Micro & Nano Systems
-
Market entry, business practice and supply chains

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Dec-07

Part 1:

Market Data from the NEXUS Report

Patric Salomon
(4M2C/enablingMNT)

Dec-07

«Design for Micro & Nano Manufacture (NoE PATENT-DfMM)»
Network of Excellence funded by the European Commission (EC FP6: IST, Unit C2, Contract 507255)

NEXUS Microsystems Association

- 1993: Launched as a European Network
- 1996: Move towards being driven by industry
- 2001: Launch of NEXUS association
- 2003: Termination of general funding through the EC
- 2004: NEXUSplus project to coordinate between EC MNT projects and help SMEs and Eastern Organisations
- 2005/2006: 3rd Market Analysis published
- 2005: New Steering Committee and Chairman
- 2006: Move of NEXUS office to Neuchatel
- 2006/2007: New strategies:
  - Re-activate Methodology Working Groups
  - Be a focal point for national, regional MNT networks
  - EC FP7 Workshops

NEXUS Email newsletter is free of charge – please contact me!

Spirit of Nexus Market Analysis III

Independent

- Not done by one consulting company but by a panel of experts
- Input from the User Supplier Clubs (USC), Methodology Working Groups (MWG), ATIP

Affordable

- €1100 for Nexus III against $2000–$5000 for other MEMS/MEMS market reports
- Historically an EC sponsored initiative: aiming at wide dissemination!
- 3rd Analysis is not funded by EC!

Strategic

- Overview and details of applications, products and markets
- Trends, market drivers and global figures

Nexus is and remains a 1st level source of MST market figures worldwide

The third NEXUS market report 2006

- 7 new products
  - MEMS microphones
  - MEMS memories
  - Wafer probes
  - Microreaction products
  - Micro energy sources
  - Micro pumps
  - Liquid lenses
- 2 new application fields
  - Consumer electronics
  - Industrial process control
- Regional analysis
  - North America / Europe / Asia / ROW
- Detailed subcategories of application fields

Sample table (accelerometers)

Average selling price, units and turnover for 2004 and 2009

Break-out by application field and by application

	2004 ASP [$]	2004 Units [million]	2004 Turnover [$ million]	2009 ASP [$]	2009 Units [million]	2009 Turnover [$ million]
Consumer and Lifestyle Products						
Mobile phone (2/3 axis sensors)	2.60	0.45	1.17	1.35	89.35	120.62
MP3 player (2/3 axis sensors)	2.60	11.20	29.12	1.65	24.65	40.67
Camcorder. games. joysticks. toys. sports. robotic toys. projectors. tilt compass (2/3 axis sensors)	3.20	1.22	3.90	1.65	9.00	14.85
IT peripherals						
Notebook. Tablet PC (2/3 axis)	3.90	4.00	15.60	1.35	26.60	35.91
Vibration in R/W heads (2 axis)	2.60	0.10	0.26	0.00	0.00	0.00
Automotive						
Airbag (mostly 1 axis sensor)	1.75	120.00	210.00	1.50	155.00	232.50
Vehicle Dynamics (ESP) (majority 1 axis sensors)	5.00	11.20	56.00	3.50	19.10	66.85
Tire pressure monitoring sensor	2.50	9.60	24.00	0.00	0.00	0.00
Roll detection (1 axis sensor). GPS navigation (2/3 axis sensor)	5.00	6.50	32.50	3.50	10.50	36.75
Active suspension (1 axis sensor)	15.00	0.10	1.50	15.00	0.15	2.25
Industrial & Process Control						
Robots (industrial. service). machine vibration monitoring (2/3 axis)	100.00	0.01	1.00	90.00	0.02	1.80
Aerospace. Defense and Homeland Security						
Munitions. missile guidance (3 sensors per module)	300.00	0.02	5.00	220.00	0.08	17.60
Navigation units for services (fireman. soldier with 2 sensors per unit. vehicle)	100.00	0.003	0.29	80.00	0.02	1.60
Laser range finder (2 sensors per unit for inclination determination)	200.00	0.010	2.00	200.00	0.02	4.00
Civil/business aviation AHRS. UAV (3 sensors/module)	300.00	0.020	6.00	300.00	0.06	18.00
Medical and Life Sciences						
Pacemaker. hospital beds	30.00	0.30	9.00	30.00	0.40	12.00
Household						
Washing machine (load unbalance)	2.00	0.50	1.00	1.50	1.50	2.25
Household robots				2.00	2.00	4.00
Chemical and Energy						
Geophones (3 sensors per module). measurement-while-drilling	282.00	0.03	8.46	180.00	0.10	18.00
Total		165.26	406.80		336.55	625.66

