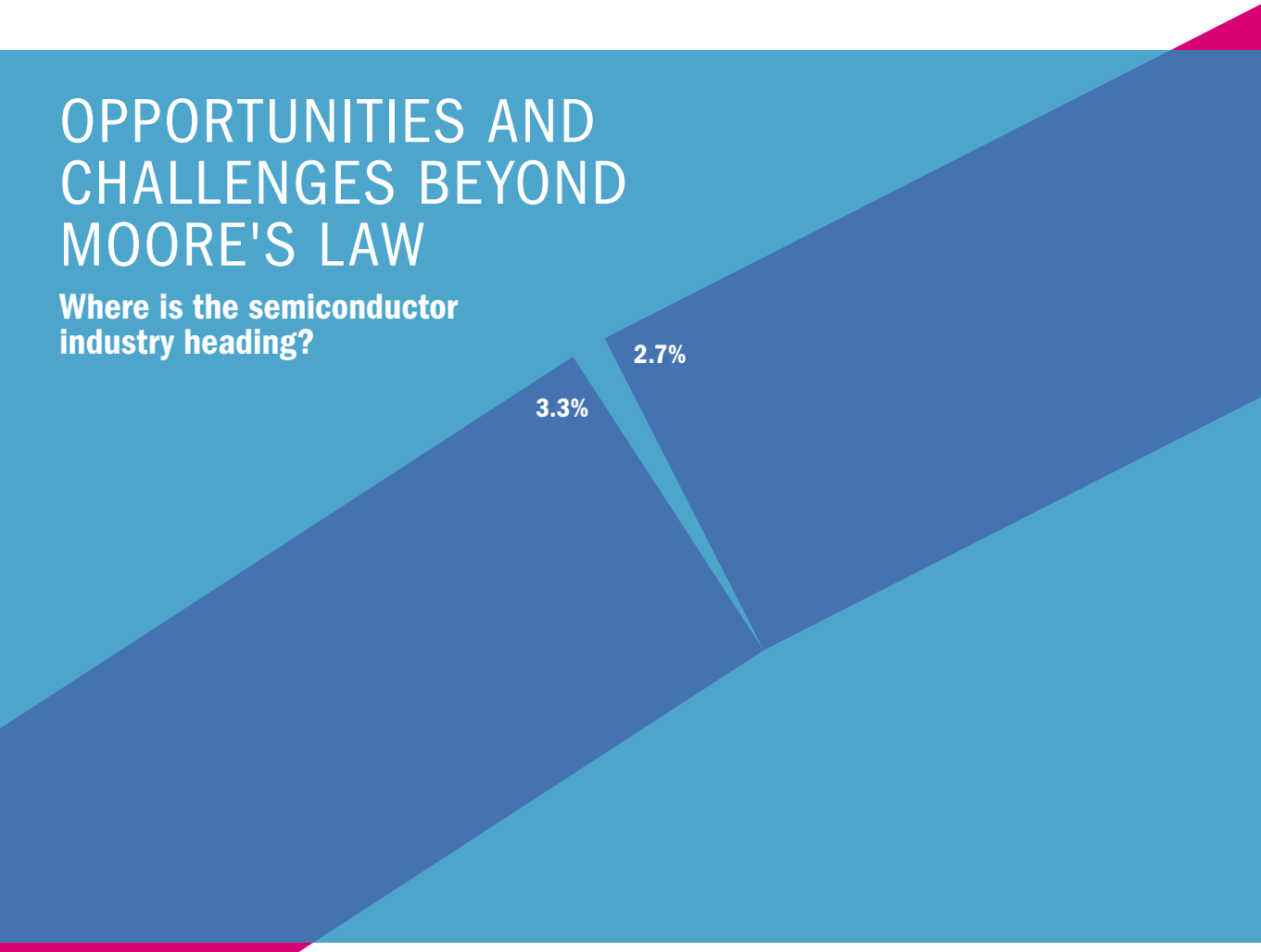
THINK ACT

OPPORTUNITIES AND CHALLENGES BEYOND MOORE'S LAW

Where is the semiconductor industry heading?



GROWTH IN WORLDWIDE SALES OF CHIPS

fell from a 3.3% CAGR in 2000-2007
to 2.7% in 2007-2013

2014

Roland Berger
Strategy Consultants

THE BIG 3

1 USD 300 bn

Growth in the worldwide sales of chips – a USD 300 bn market – fell from a 3.3% CAGR in 2000-2007 to 2.7% in 2007-2013 **p. 3**

2 40%

About 40% of the market has been a stronghold of European and Japanese companies defended by diversification ("More than Moore"). This segment is heavily under attack by abundant capacity in Asia and the US **p. 4**

3 1

There are 4 possible scenarios for European and Japanese semiconductor companies. Only 1 is favorable – and the probability of it becoming reality is low **p. 8**

+ **"More than Moore"** **p. 7**

European and Japanese players have lost ground in the semiconductor mass market. Now the niche segments of value-added products are under pressure as well. Urgent strategic action is needed.

The semiconductor industry is facing a major growth challenge. As the industry matures, its long-term growth rate is steadily decreasing. Growth in the USD 300 billion global market of chips sales fell from a 3.3% CAGR in 2000-2007 to 2.7% in 2007-2013, despite a surge in 2010 due to the investment backlog following the financial crisis. Not only that, most of Asia is gaining market share while Europe and Japan are rapidly losing out. Add in the very moderate growth expected in the coming years and you have an uncomfortable picture for industry players, especially those based in Europe and Japan.

What growth there is will mostly be driven by three factors: mobility, energy efficiency and big data. Increased mobility is driving the expansion of tablets, smartphones and novel devices such as "smart watches" and "smart glasses", boosting demand for semiconductors. E-mobility and renewables are the major growth drivers for semiconductor applications in the field of energy efficiency. At the same time, the rise of big data is fueling the industry: Novel approaches to analyzing large, complex datasets and the massive growth in demand for storage means that solid-state drives (SSDs) are increasingly replacing hard disk drives (HDDs), for example.

Going forward, the most promising growth segments for semiconductors are sensors, which are core to many mobile and energy-saving applications, and optoelectronics, as LED lighting more and more replaces traditional energy-wasting light sources, already banned in many countries. A third major growth segment for semiconductors is processors, feeding the seemingly insatiable hunger for processing power. A

In terms of the industries served by the semiconductor industry, automotive has shown good growth, albeit from a relatively small basis, over the past five or six years. However, mobile communication is still growing the fastest in absolute terms. The computer segment, by contrast, has been shrinking, as people replace their traditional PCs with mobile devices. The situation hasn't been helped by firms cutting their IT budgets following the euro crisis and the trend toward BYOD or "bring your own device" – the policy of letting employees use their own mobile devices at the workplace to access company applications and data. On the bright side, the consumer and industry segments remain relatively stable due to ongoing diversification of applications.

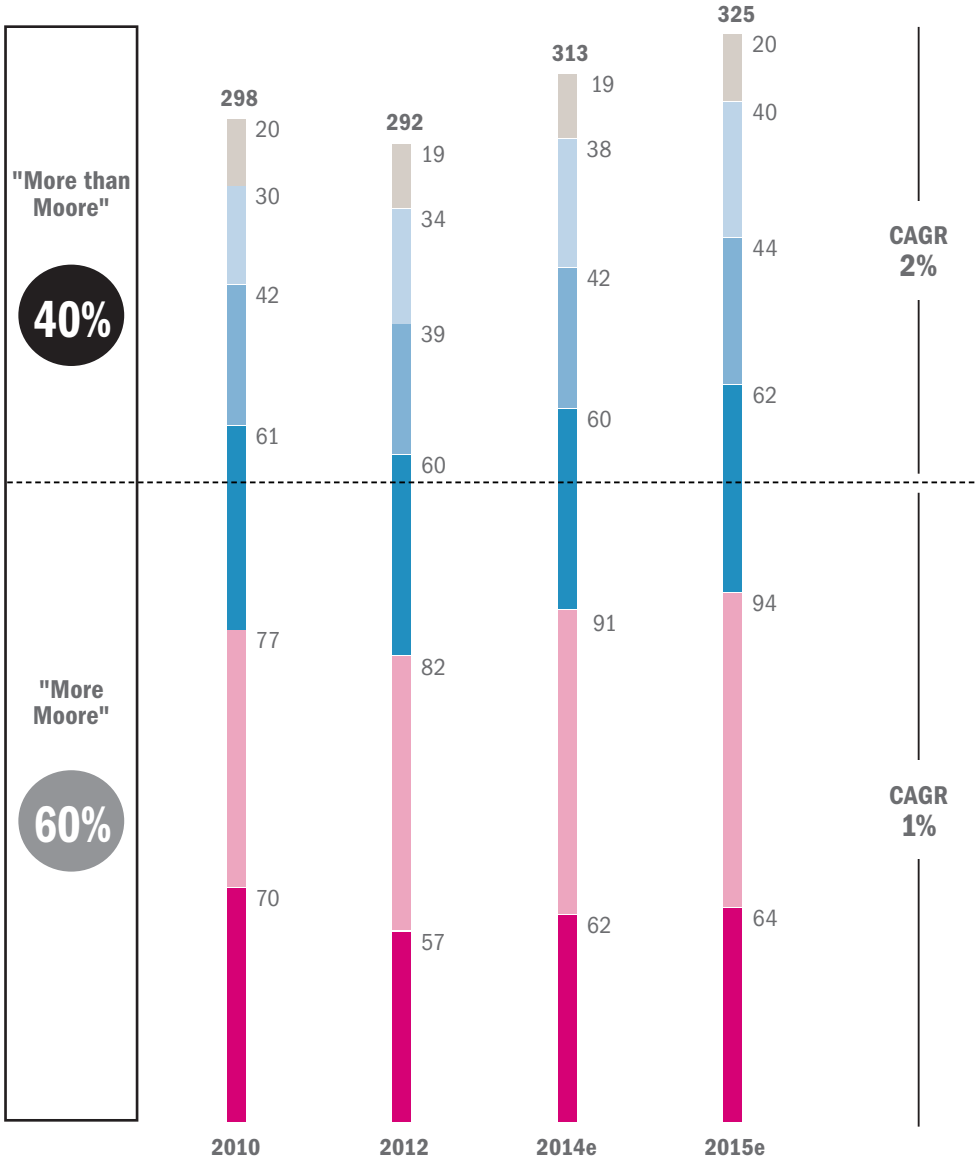
2 "MORE THAN MOORE" MARKET UNDER PRESSURE

MODERATE GROWTH AND MORE LEGACY CAPACITY

A

DEMAND PERSPECTIVE

Global semiconductor chip sales, 2010-2015 [USD bn]

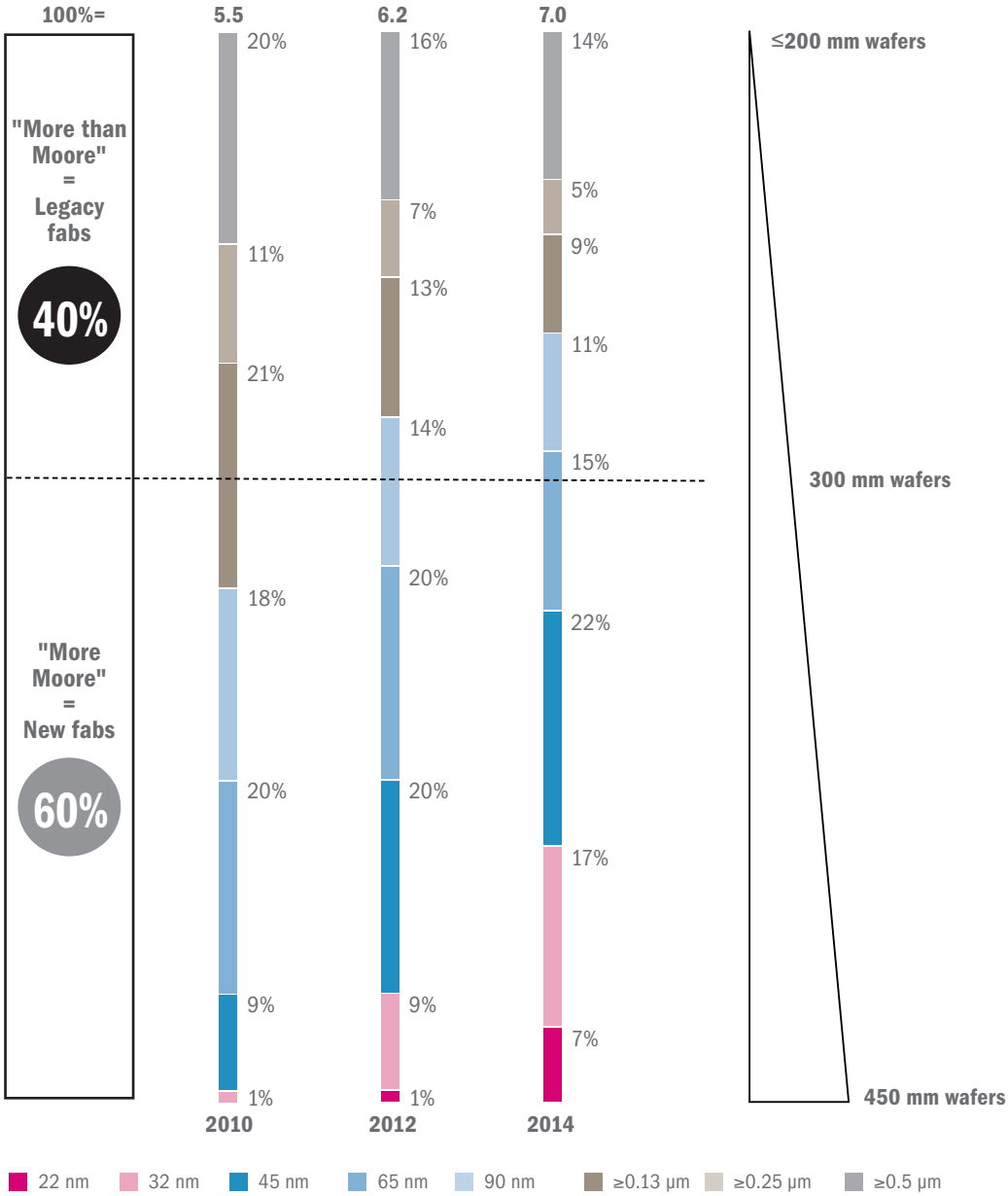


Source: WSTS, Roland Berger

B

CAPACITY PERSPECTIVE

Development of feature size, 2010-2014 [wafers km² p.a.]



Source: Gartner, Roland Berger

A fundamental shift

Growth prospects that are moderate at best are not the only problem dogging the industry, however. Semiconductors are undergoing a fundamental shift. In the mid-1960s, Gordon E. Moore, co-founder of Intel, formulated the hypothesis that soon became known as Moore's Law – the observation that the number of transistors on a chip will roughly double every one-and-a-half to two years. Moore's Law has underpinned much of the planning in the semiconductor industry ever since. His predictions of exponential productivity growth have proven largely accurate: Transistors have become smaller and smaller (they are now 1,000 times thinner than a human hair) and been produced in larger and larger batches.

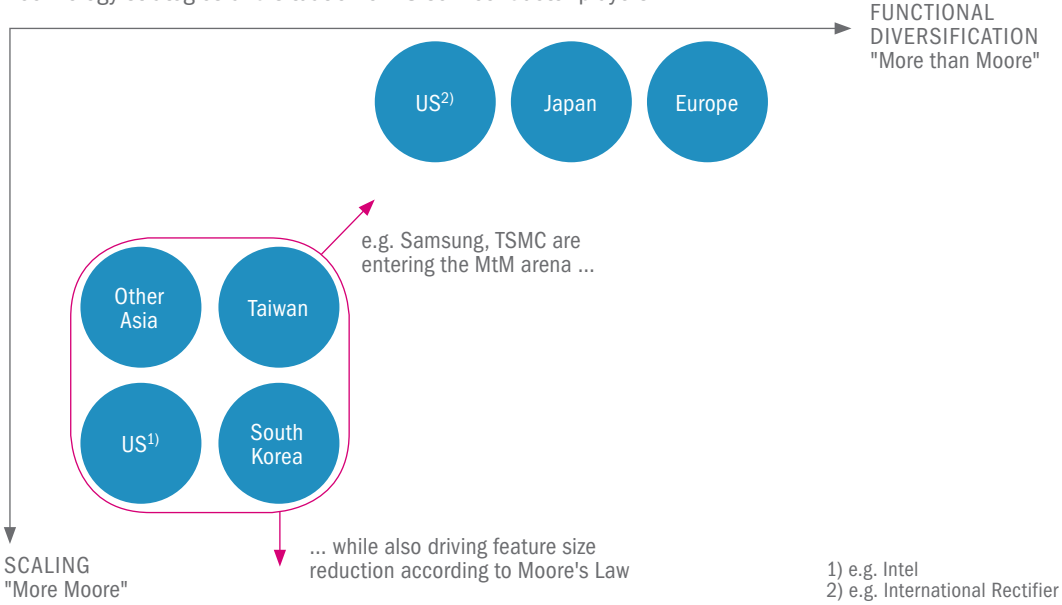
Yet it is clear that even chips have their physical limitations. Energy dissipation, overheating, resistance and other factors are making it increasingly difficult – and costly – to physically pack many more transistors onto a single chip. Transistor counts are not growing as fast as they did in the past, nor costs per transistor falling as rapidly. A fundamental shift is underway. Part of the industry is turning away from Moore's Law toward what is known as "More than Moore" (MtM) – integrating new technological features into semiconductor chips, thereby adding extra value rather than just expanding the number of transistors the chip contains. MtM technologies have a wide range of applications, from flipping the display when you turn your smartphone around to slowing your vehicle down if you get too close to the car in front. B

That is not to say that the semiconductor industry has turned its back entirely on Moore's Law. The exponential growth equation still applies, but packing more and more transistors onto a single chip as a source of competitive advantage is a strategy generally now only pursued by Asian and some US companies. In Europe and much of Japan, it is being replaced by MtM diversification, with multiple functions rather than ever smaller transistors. Globally, the market is split about 60/40, with products based on Moore's Law still making up the larger share, but MtM products growing twice as fast.

C

COMPETITIVENESS OF ASIAN PLAYERS IN THE MTM SEGMENT IS INCREASING

Technology strategies and situation of EU semiconductor players



1) e.g. Intel
2) e.g. International Rectifier

Impact on different players

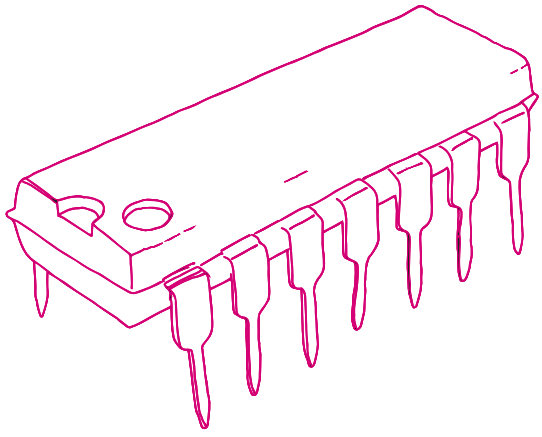
What does this shift mean for semiconductor companies? In a nutshell, for most European and Japanese players there is no future in following Moore's Law. They have already lost ground in the race for technology in this arena. In terms of wafer sizes, Europe and Japan are mostly saddled with a 150- to 200-millimeter wafer factory legacy, which further increases the labor cost gap compared to Asia due to the lack of automation and low productivity. Just three companies have 300-millimeter wafer factories in Europe: STMicroelectronics, Infineon Technologies and Globalfoundries. Until recently, only a handful of companies worldwide were expected to shift to the next generation of 450-millimeter wafers, a move that requires huge capital investments: Intel, Samsung, TSMC, Globalfoundries and probably IBM, all of them based in Asia or the US. No European player was expected to make this transition except for equipment manufacturers. However, a recent change of policy at EU level will now give funding to 450-millimeter pilot lines at five European locations. The jury is still out as to what effect this will ultimately have.

When it comes to a product strategy based on Moore's Law, it's pretty much game over for Europe, and probably for Japan too. The obvious next step for those who quit was functional diversification, the apparent option being to explore MtM niches. Demand for MtM is largely determined by increasing demand from industrial and automotive electronics, driven by high-end mobility, connectivity and energy efficiency. Ideally, European and Japanese companies have taken the capacity that has been freed up as a result of turning their back on a Moore's Law approach and redirected it toward MtM production. C

But even in the MtM market, things are not as rosy as traditional MtM players might wish them to be. Here, too, competitiveness is growing, with the likes of Samsung and TSMC entering the field and attacking established niches. European and Japanese players are not the only ones with idle capacity: Asian manufacturers are putting their facilities to good use and flooding the market with

MORE THAN MOORE

Moore's law says that the number of transistors will double every 1.5 years.



The traditional semiconductor business tried to expand the number of transistors a chip contained ("More Moore"). An alternate business is "More than Moore": Adding extra value through new transistors features with a wide range of applications, e.g. more current, higher voltages, faster switching.

D

3 FOUR SCENARIOS

POSSIBLE DEVELOPMENTS FOR THE "MORE THAN MOORE" MARKET

MARKET LEADERS PUSH CAPACITY INTO "MORE THAN MOORE" NICHES

DEMAND DRIVEN BY FRUGAL[1] PRODUCTS

HIGH-END APPLICATIONS DOMINATE DEMAND

MARKET LEADERS FOCUS THE SUPPLY ON MAINSTREAM "MORE MOORE"

COMMODITIZATION

MEDIUM PROBABILITY

SOUTH KOREA, TAIWAN, CHINA
Established and up-and-coming Asian companies, e.g. Samsung, TSMC, SMIC

Players with wrong regional focus and cost disadvantages

GLOBALIZATION

HIGH PROBABILITY

SOUTH KOREA, TAIWAN, US
Global technology and cost differentiators, e.g. Samsung, TSMC, Texas Instruments

EU and Japanese companies w/o sufficient portfolio and size

INDUSTRY RELOCATION

LOW PROBABILITY

TAIWAN, CHINA, US
Asian foundries and technical differentiators with light footprint, e.g. Texas Instruments, IBM, NXP

Companies stuck with legacy EU, US or Japanese footprint

INCUMBENT SWEET SPOT

LOW PROBABILITY

EUROPE, JAPAN, US
High-end technical differentiators from EU, Japan and US, e.g. Infineon, Mitsubishi, Intl. Rectifier

Large integrated device manufacturers and foundries in Asia

1) Functional, Robust, User-friendly, Growing, Affordable, Local

value-added products. Often, these products are technologically more advanced than those of their Japanese and European competitors, and cheaper too. Europe still faces the challenge of bridging the gap between conducting world-class scientific research (such as the work carried out at IMEC in Belgium) and meeting the market requirements. Japan has to defend its traditional stronghold in material sciences by quickly globalizing its footprint and supply chain, especially in the wake of the 2011 tsunami. If European and Japanese companies do not watch out, they risk losing in the MtM arena just as they have done regarding Moore's Law.

Four scenarios for "More than Moore"

Based on our analysis of supply and demand in MtM, we have developed four future scenarios for the market – all of them challenging for European and Japanese players. Future demand depends largely on whether sophisticated products prevail or if the market opens up for FRUGAL products – products that are **f**unctional, **r**obust, **u**ser-friendly, **g**rowing, **a**ffordable and **l**ocal. Supply will be driven by whether the new entrants discussed above take a proactive approach or simply rely on opportunities opening up for them over time:

COMMODITIZATION SCENARIO: MtM applications become FRUGAL products. Big Asian companies such as TSMC, Samsung and some up-and-coming larger Chinese companies are the winners. Smaller European, Japanese and US players are the losers.

GLOBALIZATION SCENARIO: In this scenario, MtM technologies boom on the back of new high-end technologies. Large Asian and US companies such as Samsung and Texas Instruments (TI) benefit, mergers between European and Asian players are possible. Smaller stand-alone European and Japanese companies lose out.

INCUMBENT SWEET SPOT SCENARIO: Current MtM producers flourish and there is limited competition from new players. European and Japanese companies benefit, while Asian companies can make little progress. This is the only scenario favoring current players in the market.

INDUSTRY RELOCATION SCENARIO: The MtM segment shifts to new companies in developing countries, particularly India and China. Chinese and other Asian players, and maybe also European and Japanese technical differentiators that globalize and lighten their footprint in time (e.g. NXP) are the winners in this scenario. D

The weaknesses in the semiconductor market will most likely lead to further industry consolidation. At present, the top 5 players – Intel, Samsung, TSMC, Qualcomm and TI – account for 30-40% of the global market in terms of revenue. They are also responsible for about two-third of capital expenditure. Many other semiconductor companies perform weakly and will face profit warnings in the next downcycle. Some smaller players have already encountered major problems, such as the Japanese company Elpida, whose assets have been acquired by US-based Micron. Such cases are likely to become more and more common in the coming years.

The road ahead

What is the way forward for semiconductor companies, particularly those in hard-hit Europe and Japan? Our analysis reveals that the key to long-term survival is a combination of high profitability and market leadership. Profitability, measured in terms of return on invested capital (ROIC), must be above 10% over a semiconductor market cycle in order to earn companies the right to compete in the next round of market development. In most cases, only the no. 1 company in the market achieves this level of ROIC consistently across an industry cycle. Players with smaller market shares often report low or even negative ROIC, substantially undermining their ability to make the large capital investments required to keep up with the fast changes taking place in the industry.

Now is the time for companies to prepare their next strategic move. Looking at the industry, we can observe two main approaches in terms of strategy. On the one hand, there is what you might call the "old story" approach: pushing ahead with a strategy based on

E

REPOSITIONING WITH NEW BUSINESS MODELS

Possible strategic moves of selected players

ASML **ARM**	CHANGING THE BUSINESS MODEL > ASML: Receiving USD 4 bn in investment from Intel to speed production > ARM: Established new business model based on licensing IP for mobile applications
NXP	BECOMING TRULY GLOBAL > 66% of NXP's revenue already generated in Asia – 50% from China > 75% of its employees are based in Asia
TEXAS INSTRUMENTS	ACTIVELY DRIVING CONSOLIDATION > Acquisition of National Semiconductor Corp. > Acquisition of Qimonda US assets
QUALCOMM	CONTINUOUSLY IDENTIFYING THE RIGHT MARKET SEGMENTS > Entering the RF segment > Creation of a new operational unit: "Qualcomm Technologies"
MICROSOFT **GOOGLE** **APPLE**	SOFTWARE COMPANIES GOING INTO SEMICONDUCTOR HARDWARE > Microsoft and Google entering HW tablet market (Surface and Nexus) > Apple going into chip design with its A4-A7

Moore's Law (see Intel and Samsung), growing organically, attempting to sell off unwanted capacity, and relying on subsidies and political support (e.g. in the EU and China). On the other hand, we see a more creative approach: repositioning yourself on the value chain (e.g. Apple with its A4-A7 chip design), pursuing inorganic growth (e.g. TI's acquisition of National), or entering into joint ventures, partnerships, and new business models (e.g. ASML taking on customers as shareholders, ARM's IP-only business). Whether you decide on an "old story" approach or a more creative line of attack, a detailed understanding of the markets, strategic options and implementation requirements can help you develop a strategy that really works. E

The other key element in charting a forward path is continuously optimizing your costs and cash availability. This is particularly important for European and Japanese semiconductor companies, where performance improvements form the basis for strategic moves. A three-pronged approach is needed here. The first prong is total performance improvement, involving continuous improvement of the bottom line. The second is strict management of cash and liquidity, as the basis for any strategic or tactical actions. The third prong is restructuring, where necessary, which may involve both a change of business model as well as financial and/or operational restructuring in some cases.

Time for strategic action

Semiconductor companies face a difficult road ahead, especially in Europe and Japan. Globalization continues apace and "More than Moore" niches are increasingly under attack. The time has come for strategic action. A solid, well-thought-out, future-proof strategy is the only way to ensure survival, and strict cost and cash control is vital to fund the strategic option chosen. ◆

ABOUT US

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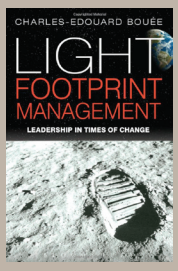

LIGHT FOOTPRINT MANAGEMENT: Leadership in times of change

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