Recent Innovations
Semiconductors and System Solutions
Mag. Dr. h.c. Monika Kircher-Kohl
CEO Infineon Technologies Austria AG

2011 MIT Europe Conference
Innovation in a Networked World: Technology, People, and Places
Wednesday, March 23, 2011
Agenda

- **Semiconductor Business - an Overview**

- **Market Driven Innovations**
  - New Challenges in Energy, Mobility and Security

- **Hidden Innovations**
  - 300 MM Thin-Wafer Technology
  - Silicon Carbide
  - iRobotics – Cooperative Robotics in Production Lines

- **Management Innovations**
  - Creating a ‘Culture of Innovation’
  - Enabling Innovations in Human Resource Management
Global semiconductor market development

Revenue in US Dollar billion and market growth rate

Global economic growth is the key driver for semiconductor market growth

In 2010, both the global economy and the global semiconductor market strongly recovered.

There is a positive correlation between real GDP growth and semiconductor market growth.

Field I represents a healthy economy and a growing semiconductor market. In field II, there is a global recession and the semiconductor market shows negative growth. In field III, the semiconductor market – in particular at the beginning of the nineties – was successful in decoupling from the economic cycle and ended with positive growth rates despite a recessive world economy. Field IV with the combination of a healthy economy and a contracting semiconductor market seems to be an anomaly.

Source: WSTS – T99, 31 January 2011; IHS Global Insight
Years are calendar years
Quarter-by-quarter-view: Growth in end markets will fuel semiconductor unit shipments

End applications’ and semi unit growth

Comments

- The positive outlook for end markets drives semiconductor unit demand in the course of 2011 and 2012.
- But there is not only unit demand that drives the semi market, also increasing semiconductor content as well as price developments contributes to semi market growth.

Source: WSTS – T99; IHS CSM, Strategy Analytics, Gartner. Years are calendar years
In addition to GDP and end markets, the following parameters also influence semiconductor market growth:

- **Chip capacity & chip production**
  - Semi unit shipments in bn [left y-axis]
  - Chip capacity [msi]
  - Chip production [msi]

- **Inventories in the electronics foodchain**
  - Semi industry inventory-to-sales ratio
  - OEM, EMS, Disti, Retail inventory-to-sales-ratio

- **Capacity utilization & Average Selling Price**
  - Capacity utilization [left y-axis]
  - Average Selling Price in USD [right y-axis]

- **Comments**
  - Under current conditions (expected GDP and end market growth, current capital spending plans in the semi industry), increasing chip production will meet demand and should neither end in oversupply nor excess inventories. Currently, the inventory situation within the electronics foodchain is stable.
  - Given that, capacity utilization is expected to remain close to 90%, leading to more or less firm ASPs. Important to know, capacity utilization is leading ASPs by 1-2 quarters.

Source: VLSI; WSTS – T99; IHS CSM, Gartner, Strategy Analytics

Copyright © Infineon Technologies 2011. All rights reserved.
Infineon at a Glance

The Company

- Infineon provides semiconductor and system solutions, focusing on three central needs of our modern society: **Energy Efficiency, Mobility and Security**

- Revenue in FY 2010*: 3.295 billion EUR

- 27,315** employees worldwide (as of December 2010)

- More than 21 R&D locations

*Note: Figures according to IFRS with Wireline and Wireless as discontinued operations; as of September 30, 2010

**Note: Including Wireless as discontinued operations; as of December 31, 2010
Agenda

- **Semiconductor Business - an Overview**

- **Market Driven Innovations**
  - New Challenges in Energy, Mobility and Security

- **Hidden Innovations**
  - 300 MM Thin-Wafer Technology
  - Silicon Carbide
  - iRobotics – Cooperative Robotics in Production Lines

- **Management Innovations**
  - Creating a 'Culture of Innovation'
  - Enabling Innovations in Human Resource Management
Key trends

- Soaring total energy demand across the globe amid dwindling fossil energy resources
- Strong CO₂ policies to achieve climate goals
- Tapping renewable energies as sustainable energy sources
- Electrification of the drivetrain of commercial and passenger vehicles

Our contribution

- Infineon delivers semiconductor innovations playing a valuable role in minimizing power loss and maximizing power savings along the entire energy supply chain, extending from generation through distribution to actual consumption.

- Our products are the basis for intelligent and optimal use of energy resources in industrial, computing and consumer applications, and in cars.
Key trends

- Rigid CO₂ regulations and rising oil price
- Increasing rules on safety, focusing on preventive measures
- Rising new requirements in cars for emerging markets
- Urbanization, globalization and demographic change
- Strong investments in local and long distance public transportation systems

Our contribution

- Leading semiconductor solutions contributing to a more sustainable mobility in terms of reduced fuel consumption/emissions, improved safety and affordability.
- As an innovation driver and supplier of key components for electric and hybrid vehicles, Infineon will actively help to shape the paradigm shift towards electro mobility on the road.
- Innovative public transportation solutions for traction and electronic tickets.
Leading national economies **promote electro-mobility** to give their industry a head start

### Subsidies per car (in € (k) / unit)

<table>
<thead>
<tr>
<th>Country</th>
<th>Subsidized Items</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>Electric Vehicles, Plug-in and Fuel-Cell</td>
<td>5.4</td>
</tr>
<tr>
<td>France</td>
<td>Vehicle with &lt; 60g/km CO₂ emission</td>
<td>5</td>
</tr>
<tr>
<td>Japan</td>
<td>Electric Car (Exchange of used cars)</td>
<td>1.9</td>
</tr>
<tr>
<td>US</td>
<td>Battery electric vehicles</td>
<td>1.8 – 5.4</td>
</tr>
<tr>
<td>China</td>
<td>Electric Car (in public transport)</td>
<td>2.2 – 6.3</td>
</tr>
</tbody>
</table>

**State Funded**
- Electric Vehicles, Plug-in and Fuel-Cell
- Vehicle with < 60g/km CO₂ emission
- Electric Car (Exchange of used cars)
- Battery electric vehicles
- Electric Car (in public transport)

**Further Incentives (examples)**
- Tax Reduction
- Free car registration
- Free car registration
- Partial Free parking
- Exemption of sales and tonnage tax
- Free parking
- No road maintenance fee and no toll
- Regional contributions

**Remark:** Only retail incentives; partially direct support for research, development and production structure

**Source:** Bain & Company, The Climate Group
Security

Key trends

- Requirements for secure systems are visible in all areas of life
- Secure communication everywhere utilizing mobile phone and internet
- Move to electronic identification of documents and products
- Contactless cards for payment and electronic tickets
- Increased electronics in cars, calling for secure data handling

Our contribution

- Tailored security according to system requirements, enabling the implementation of transparent security in everyday systems
- Leverage our worldwide leadership in security know-how for smart cards in automotive and industrial applications increasingly demanding security
- Combining both hardware security and cryptography, our products build the basis for privacy and security while maintaining personal freedom and facilitating extended communication capabilities
Agenda

- Semiconductor Business - an Overview

- Market Driven Innovations
  - New Challenges in Energy, Mobility and Security

- Hidden Innovations
  - 300 MM Thin-Wafer Technology
  - Silicon Carbide
  - iRobotics – Cooperative Robotics in Production Lines

- Management Innovations
  - Creating a 'Culture of Innovation'
  - Enabling Innovations in Human Resource Management
Infineon – R&D Network in Europe

Duisburg
Warstein
Dresden
Regensburg
Bristol
Linz
Augsburg
Graz
Munich, Neubiberg
Padova
Villach
Bucharest
Villach Production Site

Villach innovation fab

Power semiconductors on 300mm thin-wafers
- Feasibility study: 300 mm thin-wafer manufacture for power semiconductors
- First 300mm pilot line in the world in Villach/Austria

Focal area: Energy efficiency
- Further development of thin-wafer technology raises efficiency
- First large-scale manufacture in the world with 40μ wafer thickness
Thin-Wafer Technology
Demand driven and Technology Push

Applications
- Traction (trains)
- Speed-controlled motors, pumps
- Power supplies for computer and server
- Power supplies for consumer electronics
- Lighting
- Inductive cooking
- Automotive
- ...

Technologies
- IGBT
- Diodes
- MOSFET (e.g. CoolMOS)
- SPT (smart power technology)
- ...

Manufacturing Competencies
- Handling an ultra-thin-wafer
- Frontside and backside processing
- Equipment Engineering
- ...

Demand driven:
lower power losses
lower energy losses
lower resistance

Copyright © Infineon Technologies 2011. All rights reserved.
IGBTs – Semiconductor technology and special manufacturing expertise enable optimal power densities

- IGBTs are used for switching **high currents** typically occurring in the **inverter**
- **Trench + field stop** cells enable low switching losses and high robustness
- The **power losses** are primarily determined by the **thickness** of the wafers used (ultra-thin-wafers)
- Changeover from **6” to 12” wafers** will increase the IGBT area yield by **400%**

**Larger silicon wafers**

- 6” (2005)
- 8” (2010)
- 12” (future)

**Trench + field stop cell**

- Emitter
- Gate
- n-base (substrate)
- Collector

**P_{dis} \sim \text{Wafer}^{2}_{\text{thickness}}**

down to 40µm!
In pursuing organic growth, Infineon focuses on 300mm POWER manufacturing technology

- **Strong growth in revenues of ~10%** p.a. driven particularly by photovoltaics (IMM) and electrical drive (ATV) leads to significant increase of in-house production.

- **Area yield** expected to increase by 400% compared to 150mm.

- Start of **pilot line** for qualification in **FY 2011 in Villach** (~35€ Invest)

- **Technical challenges** particularly ultra-thin-wafer handling and adaption of standard CMOS in power substrates.

- Start of **volume production** in 300mm POWER within the next 2 to 3 years.
QPASS – Quick Personnel Safe Screening Cooperation Rohde & Schwarz and Infineon

Source: by courtesy of Rohde und Schwarz GmbH & Co. KG

Copyright © Infineon Technologies 2011. All rights reserved.
Summary of technical specifications

- Fully electronic personnel scanner
  - Automatic detection of hidden objects
  - Center Frequency 77GHz, high bandwidth
  - Very high resolution in x, y, z
  - Dynamic range > 40 dB
  - 3D dataset for automatic detection of hidden objects
  - RF-Output power much less than a Mobile phone

- Sensor
  - Active sparse array
  - 3072 Tx and 3072 Rx SiGe-channels and antennas
  - Modular concept with arrays and clusters

Source: by courtesy of Rohde und Schwarz GmbH & Co. KG
SiC switching elements are highly efficient, fast, able to function in high temperature and reliable.

SiC significantly extends the range of applications of power semiconductors (300 ... ~ 2500V).

The implementation of SiC products is a challenge (substrate size, crystal defects, transistor properties).
SiC:
THE power semiconductor material of the future?

- SiC enables loss-less switching
  - SiC power devices play a key role with respect to climate savings initiatives in power electronics
  - SiC power devices are mandatory to continue on Moore’s law of power density increase (switching frequency ↑, losses ↓)

- SiC allows increase of physical ruggedness of power devices
  - SiC devices can withstand very high power densities due to thermal properties
  - SiC devices are still blocking at T >> 200°C
  - Attractive switching devices without Gate Oxide, the main “Achilles heel” of MOSFETs and IGBT’s are possible

- SiC breaks by far the physical limits of Si power devices (even the state of the art of compensation technology like CoolMOS)
  - This is a key lever for further miniaturization of power devices and allows a complete new group of best in class devices
SiC:
The competitive material & market environment

- Si
  - Cheap and close to perfect base material
  - Tremendous manufacturing and application experience
  - So called „physical limits“ are already proven to be “permeable” by smart device design (e.g. CoolMOS)
  - Cost/performance gain has already started to slow down. Are we approaching the “wear out phase” of this very mature technology?

- GaN based
  - Power devices with high breakdown voltage (> 1000V) already demonstrated on GaN-on-Si
  - Very large scientific community is in place for this material system (opto-electronics, RF)
  - Very high defect density, critical surface passivation and very sensitive manufacturing processes to generate 2D electron gas

SiC power devices offer a huge upside development potential compared to Si without the essential risks of GaN power technology!
Physical Properties of Silicon Carbide

- High thermal stability (>> 500°C)
- Chemically stable
- Mechanically hard
- Radiation hard (excellent stability vs. cosmic radiation)
- Transparent
- Not toxic

Silicon Carbide
Ideal material for high-performance power electronics
Man-robot interaction, using the iRobotics pilot project as an example

Key data:

- 3 Kuka LBR-based loading systems load 11 Mattson process lines fully automatically
- Process line starts fully automatically
- Box lids are opened and closed pneumatically
- Batch identification in the box nests by RFID (based on Infineon my-d chip)
- Incoming and outgoing batch conveyance by operators

- Project duration: approx. 8 months
- Systems 1 and 2 undergoing productive test run
- System 3 prepared
- ROI: 18-24 months
- Improvements in
  - quality
  - plant utilization
  - personnel efficiency
Agenda

- Semiconductor Business - an Overview

- Market Driven Innovations
  - New Challenges in Energy, Mobility and Security

- Hidden Innovations
  - 300 MM Thin-Wafer Technology
  - Silicon Carbide
  - iRobotics – Cooperative Robotics in Production Lines

- Management Innovations
  - Creating a 'Culture of Innovation'
  - Enabling Innovations in Human Resource Management
Creating a Culture of Innovation

Leadership and target setting

Top-level expertise and innovation

Personnel and management development

Entering new markets with energy-efficient products

Innovation-management &-culture
We develop and practice an integrated innovation concept!

Geared towards the strategic fields of innovation

INNOVATION AWARDS
Innovation campaign 6 areas of action 2010
Research partnerships

INNOVATION DAY

iCommunities
Innovation Fab

Employee
Innovation culture
Innovation management annual circle
Innovation projects € 4.5 million

Copyright © Infineon Technologies 2011. All rights reserved.
IFAT Innovation Management Model

Our annual cycle

Control process
4 integrated paths:

The cultural path
The creative path
The “visibility” path
The formal path

IFAT innovation culture

Results & goals

Economic prospects
Innovative Personnel Management

Future-proofing Austria as a business location – promoting innovation and increasing appeal

Integration: Carinthian International Club (CIC)
- Cooperation between various Carinthian companies to facilitate the start and integration of international persons and their families

Women in Technology: Women encourage Women (WeW)
- From women in technology to women in technology – Development and support program for women in technical professions

Ensuring new recruits: Ö3-YPD Challenge, SEMI High Tech U
- Austria’s top companies provide the most exciting vacation placements – Hannes Jagerhofer initiative
- The SEMI High Tech U (HTU) adopts a hands-on approach to introducing youngsters to the fascination of high tech

Employee Development
- Training offensive: foreman training, technical studies at University of Applied Sciences or qualification for university entrance
- Junior Talent Program (JTP): 24-month trainee program for top graduates
- Technical Training: Internal training program, experts train staff
<table>
<thead>
<tr>
<th>„be different“ at-a-Glance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Mission</strong></td>
</tr>
<tr>
<td>- To foster key competencies of employees in application engineering, R&amp;D, technical &amp; product marketing jobs, supply chain management and manufacturing &amp; process engineering</td>
</tr>
<tr>
<td><strong>Target group:</strong></td>
</tr>
<tr>
<td>- ~20 employees</td>
</tr>
<tr>
<td>- Screened employees from PSD and OPP area</td>
</tr>
<tr>
<td>- Excellent performance demonstrated</td>
</tr>
<tr>
<td>- High predisposition to social skills</td>
</tr>
<tr>
<td><strong>Length</strong></td>
</tr>
<tr>
<td>- From 6 up to max. 24 months (individually determined)</td>
</tr>
<tr>
<td><strong>Roadmaps</strong></td>
</tr>
<tr>
<td>- 5 development platforms: R&amp;D, application engineering, product marketing, supply chain mgmt and UPD/GP/SCM</td>
</tr>
<tr>
<td><strong>Reporting structure</strong></td>
</tr>
<tr>
<td>- Project sponsor: IFAT Vorstand</td>
</tr>
<tr>
<td>- Steering Committee: A Urschitz, O Graf, T Neidhart, F Auerbach</td>
</tr>
<tr>
<td>- Project Manager: V Bianco</td>
</tr>
<tr>
<td><strong>Training structure</strong></td>
</tr>
<tr>
<td>- Structured individual “Einarbeitungsplan“ and “Patensystem“</td>
</tr>
<tr>
<td>- Internal training via technical ladder- and senior experts</td>
</tr>
<tr>
<td>- Functional training roadmap: application eng., product marketing</td>
</tr>
<tr>
<td>- On the job training</td>
</tr>
<tr>
<td>- Coaching via a mentoring program for selected people</td>
</tr>
</tbody>
</table>
SEMI High Tech University
About the Program

- **SEMI** (Semiconductor Equipment and Materials International) is a globally oriented industry association providing support for companies engaged in semiconductor manufacturing and related fields.

- In the interest of ensuring new recruits, SEMI developed the **SEMI High Tech University (SEMI HTU)** program - initiated in the USA – to stimulate the interest of scholars and teachers in science and technology and to point out career opportunities in the industry.

- Technology is presented to scholars in a **playful** way so as to give a touch-and-feel experience, using modules adapted to age and interests. The **SEMI HTU program consists of practical exercises** which establish a link between high school mathematics, science and applications in the everyday world of industry. Examples of the offering cover topics from the areas of mathematics, statistics, basics of physics and chemistry, electronics or nanotechnology.

- Since 2001 **over 100 SEMI HTU programs** have been conducted in the USA and Asia, and in 2007 for the first time in Europe. The **first event in German-speaking countries** was held at Infineon and Carinthia University of Applied Sciences in Villach in April 2008. The target group is scholars aged 13-14 years who are about to choose a career.

- You will find further information on the website [www.semi.org](http://www.semi.org)
SEMI High Tech University
Results (summary of events to date)

- 25% - 40% of the scholars per event stated that their career plans had changed as a result of the SEMI HTU.

- All the scholars stated that taking part in the SEMI HTU had widened their knowledge of microelectronics. (knowledge enhanced by 130% to 200%)

- 99% of the scholars stated that their expectations of the SEMI HTU had been met or exceeded.

“I'll never forget this SEMI project and in many years’ time I’ll look back on these two days with pleasure. The “SEMI High Tech U” project also changed my views on career choice. Since this project I'm far more interested in electronics.”
Feedback of one scholar

What was the best thing about the day?: “[...] that I now know that technical professions aren’t just for boys.”
Feedback of one scholar
# Hot Jobs@Infineon Austria
www.infineon.com/careers

## Job Profiles

### Automotive
- Analog Design
- Concept Engineering
- Application Engineering
- Digital Layout and Design
- Firmware Design
- Mixed-Signal Engineering
- Product Engineering
- Program Management
- Test Engineering

### Chipcard & Security
- System Engineering
- Mixed-Signal Design Engineering
- Contactless System Engineering
- Concept and Digital Design Engineering
- Firmware Engineering
- Marketing Management

### Industrial & Multimarket
- (Senior) Application Engineering
- Analog and Mixed-Signal, Design
- Layout and Circuit Design
- Concept Engineering
- Component Verification Engineering
- Technology Development Engineering
- Product Development Engineering
- Test and Industrial Engineering
- Product Marketing and Management

### Operations & Technics
- Quality Engineering
- Industrial Engineering
- Process Development Engineering
- Test Engineering
- Technology Engineering
- SiC Technology Engineering

## Open Positions
- ~ 25
- ~ 25
- ~ 35
- ~ 35

## Fields of Study

For High Performers (f/m) from the areas:
- Electrical Engineering
- (Techn.) Physics
- (Techn.) Chemistry
- Microelectronics (and Sensor System)
- Semiconductor and Microsystems Technology
- Industrial Engineering
- Information Technology
- Materials Science
- Metallurgy
ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.