1st level packaged MEMS, smallest commercialised unit *Example of inkjet*

You can not buy inkjet heads alone *therefore*

From the point of view of the market (products sold and bought), the smallest commercialised unit is the cartridge or printer *but*

The MEMS/MST in the cartridge/printer is worth much less than the total value of the cartridge/printer *so*

The third NEXUS study focuses on the value of the first packaged MEMS/MST to calculate the value in the inkjet market

Inkjet head

Ink, hull, assembly

~$1.7	~$22.5
Value of 1st level packaged MEMS	Value of non MEMS parts

Price of smallest unit commercialised

Market breakout for 1st level packaged MEMS / MST

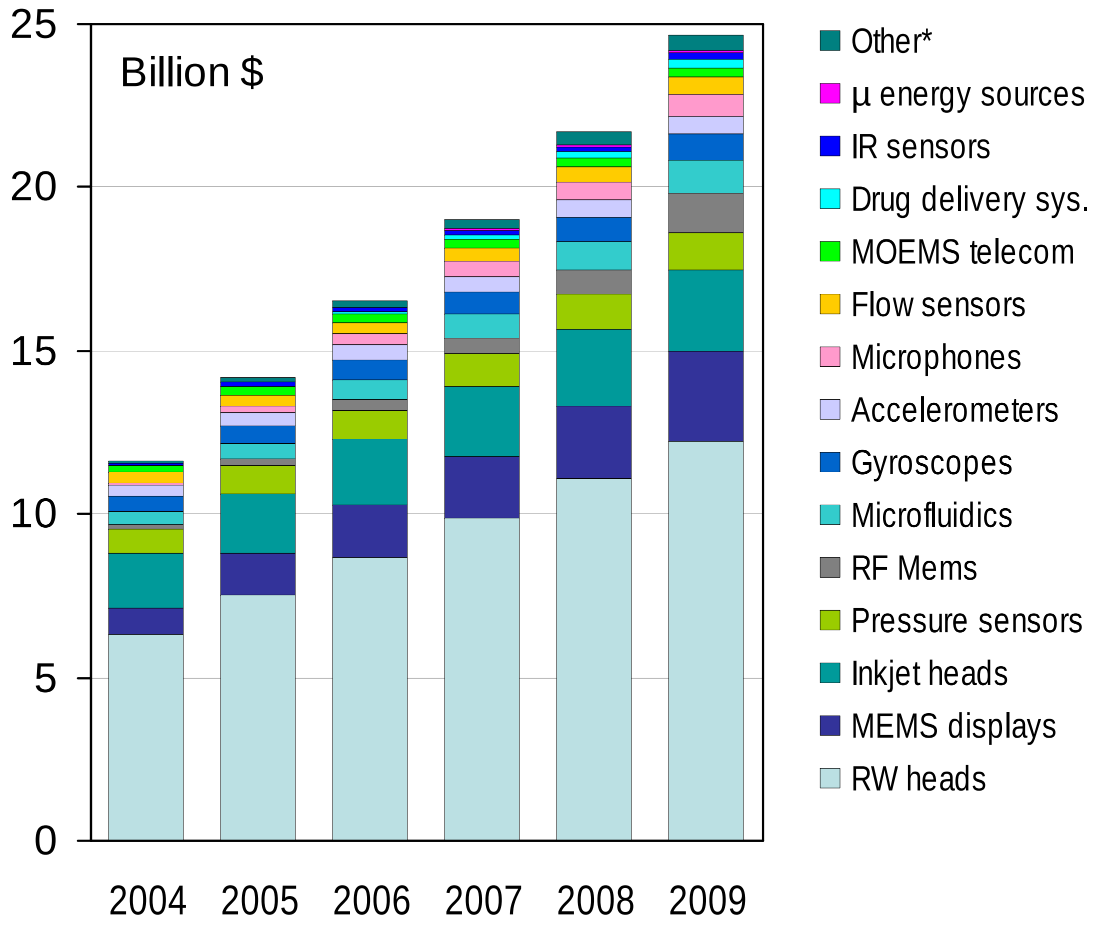
3 products will still make 70% of the market in 2009

- Read-Write (RW) heads
- Inkjet heads
- MEMS displays (will become 2nd largest MST market in 2009)

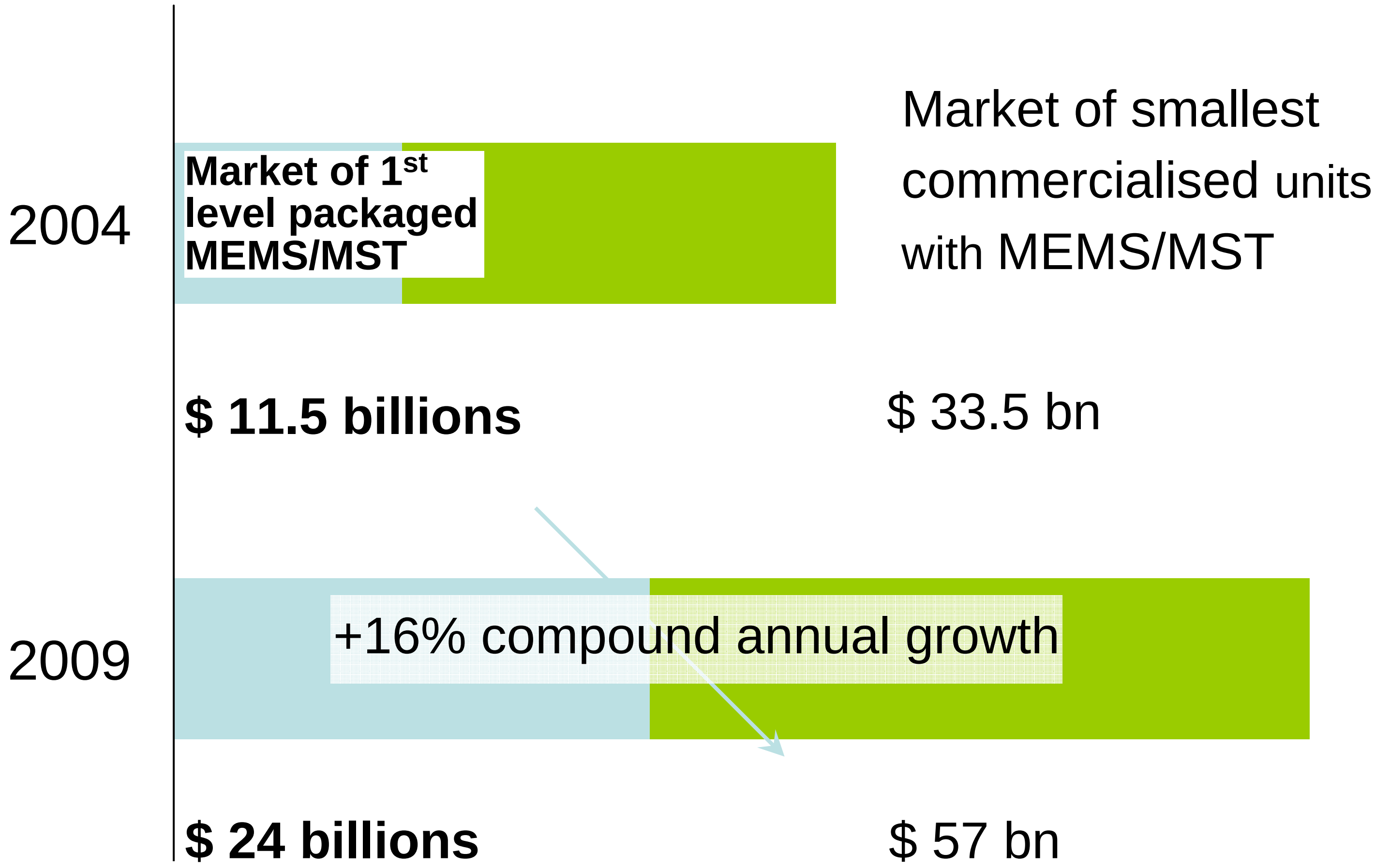
3 other products making each over $1 billion in 2009

- Pressure sensors
- RF MEMS
- Inertial sensors

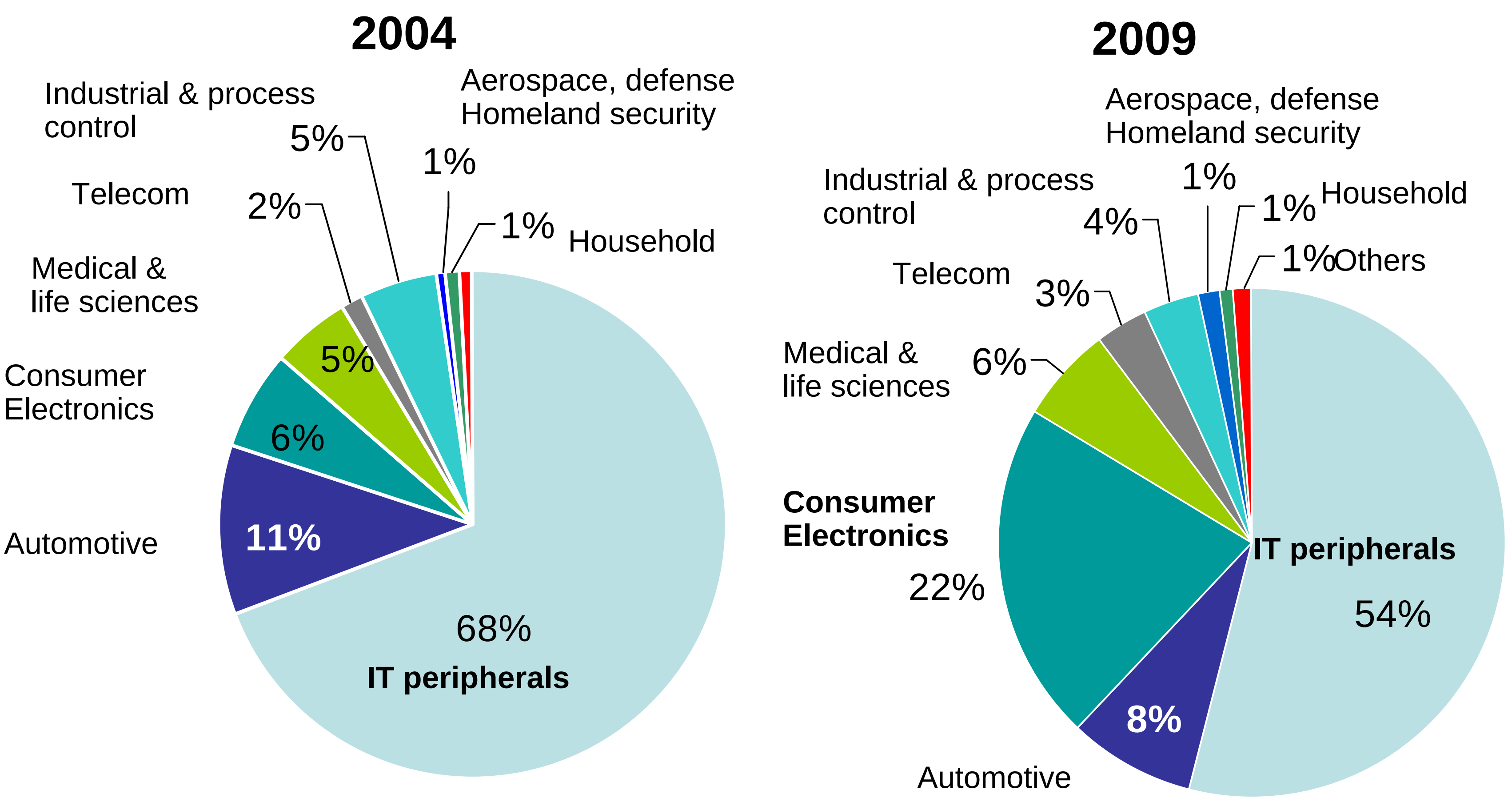
12 emerging or niche products each < $100m in 2009



Total market for MEMS / MST in 2004 and 2009



Application fields in 2004 and 2009



(total $12 billions)

(total $25 billions)

MEMS microphones: possibly $500m in 2009!

2003: first products by Knowles

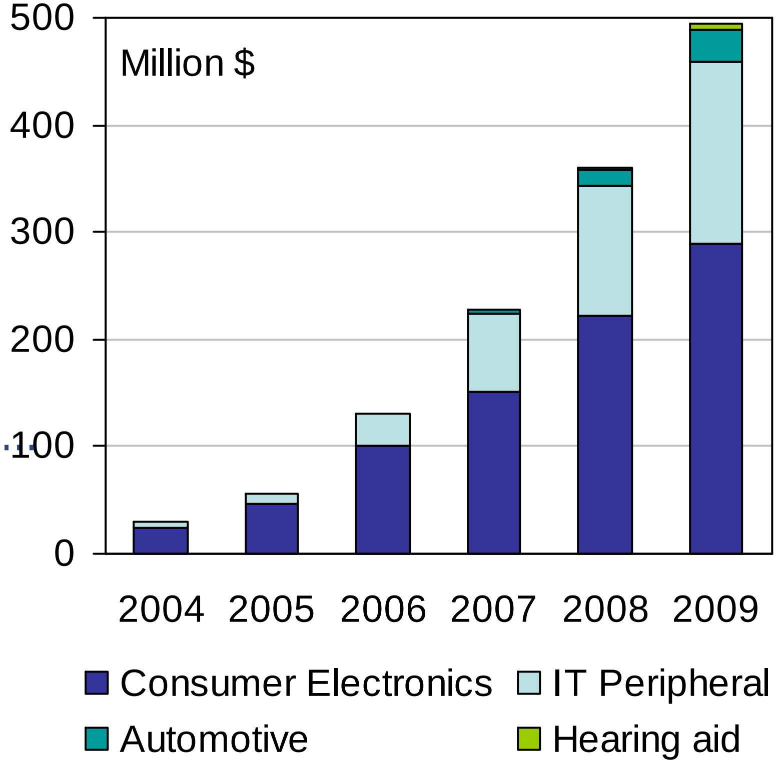
2004: already a $30m market

- 5.5% of cell phones equipped
- ASP from $0.48 for cell phones to $1.25 for cameras, PDA…

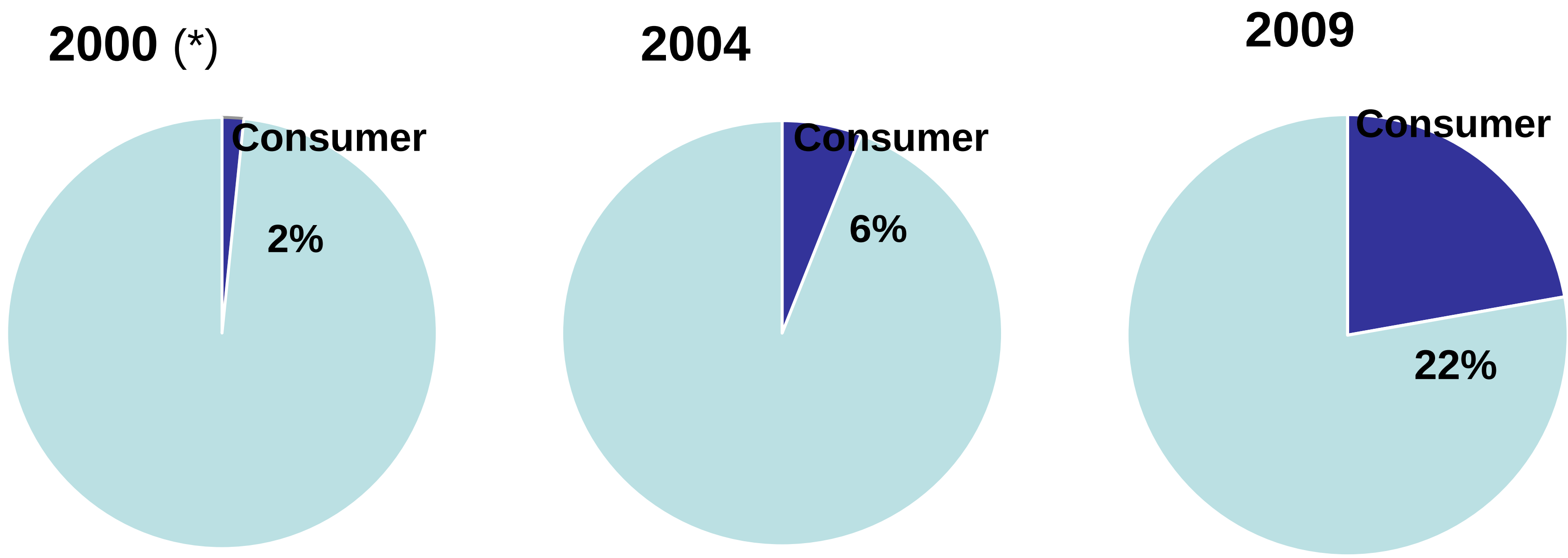
2009: $500m market

- Knowles, Sonion, Memstech, Akustika, Panasonic, BSE, Hosiden, NHK, Philips, Infineon…
- 45% of microphone market
- ASP from $0.32 for cell phones to $10 for directional arrays in automotive

Market for MEMS microphones



CONSUMER ELECTRONICS



(% in market value of 1st level packaged MEMS/MST)

(*): *extrapolated from NEXUS II*

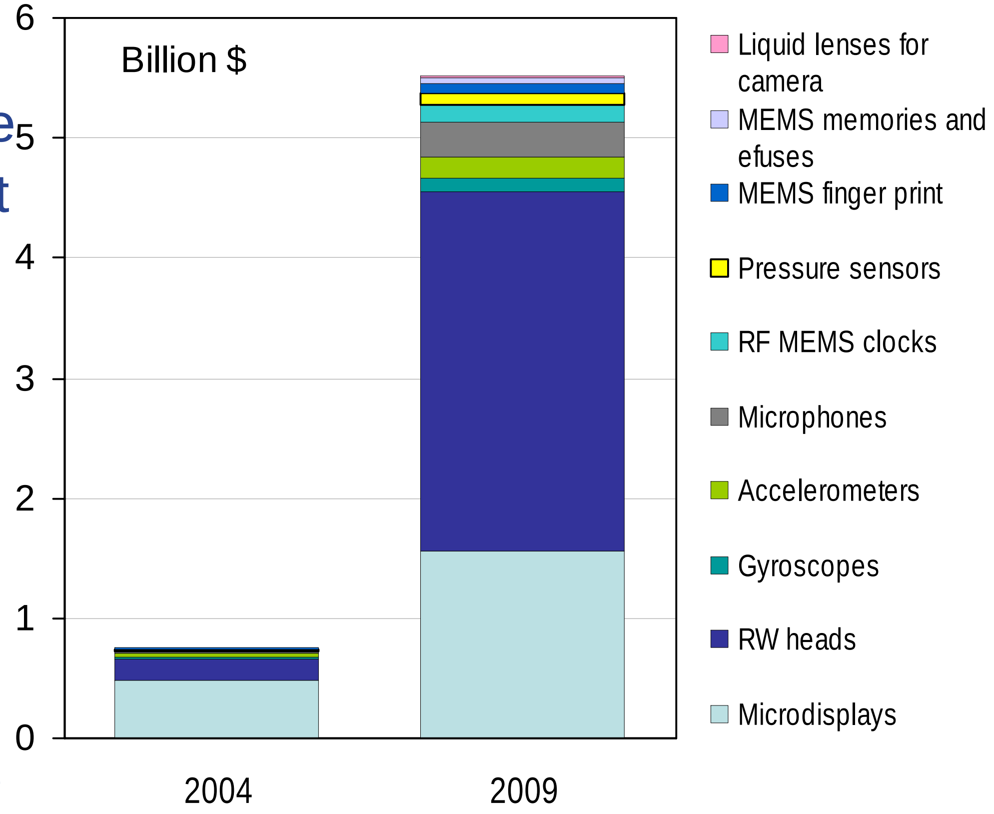
CONSUMER ELECTRONICS

In 2004, Microdisplays for projection TV was market leader

In 2009, RW heads overtake – now 55% of MEMS market for CE

3 new MEMS products will enter the CE market by 2009:

- RF MEMS clocks e.g. for digital TV, gaming, DVDs...
- MEMS memories
- Liquid lenses for cell phone camera



The 3 drivers for MEMS in Consumer Electronics

Large screens: High Definition Television for everybody

- Rear Projection TV and Front projection TV (Home theatre)
- 6,5 M units in 2005 to 11,9 M units in 2009 for projection TV (iSuppli Corp.)

More storage in digital equipment

- HDD enter digital video cameras, music players smart phones, set top players, DVD recorders
- 10,8 M units in 2004 to 201 M units in 2009!

Mobile handset…you can also us it as a phone

- MEMS accelerometer 09/03, NTT Docomo
- Next: gyro, MEMS display, micro fuel cell, MEMS fingerprint, MEMS zoom, gas sensors, weather station, projection display…

MEMS microdisplays: the new blockbuster

2004: TI dominates the market with DLP for RPTV and home theatre

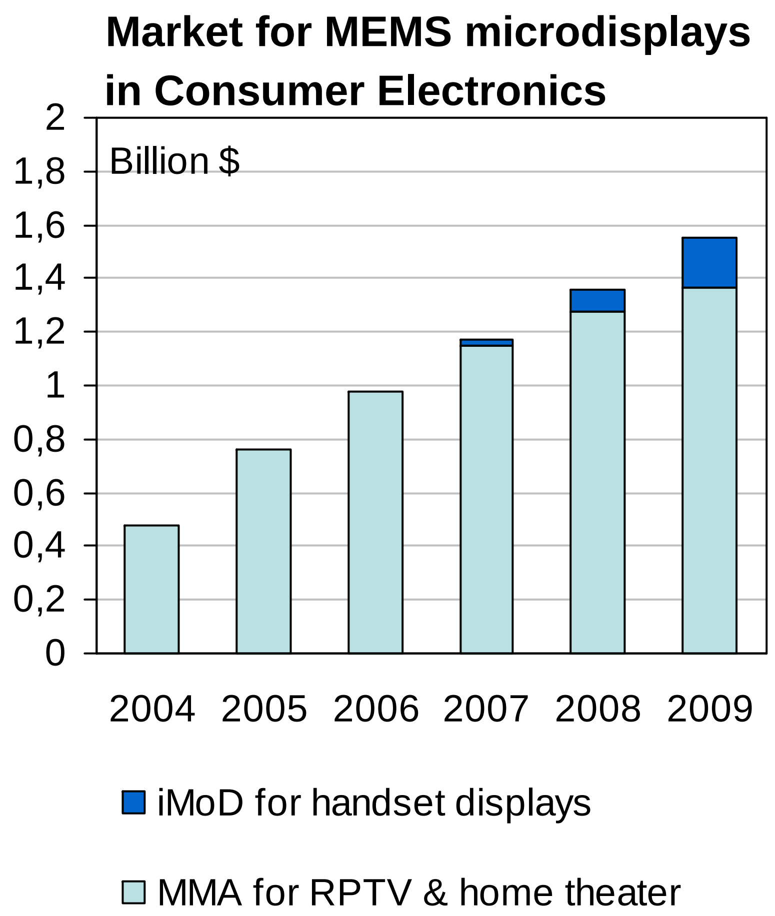
- Head-to-head race with LCD, DLP dominating in large screens over 40´´

MEMS microdisplays for mobile handsets will enter the market in 2006-2007

- iMoD (Interferometric Modulator) display, developed at Qualcomm
- Currently in the technology transfer phase, uses existing LCD manufacturing lines

US$ 1555 M market in 2009

- MMAs: $ 1365 M, ASP US$ 190
- iMoD, $190 M, ASP $3.75



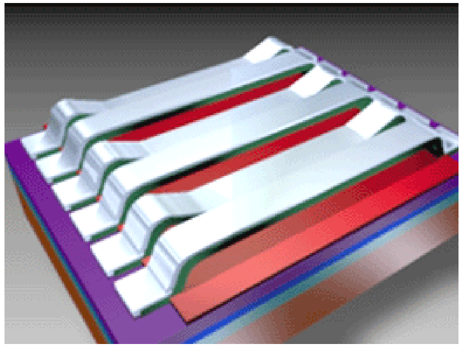
MEMS microdisplays: Opportunities for newcomers ?

DLP-like products for projection TV

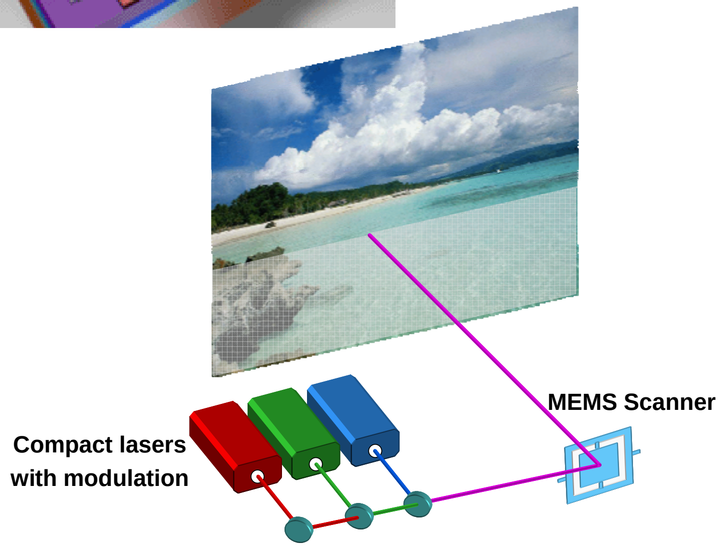
- R&D at **Miradia**, **Reflectivity** and **Keyotee.** Production "Early 2006".
- "Price advantage" / DLP
- Chance against giant TI?

New MEMS concepts with laser projection

- **Sony**: Grating Light Valves. 50 m wide HD screen at EXPO 2005 Aichi
- **Samsung**: Scanned beam display for Home theater and eventually projection displays in mobile handsets. Similar developments at **Fraunhofer IPMS** and **ISIT**.
- **Success depends on availability of inexpensive and powerful laser diodes.** Follow development at Osram and Novalux. Laser illumination system < $75 targeted.



Grating Light Valves
Courtesy of Silicon Light Machines



Scanning mirror based TV
Courtesy of Samsung

MEMS market for mobile handsets in 2009: $541M (Without RF MEMS)

MEMS microphones: $ 164 M
- ASP: $ 0,32
- Suppliers: Knowles, Sonion, Memstech, Akustika, Panasonic, BSE, Hosiden, NHK, Philips...

MEMS displays: $ 190 M
- ASP: $ 3,75
- Suppliers: Qualcomm

Micro fuel cells: $ 52 M
- ASP: $ 15
- Suppliers:, Motorola, MSI, STmicroelectronics, Moducell, MTI, Samsung, Tekion, Angstrom, Medis

RW heads: $ 75 M
- ASP: $ 6
- Suppliers: HGST, Toshiba, Fujitsu, Cornice, GSMagicStor

2/3 axis accelerometer: $ 120 M
- ASP: $ 1,35
- Suppliers: MEMSIC, ADI, Kionix, Freescale, STM, Bosch...

2 axis gyroscope: $ 44 M
- ASP: $ 4
- Suppliers: Seiko Epson, Nec Tokin, Panasonic, Murata, ST. ADI, Samsung...

Liquid lenses: $ 18 M
- ASP: $ 1,4
- Suppliers: Philips, Varioptic

IR sensor: $ 1 M
- ASP: $ 0,8
- Suppliers: HLP, Heimann, PE...

Need strategy to beat low margins

How to earn money on a $0,32 microphone or $1,35 tri-axis accelerometer?

- **Monolithic CMOS integration**: e.g. Akustika for microphones or ADI for accelerometers
- **Hermetic 3D monolithic accelerometer die** e.g at VTI. No package, directly connected onto PCB.
- Share cost for **several applications**: e.g. gaming, inertial navigation, HDD free fall, intuitive menu scrolling…

How to cope with the coming US$ 20 cell phone?

- Embedded **NEMS** in CMOS under development at ST
  - Accelerometer, 45 nm, with thin SOI
  - