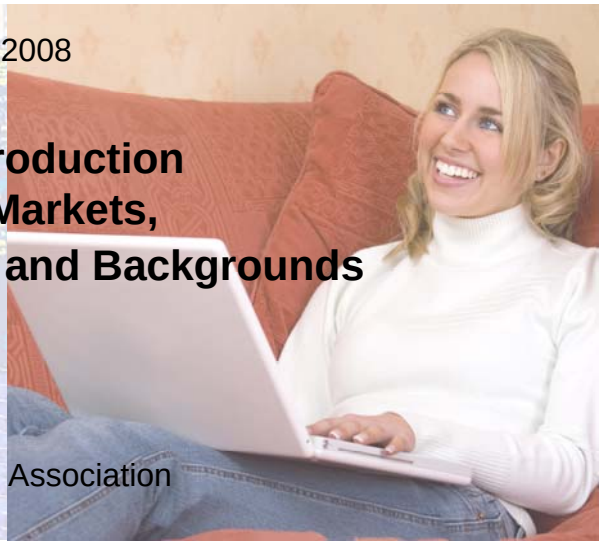
Productronic

EURIPIDES Forum 2008

Electronics Production Equipment – Markets, Technologies and Backgrounds



Picture: Darren Baker, Charles Taylor, Michael Morris, fotolia.com

October 9, 2008
Dr. Eric Maiser
VDMA Productronic Association

VDMA – Wir, die Investitionsgüterindustrie

Machinery and Plant Manufacturing "Enabling Industry", acting globally

Europe Machinery and Plant Manufacturing EU-25, 2006

Companies	23,540
Employees	2.56 M
ø Employees per Company	109
Production, total	455.2 bn €

Germany Machinery and Plant Manufacturing total, 2007

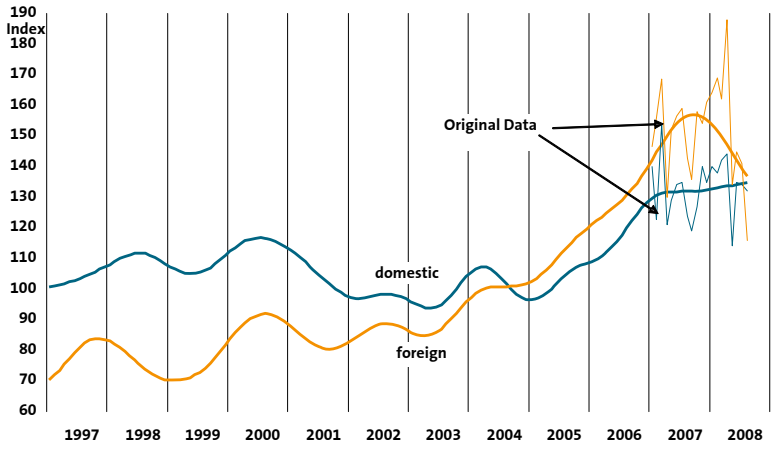
Companies	5,920
Employees	914,000
ø Employees per Company	154
Production, total	179.6 bn €
Export share	75.6 %

Volkswirtschaft und Statistik

Orders Mechanical Engineering Germany
2007: +11%, VDMA Growth Forecast 2008: +5%

Seasonally adjusted and smoothed line, Index Base Turnover 2005=100

Source: VDMA



VDMA – The German Engineering Federation

Our Industry Platform for Machinery and Plant Manufacturing

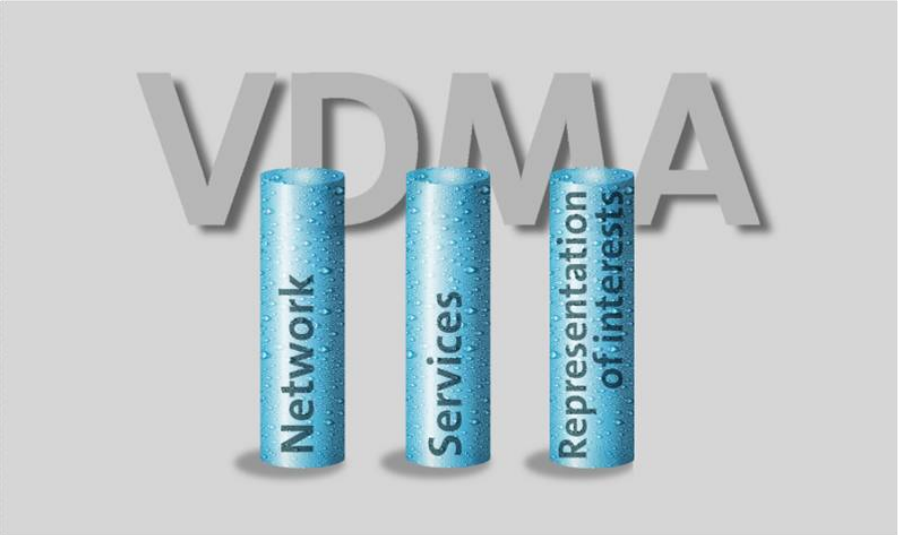
- Servicing since 1892
- More than 3,000 member companies along the value chain from components to entire plants
- 38 sector associations represent the industry
- 450 motivated staff in Germany, Europe and overseas

- 22,000 in honorary appointments
- 1,540 Events per year, 46,000 visitors

Largest Network of our Industry

VDMA – Wir, die Investitionsgüterindustrie

VDMA industry association Fields of action



VDMA – Wir, die Investitionsgüterindustrie

VDMA Organisation Structure and Service Portfolio

- Topics for all equipment makers
  - 9 horizontal departments (tax, foreign trade, legal…)
- Sector-specific topics
  - 38 sector associations
  - 9 cross-sectorial forums
  - 17 working groups
- Contact persons close to you
  - 6 regional offices
- Presence in Europe and overseas
  - German capital office, Berlin
  - European Office Brussels
  - Liaison Offices
    - Tokyo, 3x India, Beijing, Shanghai, Moscow, Gulf region
- 11 service companies (exhibitions, conferences, insurances, publishing house…)
- 17 research societies
- 7 foundations

VDMA – The German Engineering Federation

Diverse Machinery Industry: VDMA sector associations and groups

- Agricultural technology
- Air-handling technology
- Building control and management
- Cleaning systems
- Compressors and vacuum technology
- Construction equipment and building materials machines, glass
- Electrical automation
- Energy
- Engines and Systems
- Equipment for metallurgical plants and rolling mills
- Fire fighting equipment
- Flat Panel Displays
- Fluid power
- Food processing & packaging machinery
- Foundry machinery
- Garment and leather technology
- German Flat Panel Display Forum
- Lifts and escalators
- Lasers and laser systems
- Machine tools & manufacturing systems
- Materials handling & logistic technology
- Micro technology
- Mining equipment
- Municipal Equipment
- Organic Electronics Association
- Plastics and rubbers technology
- Power systems
- Power transmission engineering
- Precision tools
- Printing & paper equipment and supplies
- Process plant and equipment
- **Electronics production equipment (Productronic)**
- Pumps + Systems
- Robotics + Automation
- Surface treatment technology
- Security Systems
- Software
- Testing technology
- Textile machinery
- Thermo process and waste treatment technology
- Valves
- Weighing technology
- Welding
- Woodworking machinery

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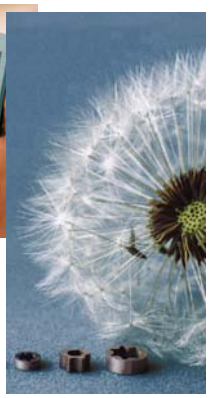
VDMA “Innovative Business”

Productronic

Organic Electronics

Micro technology

Flat Panel Displays



Productronic

Productronics Association
We enable Electronics Production

- Semiconductor components (ICs)
- Flat Panel Displays (FPD)
- Micro systems (MEMS)
- Data storage
  - optical: CD, DVD
  - magnetical: HDD, FDD
- Sensors
- Smart Cards
- Photovoltaics

Front End

Back End

- Printed Circuit Boards (PCB)
- Surface Mount Technology (SMT)
- Packaging
- Hybrids

www.productronics.org

65 Member Companies

Pictures: Maiser, fotolia

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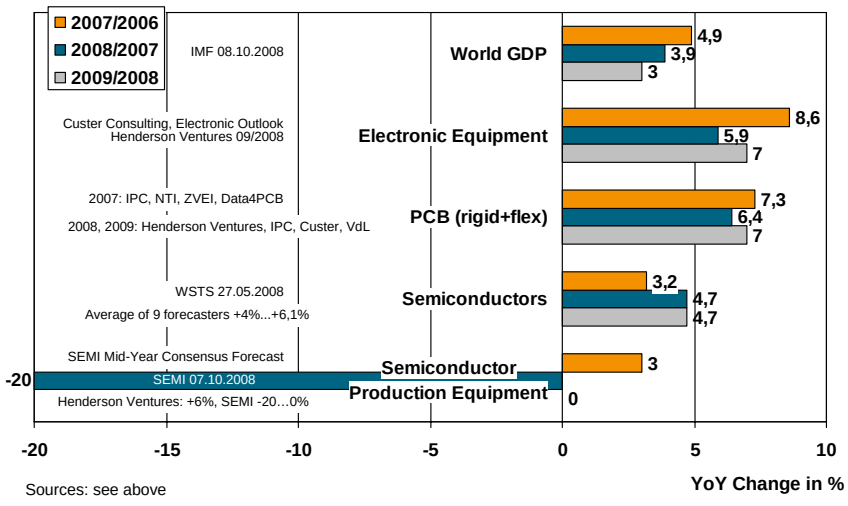
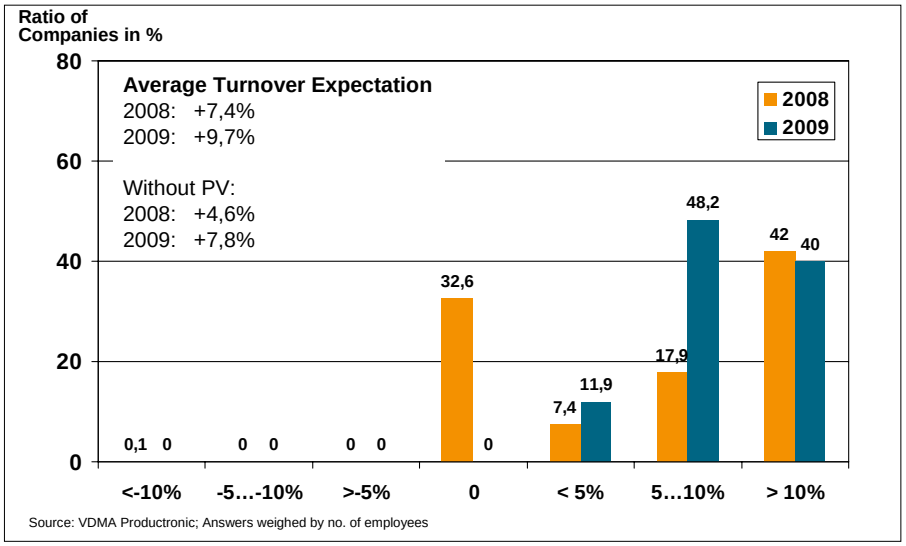
Worldwide Electronics Market Foodchain
2008 reduces growth, uncertainty 2009



Sources: see above

Productronic

VDMA Business Climate Survey May 2008
2008 / 2009 Turnover Productronic Members



Source: VDMA Productronic; Answers weighed by no. of employees

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Technology Roadmapping

Picture: Fox Movies

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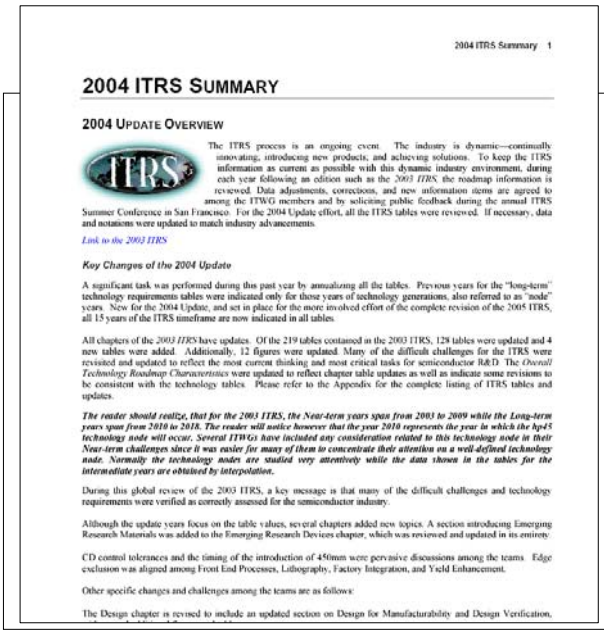

2004 ITRS Summary 1

2004 ITRS SUMMARY

2004 UPDATE OVERVIEW

The ITRS process is an ongoing event. The industry is dynamic—continually innovating, introducing new products, and achieving solutions. To keep the ITRS information as current as possible with this dynamic industry environment, during each year following an edition such as the *2003 ITRS*, the roadmap information is reviewed. Data adjustments, corrections, and new information items are agreed to among the ITWG members and by soliciting public feedback during the annual ITRS Summer Conference in San Francisco. For the 2004 Update effort, all the ITRS tables were reviewed. If necessary, data and notations were updated to match industry advancements.

Link to the 2003 ITRS

Key Changes of the 2004 Update

A significant task was performed during this past year by annualizing all the tables. Previous years for the "long-term" technology requirements tables were indicated only for those years of technology generations, also referred to as "node" years. New for the 2004 Update, and set in place for the more involved effort of the complete revision of the 2005 ITRS, all 15 years of the ITRS timeframe are now indicated in all tables.

All chapters of the *2003 ITRS* have updates. Of the 219 tables contained in the 2003 ITRS, 128 tables were updated and 4 new tables were added. Additionally, 12 figures were updated. Many of the difficult challenges for the ITRS were revisited and updated to reflect the most current thinking and most critical tasks for semiconductor R&D. The *Overall Technology Roadmap Characteristics* were updated to reflect chapter table updates as well as indicate some revisions to be consistent with the technology tables. Please refer to the Appendix for the complete listing of ITRS tables and updates.

The reader should realize, that for the 2003 ITRS, the Near-term years span from 2003 to 2009 while the Long-term years span from 2010 to 2018. The reader will notice however that the year 2010 represents the year in which the hp45 technology node will occur. Several ITWGs have included any consideration related to this technology node in their Near-term challenges since it was easier for many of them to concentrate their attention on a well-defined technology node. Normally the technology nodes are studied very attentively while the data shown in the tables for the intermediate years are obtained by interpolation.

During this global review of the 2003 ITRS, a key message is that many of the difficult challenges and technology requirements were verified as correctly assessed for the semiconductor industry.

Although the update years focus on the table values, several chapters added new topics. A section introducing Emerging Research Materials was added to the Emerging Research Devices chapter, which was reviewed and updated in its entirety.

CD control tolerances and the timing of the introduction of 450mm were pervasive discussions among the teams. Edge exclusion was aligned among Front End Processes, Lithography, Factory Integration, and Yield Enhancement.

Other specific changes and challenges among the teams are as follows:

The Design chapter is revised to include an updated section on Design for Manufacturability and Design Verification.

"The mother of all Roadmaps": The International Technology Roadmap for Semiconductors (ITRS)

http://public.itrs.net

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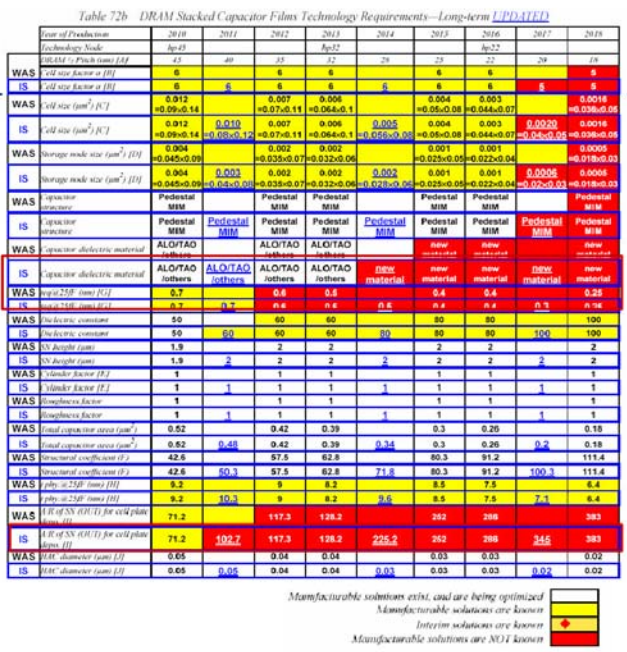

Table 72b DRAM Stacked Capacitor Films Technology Requirements—Long-term UPDATED

	Year of Production	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Technology Node	hp45			hp32			hp22		
	DRAM ½ Pitch (nm) [A]	45	40	35	32	28	25	22	20	18
WAS	Cell size factor α [B]	6		6	6		6	6		6
IS	Cell size factor α [B]	6	6	6	6	6	6	6	6	6
WAS	Cell size (μm^2) [C]	0.012 =0.09x0.14		0.007 =0.07x0.11	0.006 =0.064x0.1		0.004 =0.05x0.08	0.003 =0.044x0.07		0.0018 =0.036x0.05
IS	Cell size (μm^2) [C]	0.012 =0.09x0.14	0.010 =0.08x0.12	0.007 =0.07x0.11	0.006 =0.064x0.1	0.005 =0.056x0.08	0.004 =0.05x0.08	0.003 =0.044x0.07	0.0020 =0.04x0.05	0.0016 =0.036x0.05
WAS	Storage node size (μm^2) [D]	0.004 =0.045x0.09		0.002 =0.035x0.07	0.002 =0.032x0.06		0.001 =0.025x0.05	0.001 =0.022x0.04		0.0005 =0.018x0.03
IS	Storage node size (μm^2) [D]	0.004 =0.045x0.09	0.003 =0.04x0.08	0.002 =0.035x0.07	0.002 =0.032x0.06	0.002 =0.028x0.05	0.001 =0.025x0.05	0.001 =0.022x0.04	0.0006 =0.02x0.03	0.0005 =0.018x0.03
WAS	Capacitor structure	Pedestal MIM		Pedestal MIM	Pedestal MIM		Pedestal MIM	Pedestal MIM		Pedestal MIM
IS	Capacitor structure	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM
WAS	Capacitor dielectric material	ALO/TAO /others		ALO/TAO /others	ALO/TAO /others		new material	new material		new material
IS	Capacitor dielectric material	ALO/TAO /others	ALO/TAO /others	ALO/TAO /others	ALO/TAO /others	new material	new material	new material	new material	new material
WAS	α_{eq} 25Ø (nm) [G]	0.7		0.6	0.6		0.4	0.4		0.35
IS	α_{eq} 25Ø (nm) [G]	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.35
WAS	Dielectric constant	50		60	60		80	80		100
IS	Dielectric constant	50	60	60	60	80	80	80	100	100
WAS	SN height (nm)	1.9		2	2		2	2		2
IS	SN height (nm)	1.9	2	2	2	2	2	2	2	2
WAS	Cylinder factor [E]	1		1	1		1	1		1
IS	Cylinder factor [E]	1	1	1	1	1	1	1	1	1
WAS	Roughness factor	1		1	1		1	1		1
IS	Roughness factor	1	1	1	1	1	1	1	1	1
WAS	Total capacitor area (μm^2)	0.52		0.42	0.39		0.3	0.26		0.18
IS	Total capacitor area (μm^2)	0.52	0.48	0.42	0.39	0.34	0.3	0.26	0.2	0.18
WAS	Structural coefficient (F)	42.6		57.5	62.8		80.3	91.2		111.4
IS	Structural coefficient (F)	42.6	50.3	57.5	62.8	71.8	80.3	91.2	100.3	111.4
WAS	ρ dry-α 25Ø (nm) [H]	9.2		9	8.2		8.5	7.5		6.4
IS	ρ dry-α 25Ø (nm) [H]	9.2	10.3	9	8.2	9.6	8.5	7.5	7.1	6.4
WAS	AR of SN (OUT) for cell plate (nm) [I]	71.2		117.3	128.2		252	286		383
IS	AR of SN (OUT) for cell plate (nm) [I]	71.2	102.7	117.3	128.2	225.2	252	286	345	383
WAS	BAC diameter (um) [J]	0.05		0.04	0.04		0.03	0.03		0.02
IS	BAC diameter (um) [J]	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02

Manufacturable solutions exist, and are being optimized
Manufacturable solutions are known
Interim solutions are known
Manufacturable solutions are NOT known

"The mother of all Roadmaps": The International Technology Roadmap for Semiconductors (ITRS)

introducing

"red brick walls" (technology breakthroughs)

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Roadmapping Methodology

- Semiconductors:
  Sandia Labs Technology Roadmapping Process paper

  "Technology roadmapping is driven by *needs*,
  not by solutions"

- for further reading:
  - Garcia, Marie L., 1997, "Introduction to Technology Roadmapping: The Semiconductor Industry Association's Technology Roadmapping Process", SAND97-0666. Sandia National Laboratories, Albuquerque, NM.
  - R. N. Kostoff, R. R. Schaller, "Science and Technology Roadmaps"
    IEEE Transactions on Engineering Management, Vol. 48, No. 2 (2001), pp. 132
  - Gerrit Muller: "Roadmapping", 2003

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Selection of European Platforms with VDMA Participation

- ADRIA (Flat Panel Displays)
  Vision paper, May 2005
  Roadmap, 250 pages, March 2007
  www.adria-network.org
- **MINAM (Micro-/Nano-Manufacturing)**
  SRA, 190 pages, January 2008
  www.micronanomanufacturing.org
- Manufuture (Production Technology)
  www.manufuture.org
- **Organic Electronics**
  (printed / flexible electronics)
  2nd Edition, July 2008
  www.vdma.org/oe-a ➔ downloads
  3rd Edition, June 2009
  Conference LOPE-C
- Photonics
  www.photonics21.org

The German Engineering Federation

Manufacturing Equipment Industry Worldwide Production

Source: VDMA

	Value 2005 Billion €	Share %
Europe	470	40,4
Asia	385	33,1
America	295	25,3
Australia	7	0,7
Africa	5	0,5

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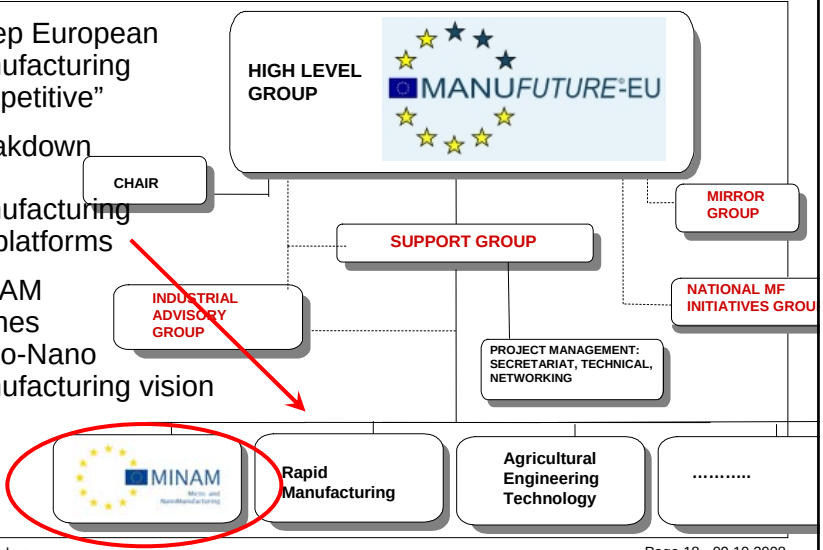
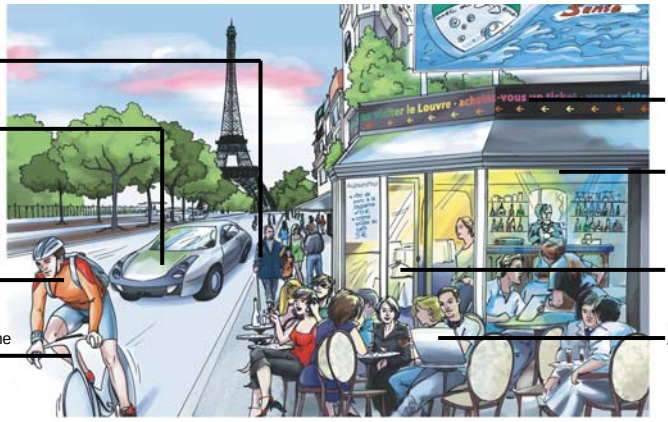
European Technology Platform for Manufacturing: *Manufuture*

- "Keep European Manufacturing competitive"
- Breakdown into manufacturing subplatforms
- MINAM defines Micro-Nano Manufacturing vision



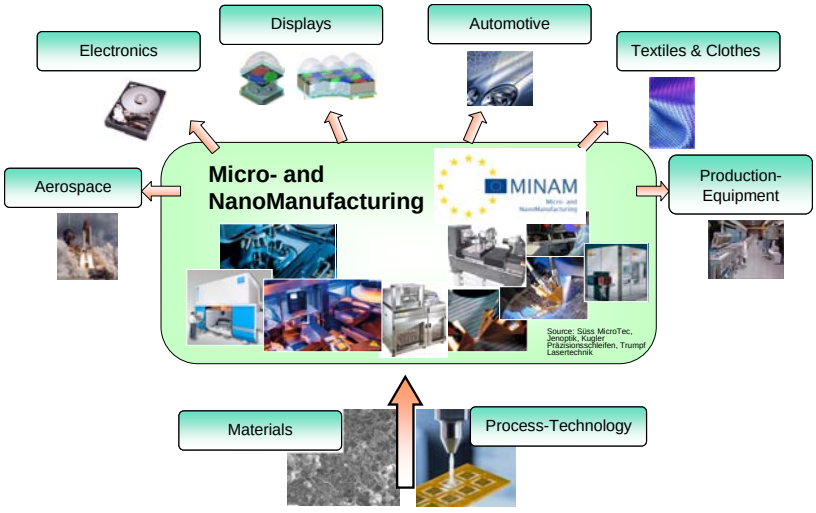
Hot topics I: Micro- NanoManufacturing
“Enabling affordable future products”



- How to coordinate research?
- How to get from lab to fab?
- How to maintain European leadership?

Source: Siemens AG, FhG-IPA

MINAM
Manufacturing as enabling factor



MINAM
Towards a common vision

- Roadmapping: defining needs and creating a vision
- Comparing needs with technology evaluation reveals roadblocks
- Targeted Research removes roadblocks

today

Vision

The European community of Micro- and NanoManufacturing aims at the **worldwide leadership of European manufacturers and equipment-suppliers** in the field of manufacturing micro- and nano-technological products –
It will be **the European network** in these fields.

➔ Roadmapping is the essential tool to define a *Strategic Research Agenda*

➔ MINAM Roadmap published 01.2008

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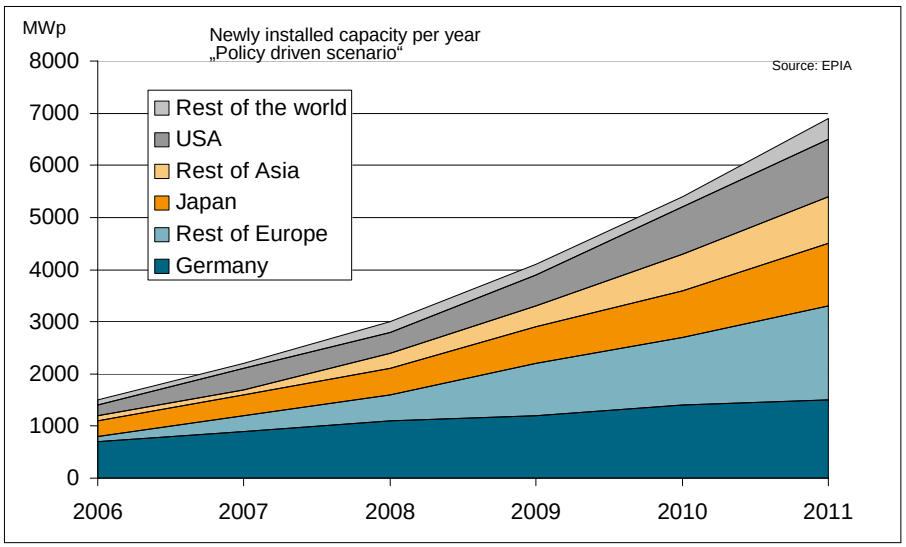
Hot Topics II: Photovoltaics
Giant Potential for Equipment Manufacturers



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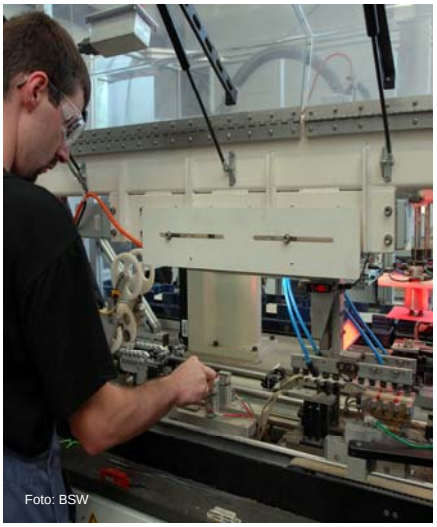
Photovoltaic Equipment Europe in Excellent Position



- European machinery and plant manufacturers are forerunners
- More than 80 companies in Germany
- Excellent growth potential
  - significant domestic market
  - but also massive increase in export to Europe (Spain, Italy), and the USA
- VDMA Forum Photovoltaic Equipment
  - Cross-sectoral organisation with 9 VDMA associations involved

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European Technology Platform Photovoltaics

- European Technology Platform for Photovoltaics Strategic Research Agenda (SRA) www.eupvplatform.org
  - Working Group 3
  - Published September 2007

PhotoVoltaic TECHNOLOGY PLATFORM

VDMA – Organic Electronics Association

Hot Topics III: Organic / Printed Electronics
Vision: „Electronics Everywhere“

Organic Electronics Applications

- thin, lightweight, flexible
- low-cost, large-area, printing processes
- First products step into the markets now:
  - RFID tags, memory, sensors
  - Games
  - Rollable displays
  - Organic photovoltaics, batteries

Organic Electronics Association

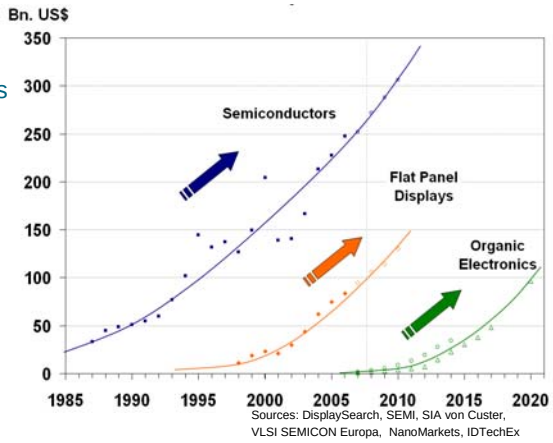
- A working group within VDMA
- International key industry association for organic & printed electronics
- more than 100 members along the value chain from Europe, North America, Asia
- **www.oe-a.org**

Pictures: pmTUC, PolyIC

VDMA – Organic Electronics Association

Organic Electronics
A Future Multi-Billion $ Market

- Organic electronics enables new applications and opens up new markets
- Market for Organic and Printed Electronics is expected to grow to 300 Bn US $ by 2027, driven by logic, memory, displays and lighting
- Market will take similar path as Semiconductors and FPDs in the past
  ➔ Experience factor of these industries



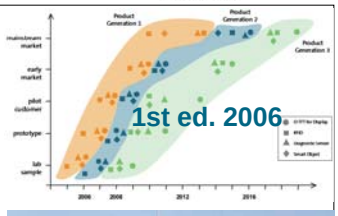
Sources: DisplaySearch, SEMI, SIA von Custer, VLSI SEMICON Europa, NanoMarkets, IDTechEx

- But will also profit from strong printing industry in Europe
  ➔ Results in very good chances for a new European industry!

VDMA – Organic Electronics Association

Second Edition OE-A Roadmap for Organic Electronics

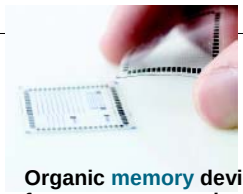
- **Supplement and improvement of the first version presented in 2006**
- **Represents common view of OE-A members**
- **Future applications and product generations**
- **Key application parameters**
- **Key technology parameters**
- **Red brick walls**



VDMA – Organic Electronics Association

Applications: Evaluation of Seven Topics

Organic **photovoltaic cells** for mobile + stationary use



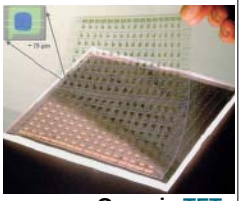
Organic **memory** devices for consumer goods

Smart objects as combination of different devices

Organic **sensors** for single use devices

Printed **RFID** for brand protection and logistics

Flexible **batteries** to power mobile devices



Organic **TFT backplanes** for displays

Source: Konarka, TFE, Poly IC, MRS

VDMA – Organic Electronics Association

Key Challenges / Red Brick Walls

oe-a Organic Electronics Association

Red Brick Walls:

Major breakthroughs are absolutely necessary:

- **Resolution, registration and process stability of the patterning processes**
  - **resolution of 10 µm and smaller with appropriate registration accuracy is necessary @ mass production**
- **Charge carrier mobility and electrical conductivity of the semiconductor and conducting materials**
  - **mobility > 1 cm²/Vs for solution processable semiconductors @ mass production**
  - **5 – 10 cm²/Vs would largely push the topic enabling more complex devices**
- **Circuit design including CMOS-like transistors**
- **New strategies for quality control**

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VDMA

Table 72b DRAM Stacked Capacitor Films Technology Requirements—Long-term UPDATED

	Year of Production	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Technology Node	hp45			hp32			hp22		
	DRAM ½ Pitch (nm) [A]	45	40	35	32	28	25	22	20	18
WAS	Cell size factor a [B]	6		6	6		6	6		6
IS	Cell size factor a [B]	6	6	6	6	6	6	6	6	6
WAS	Cell size (μm^2) [C]	0.012 =0.09x0.14		0.007 =0.07x0.11	0.006 =0.064x0.1		0.004 =0.05x0.08	0.003 =0.044x0.07		0.0018 =0.036x0.05
IS	Cell size (μm^2) [C]	0.012 =0.09x0.14	0.010 =0.08x0.12	0.007 =0.07x0.11	0.006 =0.064x0.1	0.005 =0.056x0.08	0.004 =0.05x0.08	0.003 =0.044x0.07	0.0020 =0.04x0.05	0.0018 =0.036x0.05
WAS	Storage node size (μm^2) [D]	0.004 =0.045x0.09		0.002 =0.035x0.07	0.002 =0.032x0.06		0.001 =0.025x0.05	0.001 =0.022x0.04		0.0005 =0.018x0.03
IS	Storage node size (μm^2) [D]	0.004 =0.045x0.09	0.003 =0.04x0.08	0.002 =0.035x0.07	0.002 =0.032x0.06	0.002 =0.028x0.05	0.001 =0.025x0.05	0.001 =0.022x0.04	0.0006 =0.02x0.03	0.0005 =0.018x0.03
WAS	Capacitor structure	Pedestal MIM		Pedestal MIM	Pedestal MIM		Pedestal MIM	Pedestal MIM		Pedestal MIM
IS	Capacitor structure	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM	Pedestal MIM
WAS	Capacitor dielectric material	ALO/TAO /others		ALO/TAO /others	ALO/TAO /others		new material	new material		new material
IS	Capacitor dielectric material	ALO/TAO /others	ALO/TAO /others	ALO/TAO /others	ALO/TAO /others	new material	new material	new material	new material	new material
WAS	leg c25fF (nm) [G]	0.7		0.6	0.6		0.4	0.4		0.35
IS	leg c25fF (nm) [G]	0.7	0.7	0.6	0.6	0.6	0.4	0.4	0.3	0.35
WAS	Dielectric constant	50		60	60		80	80		100
IS	Dielectric constant	50	60	60	60	80	80	80	100	100
WAS	SN height (um)	1.9		2	2		2	2		2
IS	SN height (um)	1.9	2	2	2	2	2	2	2	2
WAS	Cylinder factor [E]	1		1	1		1	1		1
IS	Cylinder factor [E]	1	1	1	1	1	1	1	1	1
WAS	Roughness factor	1		1	1		1	1		1
IS	Roughness factor	1	1	1	1	1	1	1	1	1
WAS	Total capacitor area (μm^2)	0.52		0.42	0.39		0.3	0.26		0.18
IS	Total capacitor area (μm^2)	0.52	0.48	0.42	0.39	0.34	0.3	0.26	0.2	0.18
WAS	Structural coefficient (F)	42.6		57.5	62.8		80.3	91.2		111.4
IS	Structural coefficient (F)	42.6	50.3	57.5	62.8	71.8	80.3	91.2	100.3	111.4
WAS	q-ply -@25fF (nm) [H]	9.2		9	8.2		8.5	7.5		6.4
IS	q-ply -@25fF (nm) [H]	9.2	10.3	9	8.2	9.6	8.5	7.5	7.1	6.4
WAS	AR of SN (OUT) for cell plate (nm) [I]	71.2		117.3	128.2		262	286		383
IS	AR of SN (OUT) for cell plate (nm) [I]	71.2	102.7	117.3	128.2	225.2	262	286	345	383
WAS	BOC diameter (um) [J]	0.05		0.04	0.04		0.03	0.03		0.02
IS	BOC diameter (um) [J]	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02

Manufacturable solutions exist, and are being optimized
Manufacturable solutions are known
Interim solutions are known
Manufacturable solutions are NOT known

ITRS:

Breakdown into Materials and Manufacturing Equipment!

Usually not in a lot of other technology roadmaps feature Equipment specs

➔ Roadmap coaching for Equipment makers needed!

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VDMA Productronic Working Group "Technology Scouting"

Focus: Breakdown of Electronics Roadmaps for needs of Manufacturing Equipment Industry

- Identification and priorisation of topics with relevance for Equipment makers
- Which aspects are missing from manufacturing equipment viewpoint
- What do the roadmaps imply for process technology, which requirements for materials and equipment
- Unsolved challenges

➔ Matrix structure along process chain

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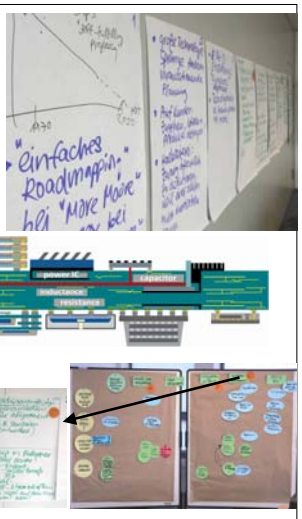
Working Group „Technology Scouting" Roadmap-Coaching

- Electronics roadmaps interpreted for equipment makers
- Focus on SiP, Hetero integration
- Coached by Fraunhofer IZM
- Metaplan discussion results, e.g.
  - Wafer-Level-Integration (Thinned Chips, Large-Area-Placement, 3D)
  - Integration into PCB (Chip-in-Polymer, Self-organising production – SOPRO new design needs)
  - Packaging technologies (Organic Electronics, changes in value chain, Tolerance chains for Chip-alignment)
  - Design for Manufacturability / Design for Testability
  - Develop machine interfaces together with customers, standards

Fraunhofer IZM Institut Zuverlässigkeit und Mikrointegration



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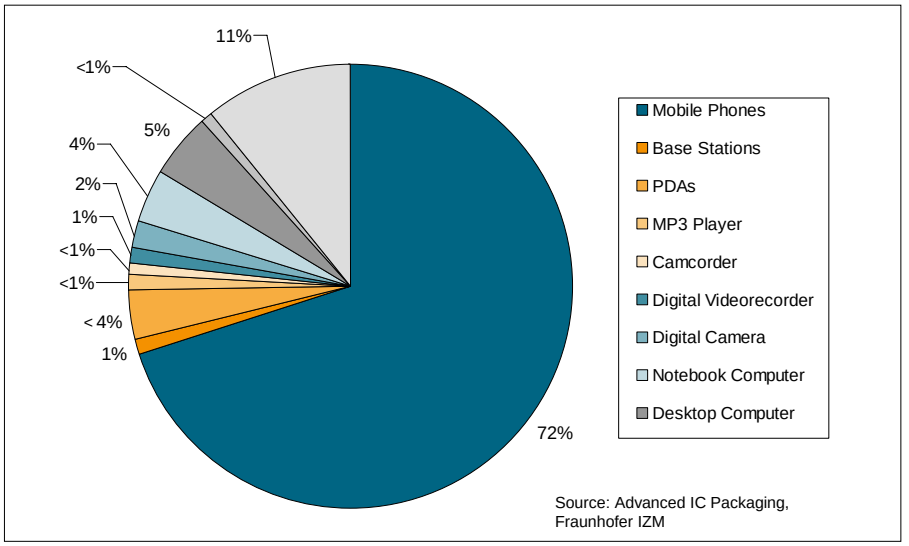
System in Package drives Consumer Electronics



Source: Advanced IC Packaging, Fraunhofer IZM

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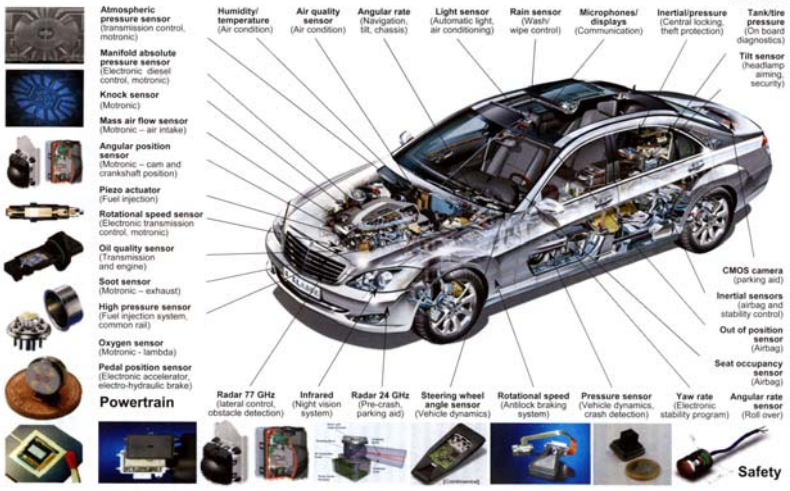
Automotive needs System Integration

Source: mst News 03-2007 (Daimler, Fraunhofer IZM)



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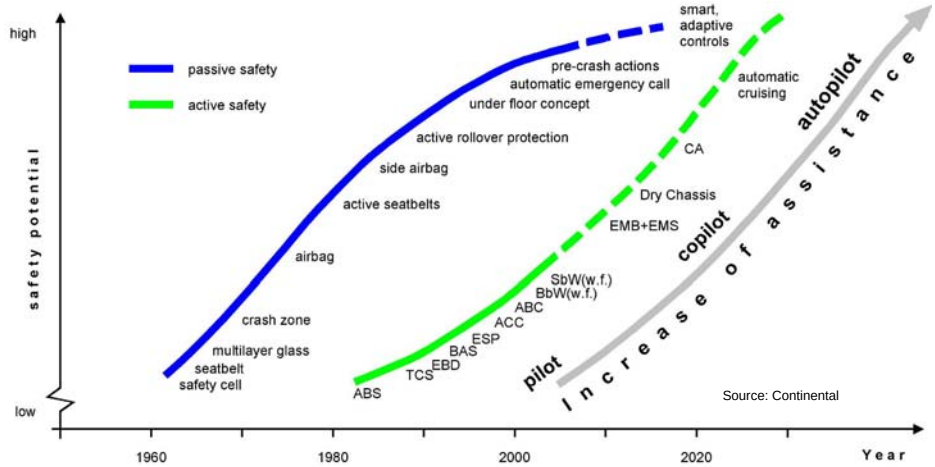
Automotive megatrends: Safety and Increase of Assistance



ABS	Anti-lock Brake System	BAS	Brake Assist System	ABC	Active Body Control
TCS	Traction Control System	ACC	Adaptive Cruise Control	EMB, EMS	Electromech. Brake, Steering
EBD	Electronic Brakeforce Distribution	BbW/SbW	Brake-by-Wire/Steer-by-Wire	DbW	Drive-by-Wire
ESP	Electronic Stability Program	(w.f.)	(with mechanical fallback)	CA	Collision Avoidance

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Conclusions

- **Manufacturing equipment Industry is enabler of mass production and pillar of European economy**
- **Equipment makers are SMEs in average**
- **Equipment makers are used to make business outside Europe (Export ratio ~80% in Germany)…**
- **… especially in electronics**
  - Asian manufacturing: Semi: 66%, PCB: 83%, Flat Panel Displays: 98%
- **With overseas operations Equipment makers secure home base (job creation etc!)**

But

- **Equipment makers need R&D support (roadmap coaching, roadmap participation important)**
- **Equipment makers need feedback from manufacturers**
- **Domestic manufacturing creates factor 3-7 jobs in supply chain**
- **If manufacturing moves away, innovation environment (equipment + R&D) moves away, too!**

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