to specific needs. At work here are two types of dynamics for this kind of *'market pull'*:

  A. Extension of current markets where electronics opportunities are steadily expanding and improving in existing application areas. Examples of European excellence and leadership are found in:

  - *Automotive,* where the ever-growing electronics content in automotive applications, encompassing all opportunities linked to safety (reduction of fatalities), ecology (emission reduction), quality (zero defect and total cost of ownership reduction), customer experience (comfort, infotainment) and sub-segments create a whole new set of challenges in cases where these packages contain integrated sensors, actuators, mechatronics or opto-electronic functions. This represents 90% of automotive innovation. (Fig. 3)

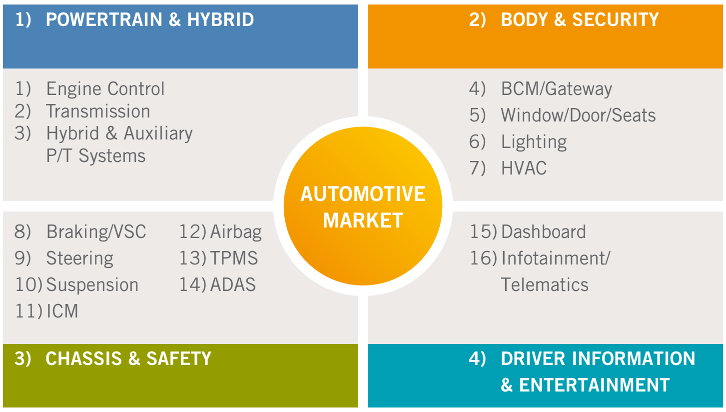
Fig. 2 - Mutual links between work areas and societal needs.

WORK AREAS	SOCIETY NEEDS: COMMUNICATIONS	SECURITY	TRANSPORTATION	HEALTHCARE	ENVIRONMENT	ENTERTAINMENT
High- quality, high- speed, user- centered communication systems	■	■	■	■		■
Smart-card system, trusted platform, secure platform	■	■	■	■		■
Transport electronics for safety/security, environnemental protection, communications	■	■	■		■	
Healthcare devices and systems				■		
Energy efficient devices and energy control systems	■			■	■	
Devices and systems for digital entertainment	■		■	■		■

SOURCE: CATRENE WHITE BOOK, 2008
(Cluster for application and technology research in European Nanoelectronics).

7 In particular the [ENIAC SRA 2007] and [Catrene Whitebook 2007] reports, both amplifying the call for "Creating and Innovative Europe" [Aho Report 2005] and for "Shaping Europe's Future Through ICT" [ISTAG Report 2006], provide a most comprehensive list.

Fig. 3 - Main Automotive Application Segments & Sub-Segments



SOURCE: FREESCALE SEMICONDUCTOR

- *Communications*, which represents 40% of the total ICT market where fixed and mobile broadband networks are evolving towards higher speeds, along with the emergence of direct and intelligent communications between different appliances, systems and man-machine interfaces in local and residential networks. Materializing the potential for increasing the broadband connection rate from the present rate of 10% of European households at 2 Mbit/s to 100% at >100 Mbit/s will allow the implementation of a wealth of new applications, such as the use of video and multimedia services at any time and in every situation, thus paving the way towards guaranteeing ubiquitous broadband access.

- Other examples for continuously extending the scope of opportunities in current markets are linked to *infotainment, security, industrial equipment (including factory automation, building control, appliances, electronics payments and fund transfer systems, power and energy, and medical).*

B. ***Venturing into new application areas*** where the increased use of electronics is about to create new market segments and where the convergence of technology capabilities with emerging needs are able to generate high value-added. (Fig.4)

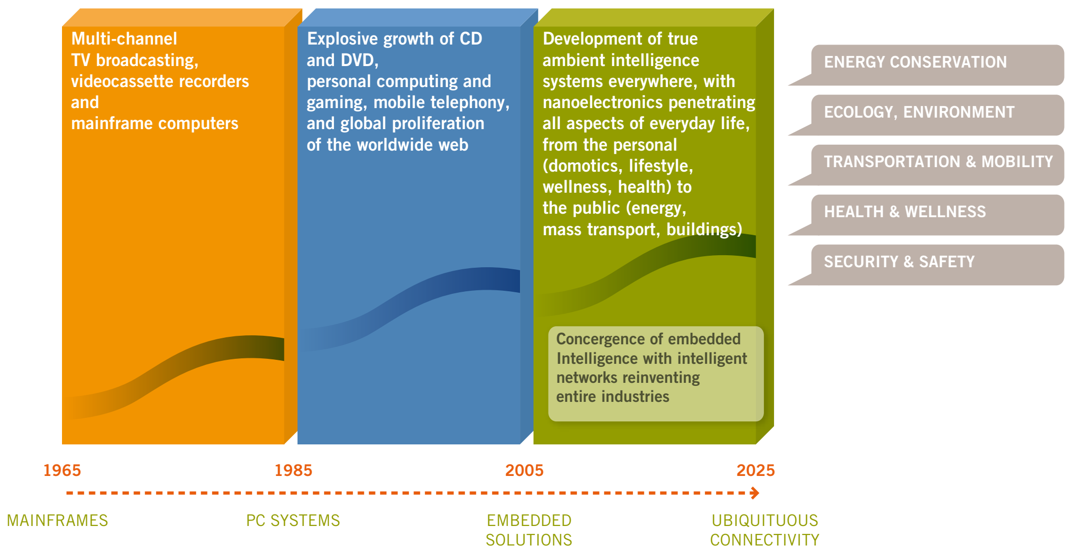
Many of these areas, where up until now electronics have held only a minor position, have their origin in a pressing need to respond more effectively to societal challenges, for example:

- *Energy conservation*, i.e., better control of energy transfer mechanisms and more efficient energy consumption per function, including new energy efficiency and alternative energy generation technologies as well as conservation; enabling the development of electric transportation to replace vehicles driven by internal combustion engines; developing low-power operations in electronic circuits, solid-state lighting, etc.

- *Eco-innovation and environmental conservation*, i.e., increased support for encouraging compliance with green public policies; enabling the introduction of new, CO2-free energy sources such as highly-efficient solar energy conversion and hydrogen fuel as well as recycling, waste reduction, emissions and environmental monitoring. The latter uses smart sensor networks and control in all relevant economic sectors such as transport, construction, agriculture, etc. (Fig. 5)

- *Transportation and mobility*, i.e., lower energy consumption and cleaner energy; reducing traffic congestion by using road intelligence systems for real-time interaction between vehicles with their environment; generating alternative mobility; more efficient use of existing infrastructure, basic transportation mechanisms and logistics, etc.

Fig. 4. - Waves of evolution in electronics-enabled application development



SOURCE : ESIA, CATRENE

- *Healthcare and wellness*, i.e., more efficient processes for consultation, diagnosis, treatment and administration; care for the ageing population; e-health that provides real-time access to patient- and therapy-specific data; bio-sensors for in-vitro diagnosis; DNA/protein assays; molecular imaging; nanomedicine in prosthetics, bio-implants, automated drug-delivery implants, etc.

- *Security and safety*, i.e., increased safety and security in virtually every aspect of our lives, exploiting the ability of ambient intelligence in safety-critical systems or applications at both individual and business levels. These include banking, passports, ID cards, telecoms etc., turning their complex requirements for reliability, wireless communication, miniaturization and robustness into an applications advantage, etc.

- *Digital content and entertainment*, i.e., ensuring the appropriate generation, quality, management, distribution and protection of rights by content providers beyond ubiquitous access to content anywhere; enabling users to create their own content; or spearheading "beyond-Google-revolution" applications able to reach a next level of convergence of shared technologies (all-mobile) and markets (all-info).

▪ The trend towards *forming centres of excellence or poles of competitiveness based on common interests and capabilities* enables IP generation, ensures competitive differentiation, captures new market opportunities, provides strong support for developing new applications and allows Europe to stay in the competitive race to lead in the emerging markets. (Trend R2: innovation clusters).[8] These clusters, built on the networks created under public-private partnerships, along with regional competence clusters connected to local players from large-scale multinationals and SMEs as well as to research institutes and universities, offer an ideal breeding ground for developing new opportunities. Such ecosystems enable new initiatives in lead markets thanks to the proximity of R&D to production capabilities, stimulating cross-fertilization and openness to innovation while protecting the IPR of players involved. This eventually allows entrepreneurial companies to create *'market pull'* for innovative products and provides access to leading customers.

▪ To be able to design and produce the above applications, corresponding processes and technologies need to be available. *Multichip ICs and heterogeneous systems integration are key enabling technologies* for the production and further development of applications, as confirmed by accelerating demand for them. (Trend D4: multichip solutions) Beyond integrating multi-functional components into one package, heterogeneous integration provides an interface to the application environment and represents the 'glue' between the worlds of nanoelectronic devices and systems with which humans can interact.[9]

▪ Finally, as demonstrated by the proximity of semiconductor players to end-user OEMs and their long established relationships, the increasing cross-fertilization and even *blurring of boundaries between semiconductor players and OEMs* facilitates an additional "market pull" for new applications. (Trend V1: blurring boundries s/c-OEM). In order to meet the demand by OEMs that complete control over system hardware and software be achieved with full platform-tested support for main operating systems, OEMs and semiconductor suppliers are making joint investments in R&D and are sharing design teams under various collaborative schemes. This is generating value-added and is enabling more efficient and effective integration of systems know-how, greatly benefiting the development of targeted applications and first-to-market solutions.

To summarise, based on the competence and experience accumulated by the industry, Europe has a major competitive opportunity to give rise to market leaders in the new applications area and to succeed in turning societal needs into lead markets. By establishing de-facto standards with the support of the semiconductor industry, Europe is enabling all involved industry players to take leading positions in these market segments worldwide.

Fig. 5 - How the semiconductor industry contributes to green IT

SOURCE: WORLD SEMICONDUCTOR COUNCIL (WSC) MAY 2008[10]

8 The semiconductor industry in Europe has given rise to ecosystems based on national and regional programmes main¬ly centred around one company or clusters formed around a research centre, e.g. Silicon Saxony (D), the Pôle de Compétitivité Minalogic (F) or Point-One (NL); or clusters centred on companies having a common inter¬est to share development of close-to-market technologies and applications e.g. the EUREKA CATRENE or the former MEDEA and MEDEA+ clusters; or the more open and non competitive JTIs (Joint Technology Initiatives) in the EU-Framework Programme.

9 Examples include, e.g., optical and infrared sensors; optoelec¬tronic components; low-cost RF; high-speed circuits operating at 40 GHz, 80 GHz or even higher; biological sensors integrated with logic and RF devices; digital processing of analog data; etc.

10 For a full presentation see http://www.eeca.eu/index.php/esh_about/en/

4.3 PRODUCTION-FOCUSED OPPORTUNITIES

Observing key trends in manufacturing activities in Europe offers a rather bleak picture of semiconductor production opportunities and of the possibilities of their re-orientation in the mid- to long term. In the global competition Europe has lost some of its ability to attract domestic and/or foreign semiconductor investments.[11]

In the global competition Europe has lost some of its ability to attract domestic and/or foreign semiconductor investments.

The issue is, therefore, under what conditions can the attractiveness of Europe be restored

Companies are making their own decisions on the global level playing field to find the best solutions meeting their core competences and to enhance competitiveness. The issue is, therefore, under what conditions can the attractiveness of Europe be restored and is Europe still willing to join this global competition, putting in place appropriate support frameworks in order to retain its semiconductor capabilities, or gradually see its semiconductor manufacturing capabilities degrade.[12]

In order to maintain or renew an innovative production capacity, the semiconductor industry in Europe needs to reassess the challenges and opportunities the shifting landscape has created. The changes that the semiconductor industry has undergone over the last 10 to 12 years have fundamentally redistributed possible future roles for semiconductor manufacturing in Europe among different types of activities. Possible roles for manufacturers basically fall into two categories: one following the scenario of fabrication lines for memories and standard products[13]; and another following a scenario for either logic products made using standard CMOS processes or for dedicated products with differentiated processes[14](see also trend R4 referring to the increasingly-differentiating semiconductor manufacturing models under three scenarios).

Based on our assessment, the trends related to manufacturing include opportunities but also some very serious threats (Trends R1: applications driven R&D; R2: innovation clusters; R3: CMOS platform R&D consolidation; R4: differentiating manufacturing models; V2: shifting business models, V3: shifting revenue streams for E&M suppliers; V4: role of fabless providers). These challenges must be taken urgently into account if the observed mismatch between the interests of the semiconductor industry in Europe and those of Europe in being a globally-leading technology provider is to be closed. More is required than just punctual actions – harmonised structural programmes would be needed in order to turn such actions into opportunities for maintaining or renewing Europe's manufacturing base:

- A further *consolidation and concentration of advanced CMOS R&D* capabilities under a few global consortia or industrial alliances in order jointly to develop common processes (Trend R3: CMOS platform R&D consolidation). *The emergence of three distinct manufacturing models* (Trend R4: differentiating manufacturing models) challenges the maintenance, let alone the creation of new semiconductor manufacturing facilities. This will accelerate the decision-making of some companies towards incorporating increasingly fablite strategies that imply adopting corresponding *alternative business models* that rely on third-party foundries for manufacturing, or that depend on outsourcing shareable tasks to specialised design and service businesses. (Trend V2: shifting business models).

- In a context where access to financial capital is highly competitive, private equity has started to play an increasingly decisive role in the restructuring of the industrial fabric. The shifting business models stress the 'division of labour' between IC suppliers and foundries and should encourage new options for investment allocations towards more value-added activities. On the one hand, companies facing the increasing cost and reduced performances in the field of basic CMOS for logic will seek to engage in strategic alliances among industries to share research costs and risks or to participate in joint ventures, involving major silicon foundries as well. On the other hand, companies will increasingly reorient their priorities toward the added value that can be generated from *creating new designs and proprietary intellectual property (IP)*. (Trend R2: innovation clusters)

- Inevitably, semiconductor companies in Europe will have to reconsider their business models and strategy, and eventually redefine their core business. (Trend V2: shifting business models). In the *'more Moore'* domain, European IDMs have stayed competitive in the memory and flash markets either by spinning out their memory activities into separate companies or by forming JVs that maintain strong European roots. Further consolidations of pure-play memory manufacturers must be foreseen. (Trend R4: differentiating manufacturing models).[15]

- In the digital logic segment, manufacturing has become increasingly difficult for independent IDMs. (Trend R4: differentiating manufacturing models) Their addressable markets no longer allow them to achieve the required economies of scale and the pace of the *trend towards fabless and foundry models* for virtually all logic products other than microprocessors and memories is increasing. (Trend V2: shifting business models) It is therefore crucial to emphasise the opportunities that the *'more than Moore'* domains offer in terms of specialised processes for dedicated products with larger added value, linked to specific applications of the final product. (Trends R1: applications driven R&D; R2: innovation clusters)

- The *role of foundries* themselves as a key focal point for manufacturing for IDMs and fabless IC providers will increase, as will the range and scope of the services they provide (Trend V4: role of fabless providers), making these players more independent and central. While this creates more opportunities - and challenges as well - for all types of semiconductor device manufacturers and for the foundries themselves, the current lack of large scale foundry capabilities in Europe will no doubt weaken the link of the semiconductor industry to Europe. It currently seems that only a larger-scale investment in Europe would allow it to profit substantially from new foundry opportunities.[16] (Trends R4: differentiating manufacturing models; D3: testing & simulation)

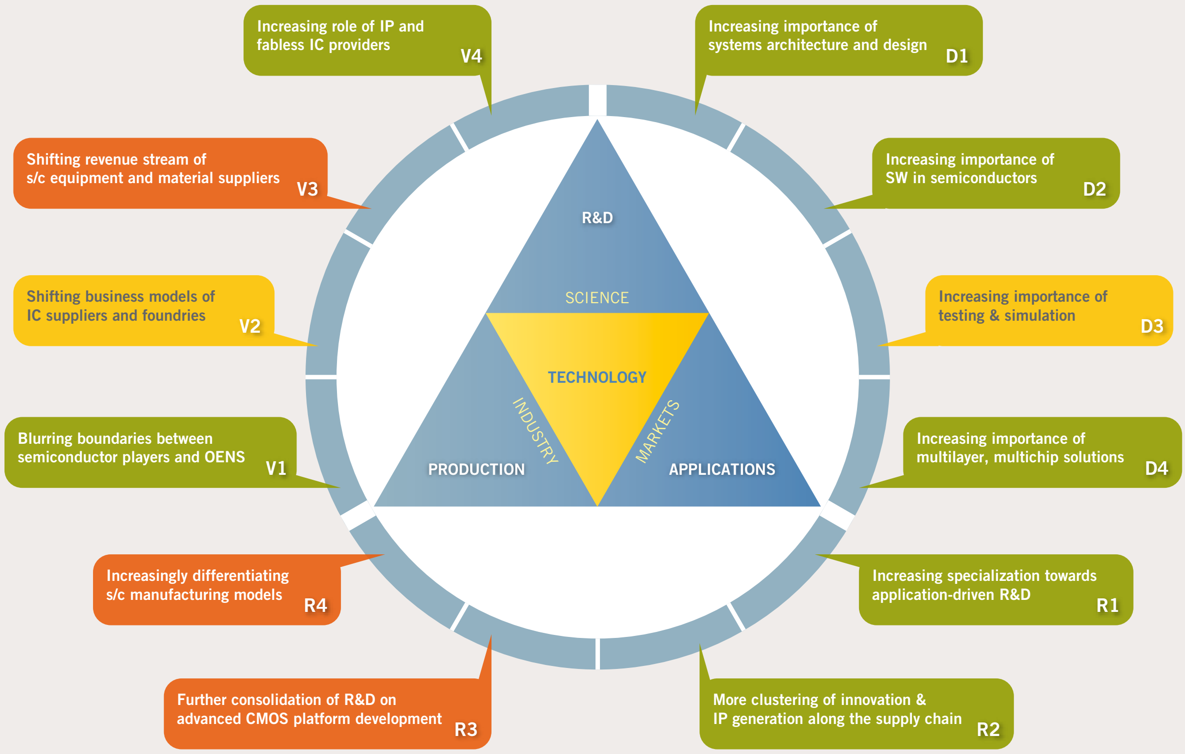
- All these options for refocusing production opportunities in Europe would have a significant impact on *equipment and materials suppliers*. (Trend V3: shifting revenue streams for E&M suppliers) The ongoing restructuring of semiconductor manufacturing activities in the European industry base is likely to put *pressure on the revenue stream generated from semiconductor companies* in Europe. At the same time, equipment and materials suppliers have opportunities for taking part in advanced R&D initiatives engaged in by the semiconductor industry. Being a highly-globalised market, the equipment and materials industry will have to compensate for a slowdown in investments due to the migration of the European manufacturing capacities to other regions.[17]

4.4 CONCLUSIONS

The trends reviewed in Section 3 all align in various ways with the opportunities highlighted in the three focal areas: *R&D, Applications and Production*. Although the picture of trends and opportunities is not exhaustive, it nevertheless underscores the enormous potential asset the semiconductor industry has in Europe.

The figure below visualises the analysed trends in the semiconductor industry as they relate to the three opportunity areas (Fig. 6)

Fig. 6 - Trends and Competitive Opportunities for Europe



11 The semiconductor industry's long term evolution is dominated by two major factors: its higher-than-proportionate technology and capital intensities. This high dependence on R&D and manufacturing investment, together with its high economic stake on a world scale, have caused the industry to migrate from a classical linear and largely vertically integrated supply chain (see Fig. 5, Section 2.2.) to a more network structure, offering opportunities for specialised players such as original design manufacturers (ODMs), electronics manufacturing services (EMS) and design houses - a trend also referred to as de-verticalisation. On the other hand, at the global economy level it has also caused competition among countries to attract semiconductor activities and hence investments. Countries have competed by offering a wide range of generous incentive schemes (see Appendix 1), a trend that has led to the entry of new countries into the semiconductor arena and has made the choices associated with decisions concerning localisation of manufacturing activities more complex.

12 The urgency of this issue is also highlighted in the Senator Saunier Report. [Rapport Saunier 2008]

13 This first category includes manufacturers of highly-sophisticated standard products such as MPU, DRAM, Flash, FPGAs etc. who require leading edge technologies based on the smallest possible nodes and extreme mass production, e.g. 300mm wafers. These fabs have to have critical size as production cost is one of the key issues for success, especially for memory products. (For FPGA companies this is not necessary, as they are produced in foundries and so their numbers are too small to fill a state-of-the-art fab). Pursuing the greatest cost and volume efficiencies, the number of companies globally in this category would be limited and subject to consolidations. Size matters. Europe has recently seen (and will see) a number of examples of new companies issuing either from spin-offs or from joining forces.

14 In this second category are manufacturers of all types of analog/mixed-signal and logic ASICs and ASSPs who need dedicated fabs that are able to produce ICs in leading edge technologies in extremely high numbers. Currently, typical fabs for these kinds of products are two-to-three generations behind and produce devices on 200mm wafers in relatively 'moderate' numbers. However, their overwhelming advantage is derived from their local presence and proximity to the end-use customer which offers a more effective response to application challenges, especially for the analog parts of the ICs. Europe is and must be able to afford a sufficiently large number of such production capacities. Strengthening or maintaining the presence of this category of fabs in Europe, extending their 'end-of-life' and ensuring critical capacity are all key elements for exploiting the competitive advantage that the European 'neighbourhood' factor brings for given industry sectors. This may take different forms of collaboration. 15 The future outlook is worthwhile considering: Because of the increasing demand by multimedia, port¬able applications and computers, memory and microprocessor companies will continue to drive the race toward smaller feature sizes. However, the 32 nm generation is close to the physical limit for conventional flash and DRAM memories, so new alternatives will have to be explored. Here, too, mergers and strategic alliances will be required to exploit economies of scale and to define standards. cf. [CATRENE White Book 2007] Part B. p. 64

16 See also Section 2.1. p. 5: Timind investment support/incentives, footnote 4.

17 This may take different forms. On one hand, the long-established expertise and experience in equipment manufacturing and material supply continues to be of high value and ensures world leadership in segments such as lithography, MEMS, SOI substrates and other technologies despite the fact that an ever-smaller fraction of this business will be produced in Europe. This high value knowledge base is key to maintaining acquired global competitive advantage and to entering further research collaborations with users, academia and research institutes, in particular regarding the introduction of 450 mm wafers and in nanotechnology domains where future technology breakthroughs or prototyping new equipment and material are becoming critical success factors. On the other hand, the emergence of new applications offers the equipment and materials industry opportunities to diversify their superior know-how towards manufacturing areas, such as for example LCD panels or photovoltaics, along other than the classic semiconductor value chain.

Overcoming competitive challenges

In the 2005 Competitiveness Report ESIA envisaged a scenario called *'Restoring EU Competitiveness'* that would address the competitive factors inhibiting the semiconductor industry in Europe from assuming its role on the global level playing field.[18]

There are two historic shifts that have taken place since and have, according to our assessment, modified today's starting point

In today's prevailing European economic and socio-political environment as described in Secton 2.1. above, most of the main competitive pressures persist. The assumption in 2005 was that strong political action by policy makers both in the EU and in Member States would be able to correct the imbalances an increasingly globalised world has caused. The assumption was that industrial policies similar to those of Asian countries, using the complete set of political tools ranging from facilitating access to capital to generous incentive schemes, would suffice in restoring better parity to competitive chances on a global level playing field. Although the observation was correct at the time, there are two historic shifts that have taken place since and have, according to our assessment, modified today's starting point.

- While in 2005 the battleground for the semiconductor industry in Europe was still largely dominated by the presence of manufacturing capacity in Europe, the fact today is that companies, for performance-driving and strategic positioning reasons, have largely been redistributing their operational activities on the global scene. As shown in Section 3 this may have taken very different forms, from incorporating fablite strategies to joining technology alliances, but the fact remains that with a few exceptions the situation ante quo will most probably not be restored.

- The other main difference between today and the situation in 2005 is that the global society has awakened to the fact that sustainability is a condition for saving the planet. The assumption used to be that microelectronics would continue to improve successful application areas incrementally such as automotive, consumer, communications – going green being a nice to-do add-on -, and along the way helping to make other, more traditional ones equally successful in turn. It appears, though, that, a paradigm shift in the mindset of decision makers has occurred, for suddenly more urgent economic reasons. These reasons include new agenda settings undertaken by political elites and subscribed to by an industrial leadership eager to revisit a number of social priorities in vital areas of people's needs, from energy conservation to eco-innovation to mobility, wellness, safety and ambient intelligence. What is most important for the semiconductor industry, however, is that in this focus on applications the common denominator and critical success factor will be a more disruptive shift to new technologies, allowing for the most complex integration of hardware and software supported in large part by advances in nanotechnologies.

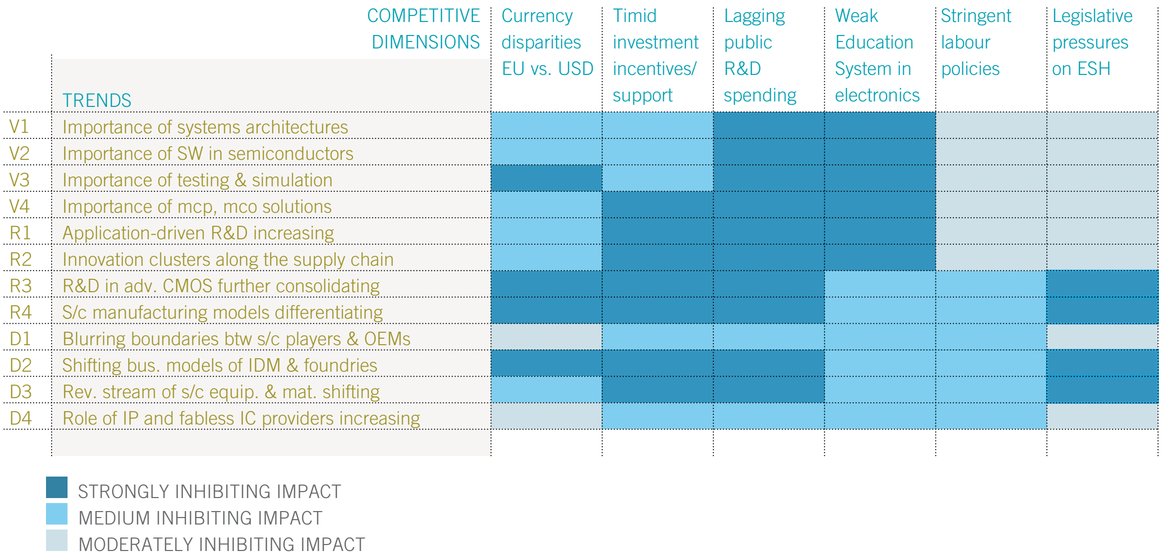
In this focus on applications the critical success factor will be a more disruptive shift to new technologies, allowing for the most complex integration of hardware and software supported in large part by advances in nanotechnologies.

This is not to say that with these two macro-shifts the pressures in the European competitive environment have become easier to overcome. Whether in the competitive opportunity areas of R&D, or in those of Applications or Production highlighted above, the need to correct currency disparities; to improve dramatically the incentives for, and public contribution to, major R&D investments; to ease the legislative burdens and uncertainties regarding labour conditions and ESH compliance; still remain a major concern for all the concerned parties in the industry. But the 'new' situation created by these two objective facts today raises the question of which war to fight rather than of which battle to win.

The following competitive dimensions discussed in Section 2.A (Fig. 7) are seen by ESIA members as having particular impact on the semiconductor trends described in Section 3. Dissolving some of their limiting effects would certainly create a firmer base for adequately responding to the societal expectations engendered by technological progress.

18 "Both the semiconductor industry and the EU & Member States embrace, in a concerted win-win effort, the competitive investment challenge and seek to initiate a virtuous circle throughout the semiconductor and the global end-user industry. The EU aims to invest in the future, rather than subsidise the past, focusing resources on future-oriented 'mega-projects' and the creation of new poles of excellence. Significant and measurable steps are taken to close the R&D gap and achieve over 3% of GDP for R&D. This, in addition to implementing a sectoral semiconductor framework, provides an environment for the industry, to succeed and to drive breakthrough technology advances in microelectronics and nanotechnologies. This benefits the industry at large, in particular the global European industry leaders in the automotive and wireless segments. As a consequence, joint public- and industry-led innovation and EU R&D policies gain momentum and enable advanced semiconductor technology to again become a key industrial competitive differentiator." cf. [ESIA 2005] p. 49

Fig. 7 - Impact of competitive dimension on trends in the semiconductor industry



In conclusion, this section has shown the tremendous opportunity potential that exists in Europe for the semiconductor industry. Our assessment of the matching interests between the semiconductor industry in Europe and the EU as a leading major economic world region has demonstrated this. In order to unleash such a potential, two dominant aspects need to be borne in mind:

- *Political voluntarism*: There will always be a need for decisive, dedicated voluntary action by policy makers to face the competitive challenges that we observe in the European context. This action is needed to give the opportunities the semiconductor industry confronts a fair chance to be realised. Grasping the priority requirements inherent in the various reports and analyses produced by a number of key stakeholders, including our report, is necessary although not sufficient for setting the appropriate framework conditions needed by the semiconductor industry in Europe if that industry is to take the initiative in shaping the next stages of innovation both globally as well as in and for Europe.

- *A new innovation age*: In contrast with the competitiveness situation in 2005, the semiconductor industry is entering a new innovation age that will reshape the way technology will be brought to society in the future. As trends confirm, this creates new areas of opportunity for the industry in Europe through which it can again assert leadership in the competitive race. Succeeding in an industry transition of this magnitude requires gaining control of key technologies that are the basis of achieving expected results in these new application areas. It is therefore necessary for all concerned stakeholders in Europe to recognise the same overriding innovation imperative.

The next section summarises the main actions point ESIA recommends taking into account in order to overcome some of the negative competitive factors confronted so far and to align with the imperative of restoring and launching a much more favourable and future-oriented technology investment environment.

APPENDIX A3:

Four priority technology domains in ENIAC's Strategic Research Agenda[20]

In its Strategic Research Agenda (SRA), the ENIAC technology platform - representing semiconductor manufacturers, equipment and material suppliers, research institutes and universities, has established ambitious research priorities for Europe in the following four technology domains:

- The ***'More Moore'*** domain, which is internationally defined as an attempt to develop further advanced CMOS technologies and reduce the associated cost per function. This is achieved based on: a) geometric scaling, i.e. the continued shrinking of horizontal and vertical physical feature sizes of on-chip logic and memory storage functions; and b) on a scaling that relates to the 3-dimensional device structure ('Design Factor') improvements plus other non-geometrical process techniques and new materials that affect the electrical performance of the chip (see also Fig. 7 in trend R4, Section 3).

- The ***'More than Moore'*** (MtM) domain, which from a technology perspective refers to *"a set of technologies that enable non-digital micro/nanoelectronic functions. They are based on, or derived from, silicon technology but do not necessarily scale with Moore's Law. From the application perspective, MtM enables functions equivalent to eyes, ears, arms and legs that allow the world of digital computing and data storage (the brains) to interact with the real world. MtM devices typically provide conversion of non-digital as well as non-electronic information, such as mechanical, thermal, acoustic, chemical, optical and biomedical functions, to digital data and visa versa."*

- The ***'Heterogeneous Integration'*** domain, which aims at a combination of 'More Moore' (MM) and 'More than Moore' (MtM) components, integrated in the form of 'System-in-Package' (SiP) solutions. The key technology underlying SiP is Heterogeneous Integration (HI). HI not only allows the integration of multi-functional components into one package, it also provides an interface to the application environment. It therefore includes the 'glue' between the world of nanoelectronic devices and systems with which humans can interact.

- The ***'Equipment and Materials'*** domain addresses equipment companies that exist in all shapes and sizes, from global companies offering a full spectrum of equipment to small niche companies with very specific products or know-how. While the first group has the capabilities to make integrated products that drive down cost-of-ownership for device makers, the latter group has the agility to bring innovative products quickly to market.

These technology domains are derived from their place in the industrial ecosystem and determine the recommended innovation paths over the next decade.

APPENDIX A4:

CATRENE lighthouse projects and key work areas[21]

CATRENE is built on the convergence of applications and technology. Innovation for growth in Europe is based on solving large societal needs efficiently through new products and services, bringing more added value and employment. Experience shows that technology innovation plays a determining role in applications development and that large applications markets also set new challenges for technology. Based on this view, CATRENE proposes an architecture of projects and programme management linking applications and technology closely.

Lighthouse projects address large and global socioeconomic needs such as transportation, healthcare, security, energy, environment, entertainment and communications through new R&D and deployment projects. They present a clear vision of the technical challenge and of the expected benefits and economic returns and are understandable by the public.

At the beginning of the programme, the following lighthouse projects are envisaged:
- Towards autonomous vehicles;
- 20% energy saving in products by 2020;
- Ubiquitous health monitoring and treatment;
- Secure technical society and communications.

The foundation for the CATRENE programme is the ambition of Europe and European companies to deliver nano-/microelectronics solutions that enable lighthouse projects and respond to the needs of society at large, improving the economic prosperity of Europe and reinforcing the ability of its industry to be at the forefront of global competition. This allows the creation of new GSM-like lead markets, which are the foundations for European leadership.

The following ***application work areas*** have been defined on this basis:
- High quality, high speed, user-centred communications systems;
- Smart-card systems, trusted platforms and secure applications;
- Transport electronics for safety and security, environmental protection and communications;
- Healthcare devices and systems;
- Energy-efficient devices and energy control systems; and
- Devices and systems for digital entertainment.

Succeeding in these application areas means mastering the convergence with key ***technology work areas:***
- Electronic design automation (EDA) for extreme SoC and SiP design
- Process development: including next generation CMOS process (more Moore), process options (more than Moore) and heterogeneous systems integration;
- Manufacturing science : cross-cut technologies, equipment and materials;
- Smart sensor and actuator systems.

During the 21st century, these needs are expected to have increasing importance not only in Europe but worldwide. These are the areas where high quality employment and value creation will materialise – and this must be a strategic focus for Europe and European companies.

20 cf. [ENIAC SRA 2007] p. 17ss.
21 [CATRENE White Book 2007] Part B. p. 12ss.

RECOMMENDATIONS: MASTERING INNOVATION - SHAPING THE FUTURE

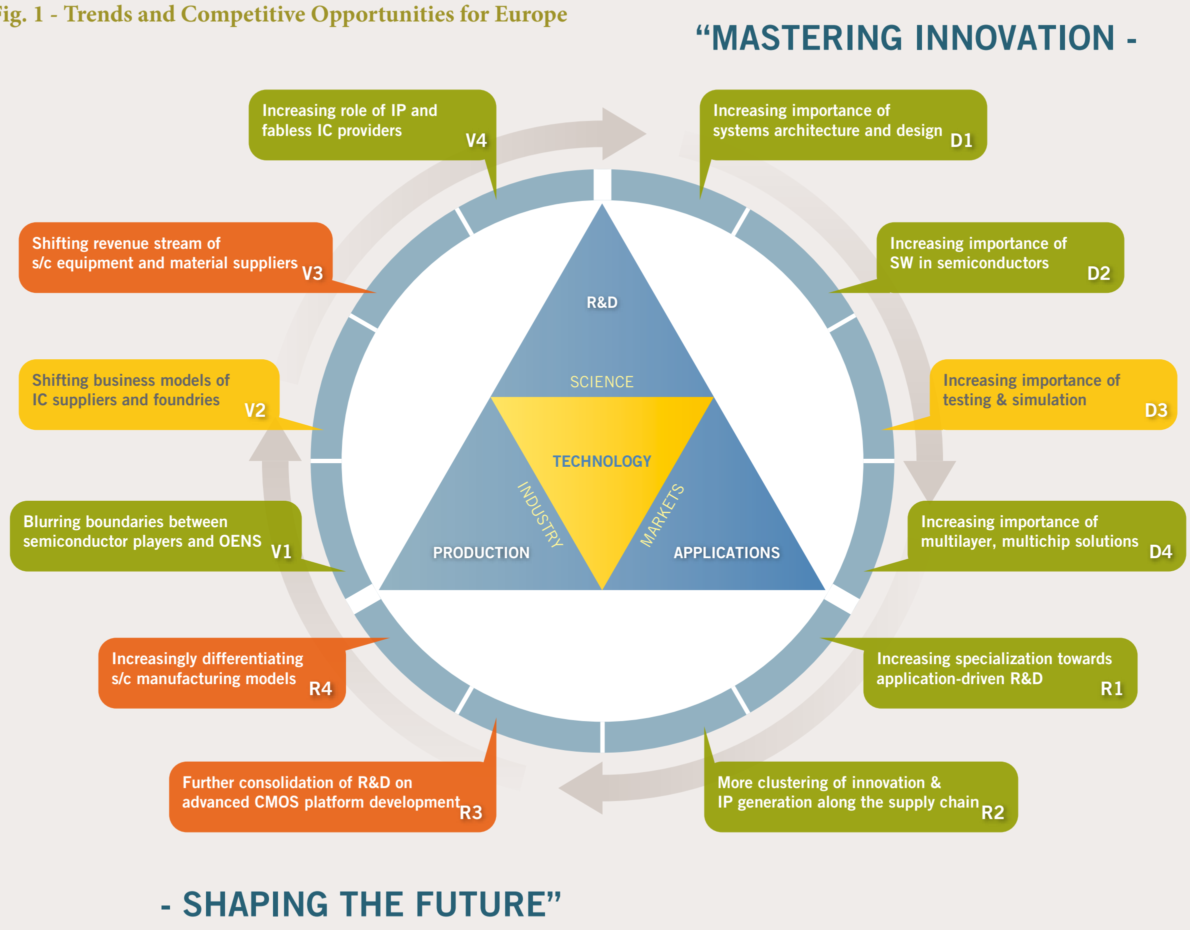
5

All of our trends underscore the competitive opportunities the three focal areas of *R&D, Applications and Production* represent for Europe. The question now is what needs to be done in order for Europe to capture these trends and to ensure that the opportunities they offer are turned into a sustainable competitive advantage for both the semiconductor industry in Europe and the European economy overall? Matching the expectations emerging from the dynamics of the semiconductor industry with the competitive realities in Europe calls for concerted action aimed at *"mastering innovation"* and *"shaping the future"*. (Fig. 1)

5.1. MASTERING INNOVATION

"Mastering innovation" means that the semiconductor industry in Europe has a chance to take control over its destiny once more and that its competitiveness has not been lost to globalisation. Today the semiconductor industry, with technology at its heart, is at a historic turning point. Following half a century of exponential improvements in silicon chip performance, device reduction is reaching its natural physical limits and the industry is undergoing a nanoelectronics revolution that is transcending ultimate scaling boundaries and wafer-bound 2-dimensional planarity. The semiconductor industry is working to develop

Fig. 1 - Trends and Competitive Opportunities for Europe



3-dimensional structures and interconnects, and to integrate components based on radically new technologies and materials[1]. Taking part in this innovative revolution will allow the industry in Europe not only to assert world class expertise but also to lead the entire initiative.

"Mastering innovation" means that the semiconductor industry in Europe has a chance to take control over its destiny once more and that its competitiveness has not been lost to globalisation

Control over key technologies is the basis for keeping a foothold in the competitive race. The dynamic demonstrated by the trends should motivate the industry to manage the transition from its past achievements to the new frontiers of technology. The semiconductor industry is entering a new innovation age. Today it has many assets that will enable Europe as a whole to succeed in a world evolving out of a decade of industrial globalisation towards a new geo-political and social balance between innovation and production.

A first set of recommendations therefore deals with priorities for actions to create the momentum necessary for the semiconductor industry to live up to the *'innovation imperative'* based on R&D- led investment. The objective of such actions is to introduce changes that allow the industry to gain more decisive influence in defining allocation objectives, asserting industrial leadership, aiming for relative independence and encouraging regional solidarity among all stakeholders. This requires first of all a *consensus on the priorities.*

Main action points responding to some of the aforementioned competitive pressures align with the *'innovation imperative'*. They involve restoring a more favourable R&D and technology investment environment by setting priorities in the following critical policy making areas:

Stimulating a Europe-led "market pull" for new applications paving the way toward emerging markets by:

- Focusing industry-wide innovation incentives on semiconductor systems know-how for new applications by aligning the European political agendas on the creation and development of solutions in energy conservation, eco-innovation, transportation and mobility, healthcare and wellness, security and safety and digital content.
- Leveraging all the European semiconductor industry's strengths to maintain industries' electronics innovation leadership in the global market: primarily in wireless communication and networking, automotive, consumer, and industrial equipment, while encouraging European-branded applications in lead markets.
- Launching cross-industry, cross-border initiatives (clusters, public-private partnerships, etc.) stressing the contributions of semiconductors in specific technology areas such as software engineering, mixed/mode analog design, heterogeneous integration and development of multi-chip and multi-component integrated circuits (MCPs and MCOs), advanced testing and simulation, photovoltaics.
- Orchestrating a Euro-microelectronics invention awareness programme and encouraging the end-use industry base, from large-scale companies to SMEs, to become lead users. This might also include launching customers who are prepared to take the higher initial costs and risks involved in early adoption of an innovation, thus setting an example for developing and implementing new applications in the targeted domains as a practical step to *"Creating an Innovative Europe"* encouraged by the Aho report.[2]
- Setting objectives for reaching standard agreements quickly and efficiently in critical development areas demanding high technical performance and quality levels on new application features. This would be accomplished by an efficient use of standards-setting bodies and industry-wide concertation.

Establish micro-/nanoelectronics as one of the overriding European R&D investment priorities for EU framework programmes and public-private partnerships (others being, e.g., biotechnologies and cognitive and neurosciences) as proposed under ENIACs strategic research agenda and CATRENE work areas and projects, by:

- Seeking a broad alignment of all stakeholders, i.e. the EU Commission collectively represented by DG Enterprise, Information Society, Research, and Competition, EU Member States, companies, universities and research institutions, with the proposed programmes and agendas.
- Promoting and leading international cooperation on issues that are shared with the European industry; this should allow the EU institutions and Member State administrations to pooling the considerable semiconductor expertise.
- Fostering the necessary collaborative conditions by creating incentives for all possible forms of clusters, public-private partnerships and ecosystems.
- Applying an improved and Europe-wide generalised / harmonised tax credit scheme for R&D; if necessary by establishing topical specifications related to micro-/nanoelectronics in order to apply it on a case by case basis.
- Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education followed by developing multi-disciplinary curricula in academic training.

1 cf. [ENIAC SRA 2007] p. 6

2 cf. [AHO Report]

5.2. Shaping the Future

"Shaping the future" means understanding the structuring importance of this industry in the economy, in intellectual capital creation and for excellence of the academic research.[3] It means that, in addition to consensus on priorities, a sizable level of voluntarism will be required from all concerned stakeholder in order to translate these priorities into workable conditions. Today, in a world that is seeing an increasing concentration of centres of production versus a multipolar diversity of innovation centres in an economy that seeks to rebalance corresponding capital flows between all activity sectors on a global level, Europe, as a major innovation region, has an increasing need for decisive, dedicated action to be undertaken by policy makers in order to face the competitive challenges.

In a second set of recommendations, therefore, we call on the EU and its Member States to take action, together with the semiconductor industry, to create the necessary framework conditions that would enable the semiconductor industry to engage without delay in the next stages of innovation. Adopting these recommendations should further help the industry to initiate those areas of opportunities that we have highlighted in this report. This is required by the convergence of the semiconductor industry's interest with a very broad scope of those of Europe as a whole. Such measures must support a value creation process that is "predominantly influenced by vicinity to appropriate partners (including suppliers and customers) and availability of know-how, followed by state support conditions."[4]

Main action points here consist of measures that have more of a 'shaping' nature insofar as they aim at supporting the necessary deployment of R&D and facilitating backup of technological developments with design skills, engineering know-how and the still significant remaining manufacturing expertise required to implement and execute.

Adopt a number of specific regulatory and legislative flanking measures aimed at accompanying the stated innovation priorities and ensuring their effective implementation by:

- Supporting policy actions at both European and international levels aimed at correcting disadvantageous currency distortions, e.g. the EURO vs. the USD, thus strengthening more balanced bilateral and international trade relationships in critical hi-tech business domains.

- Stimulating the development of regulatory frameworks for labour policies that anticipate and manage change better, e.g. along the lines of the recommendations in the EU green paper, i.e. advancing a "flexicurity" agenda in support of a labour market that is fairer, more responsive and more inclusive, with special attention to the mobility of engineers and scientists both between academia and industry and between different countries.[5]

- Removing possible legislative roadblocks to the introduction of new technologies and systems, in particular in the EHS arena, reminding policy makers that the semiconductor industry essentially is an up-stream supplier of its devices to the OEMs and that it has a proven track record of voluntary measures complying with, or even exceeding, requirements of the set rules.

- Working in close collaboration with the industry in order to anticipate legislative initiatives and measures in sensitive application areas (e.g. energy, ecology, mobility, health) that will be of significant importance, in particular with regard to the development of nanotechnologies, emphasising that ignoring feasibility would jeopardise the competitive position of both technology suppliers and OEMs.

"Shaping the future" means understanding the structuring importance of this industry in the economy, in intellectual capital creation and for excellence of the academic research

Leverage the public R&D funding potential that exists in Europe in order to create a Europe-wide infrastructure for open innovation and knowledge-sharing that recognises the individual and collective societal contributions of R&D by:

- Restoring in targeted, EU-wide priority R&D programmes increased public funding levels in alignment with the Lisbon agenda, thus revitalising a sectoral innovation pipeline and avoiding the fragmentation issue specific to Europe. (This fragmentation has resulted from spreading funding across too broad a scope of research topics and from too close adherence to national research preferences and policies.)

- Making all available incentive schemes, from R&D tax credits to loans and grants as well as from EU structural funds to national and local measures, in order to attract internationally all stakeholders to ecosystems or centres of excellence dedicated to agreed technology roadmaps and work programmes under public-private partnerships.

- Encouraging the creation and expansion of new firms in high-technology sectors in order to allow Europe to achieve its R&D potential, calling on EU financial markets and Europe-based venture capital investment capabilities to support increased funding of new technology-based firms.

Encourage the essential role played by education as the long-term foundation of intellectual innovation capital and a solid science base from which future generations of researchers and engineers will be able to draw by:

- Launching programmes and curricula at all levels - schools, universities, post-graduate training - able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/ microelectronic sciences.

3 cf. [CATRENE White Book 2007] Part A. p. 13
4 cf. [ENIAC SRA 2007] p. 8
5 cf. European Commission. DG Employment. 2006

- Leveraging the 'institutional' capabilities academia (universities and research institutes) and regional and local government bodies and knowledge transfer organisations provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering, etc., to support the creation of young, high-tech SMEs.

- Opening much more jointly-coordinated and regulated industry training or PhD specialisation opportunities with established R&D institutions for highly specialised talent aimed at generating the required hi-tech knowledge and skills. This training should be linked to practical professional experience as well as aimed at increasing intellectual property right (IPR) creation capabilities.

- Facilitating the mobility of highly-skilled human resources in science and technology (S&T)disciplines, allowing for a more targeted cross-border intake of both students and a young R&D labour force, enhancing the attractiveness of Europe for scientific innovation while at the same time offering EU-born educational and professional opportunities abroad.

Encourage the maintenance and renewal of European-based manufacturing capability by restoring the conditions of Europe's attractiveness, specifically:

- Devising a set of framework policies for *existing* sites that supports the development of manufacturing capabilities - including new processes, tools and methods among others - for a large range of innovative products and technologies building on the acquired expertise in semiconductor manufacturing, thus extending the economic life of the existing European manufacturing base.

- Supporting initiatives that encourage *new* EU- and national-based development programmes aimed at enhancing innovation and manufacturing capabilities for advanced semiconductor products in specific application segments or for dedicated types of devices; such initiatives may take different forms, e.g. joint ventures, global alliances, foreign investments, etc.

- Setting adequate priorities to encourage, at EU and national levels, the creation of economic value by diversifying the manufacturing capabilities of both semiconductor device manufacturers and equipment and materials suppliers into new targeted application areas where Europe has technology leadership. This should be done while assisting the creation of new competency clusters and in close co-operation with users, academia research institutes.

- Encouraging the development in Europe of new tools, methods, equipment or materials needed both for 'more Moore' and 'more than Moore' technologies, thus enabling new opportunities for the European semiconductor industry.

5.3. CONCLUSIONS

"Mastering innovation" and *"Shaping the future"* are the two sides of the same coin. ESIA, representing the semiconductor industry in Europe, believes that by reaching consensus on research priorities Europe stands a unique chance to gain better control over the direction and pace in which innovation takes place and hence deliver to all concerned stakeholders the necessary focus, energy and mindset to translate innovation inputs into winning propositions and to realise their competitive advantage in the global economy. For Europe to play a world- leading role in key applications for energy, transport, security, logistics, health, industry, consumer and communications, mastering the next innovation waves of semiconductor technology is a must.
ESIA is also convinced that by improving the industry's abilities to benefit from the innovations ahead, industry members together with all concerned decision makers - the EU, Member States, universities and research institutes - will contribute to shaping the destiny of Europe by competing in the world economy and by being rewarded with strong economic returns. Keeping Europe's micro-/ nanoelectronics assets and credentials in Europe is the stakeholders' collective responsibility. By jointly committing to innovation roadmaps, master plans and programmes that are benchmarked for the future, Europe takes in its own hands all its chances to achieve the wider objective to assert its role as a strongly-competitive economy and a leading technology provider.

By improving the industry's abilities to benefit from the innovations ahead, industry members together with all concerned decision makers - the EU, Member States, universities and research institutes - will contribute to shaping the destiny of Europe by competing in the world economy and by being rewarded with strong economic returns

Summary of recommendations

Mastering Innovation	
Stimulating a Europe-led "market pull" for new applications paving the way toward emerging markets	Focusing industry-wide innovation incentives on semiconductor systems know-how for new applications.
	Leveraging all the European semiconductor industry's strengths to maintain industries' electronics innovation leadership in the global market.
	Launching cross-industry, cross-border initiatives (clusters, public-private partnerships, etc.) stressing the contributions of semiconductors in specific technology areas.
	Orchestrating a Euro-microelectronics invention awareness programme and encouraging the end-use industry base, from large-scale companies to SMEs.
	Setting objectives for reaching standard agreements for new applications quickly and efficiently in critical development areas demanding high technical performance and quality levels.
Establish micro-/nanoelectronics as one of the overriding European R&D investment priorities for EU framework programmes and public-private partnerships	Seeking a broad alignment of all stakeholders, i.e. the EU Commission collectively represented by DG Enterprise, Information Society, Research, and Competition, EU Member States, companies, universities and research institutions, with the proposed programmes and agendas.
	Promoting and leading international cooperation on issues that are shared with the European industry.
	Fostering the necessary collaborative conditions by creating incentives for all possible forms of clusters, public-private partnerships and ecosystems.
	Applying an improved and Europe-wide generalised / harmonised tax credit scheme for R&D; if necessary by establishing topical specifications related to micro-/nanoelectronics in order to apply it on a case by case basis.
	Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education followed by developing multi-disciplinary curricula in academic training.

Shaping the Future	
Adopt a number of specific regulatory and legislative flanking measures in support of the semiconductor industry	Supporting policy actions at both European and international levels aimed at limiting disadvantageous currency distortions, e.g. the EURO vs. the USD.
	Stimulating the development of regulatory frameworks for labour policies that anticipate and manage change better, e.g. along the lines of the recommendations in the EU green paper.
	Removing possible legislative roadblocks to the introduction of new technologies and systems, in particular in the EHS arena.
	Working in close collaboration with the industry in order to anticipate legislative initiatives and measures in sensitive application areas (e.g. energy, ecology, mobility, health) that will be of significant importance, in particular with regard to the development of nanotechnologies.
Leverage the public R&D funding potential that exists in Europe	Restoring in targeted, EU-wide priority R&D programmes increased public funding levels in alignment with the Lisbon agenda.
	Making available all possible incentive schemes, from R&D tax credits to loans and grants as well as from EU structural funds to national and local measures.
	Encouraging the creation and expansion of new firms in high-technology sectors in order to allow Europe to achieve its R&D potential, calling on EU financial markets and venture capital investment capabilities.
Encourage the role played by education as the foundation of intellectual innovation capital and a solid science base	Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/ microelectronic sciences.
	Leveraging the 'institutional' capabilities academia (universities and research institutes) and regional and local government bodies provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering, etc.
	Opening much more jointly-coordinated and regulated industry training or PhD specialisation opportunities with established R&D institutions.
	Facilitating the mobility of highly-skilled human resources in science and technology (S&T) disciplines allowing for a more targeted cross-border intake of both students and a young R&D labour force.
Encourage the maintenance and renewal of European-based manufacturing capability	Devising a set of framework policies for existing sites that supports the development of manufacturing capabilities for a large range of innovative products and technologies.
	Supporting initiatives that encourage new EU and national-based development programmes aimed at enhancing innovation and manufacturing capabilities in specific application segments.
	Setting adequate priorities to encourage, at EU and national levels, the creation of economic value by diversifying the capabilities of both the device manufacturers and equipment & material suppliers.
	Encouraging the development in Europe of new tools, methods, equipment or materials needed both for 'more Moore' and 'more than Moore' technologies.

Glossary for Competitiveness Report 2008

APAC	Asian Pacific market
ARTEMIS	A Joint Technology Initiative (JTI) by the European Commission; public-private partnership on embedded computing systems
AUTOSAR	Automotive Open System Architecture; an open and standardized automotive software architecture, jointly developed by automobile manufacturers, suppliers and tool developers.
CAPEX	Capital expenditures
CATRENE	Cluster for Application and Technology Research in Europe on NanoElectronics, EUREKA programme
CEA-LETI	Commissariat à l'Énergie Atomique - Laboratoire d'Electronique et de Technologie de l'Information, Grenoble
CMOS	Complementary MOS (Metal Oxide Semiconductor)
CNT	Fraunhofer Center Nanoelectronic Technology, Dresden
DG	Directorate-General of the EU
DISTI	Distributor
DRAM	Dynamic Random Access Memory; a type of semiconductor memory
EBIT	Earnings before interest and taxes
EC	European Commission
EDA	Electronic Design Automation
EE	Electronic Equipment
EFTA	European Free Trade Association
EIM	European Investment Monitor
EIT	European Institute of Innovation and Technology, Budapest
ELV	End of Life Vehicles; EU Directive
EMEA	Europe, Middle East and Africa
EMS	Electronic Manufacturing Services
ENIAC	European Nanoelectronics Initiative Advisory Council; a Joint Technology Initiative (JTI) by the European Commission; public-private partnership on nanoelectronics
EPO	European Patent Organisation
ESH	Environment, Safety and Health
EUREKA	A Europe-wide Network for Industrial R+D
EURIPIDES	Eureka Initiative for Packaging and Integration of μ-Devices & Smart Systems
EUVL	extreme ultra-violet lithography
FDI	Foreign direct investment
FPGA	Field Programmable Gate Array; a semiconductor device
FTE	full-time employed
GDP	gross domestic product
GDS2	or GDSII Graphic Design Station II
GERD	Gross Expenditure on R&D
HW	Hardware
IC	Integrated circuit
ICT	Information and communications technology
IDM	Integrated design manufacturer
IPD	Integrated Passive Deiscrete
LP	Low power
MCO	Multicomponent IC
MCP	Multichip IC
MEDEA+	Industry-initiated pan-European Programme for advanced co-operative Microelectronics R&D
MEMS	Micro-Electro-Mechanical System
MPU	Microprocessor Unit
MTBF	Mean Time between Failures
NAND	Type of Flash memory
NIE	Newly industrialized economies
NMOS	Type of Flash memory
NS&E	Natural science and engineering
ODM	Original Design Manufacturer
OECD	Organisation for Enconomic Co-operation and Development
OEM	Original Equipment Manufacturer
OS	Operating System
PFOS	Perfluorooctanesulfonic acid; is used in multiple photolithographic chemicals
PPP	Purchasing power parity
R&D	Research & development
REACH	Registration, Evaluation, Authorisation of Chemicals; EU Regulation
RF	Radio frequency
ROI	Return on investment
RoHS	Restriction of use of certain hazardous substances in electrical and electronic equipment; EU Directive
RTC	R&D tax credits
RTOS	Real Time Operating System
S&E	Science and Engineering
S&T	Science and Technology
SATS	Semiconductor assembly and testing services
SC	Semiconductor
SIA	Semiconductor Industry Association of the US
SiP	System-in-Package
SMEs	Small and medium enterprises
SoC	System-on-Chip
SOI	Silicon-On-Insulator
SOS	Silicon-On-Sapphire
SW	Software
USD	United States Dollar
WEEE	Waste Electrical and Electronic Equipment; EU Directive
WSC	World Semiconductor Council
WSTS	World Semiconductor Trade Statistics
WTI	West Texas Intermediate
WW	Worldwide

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EECA-ESIA

The European Semiconductor Industry Association (ESIA), part of the European Electronic Component manufacturer's Association (EECA), represents the European-based manufacturers of semiconductor devices. The semiconductor industry provides the key enabling technologies at the forefront of the development of the digital economy. This sector supports around 115 000 jobs in Europe, in a market valued at around EUR30 bn in 2007.

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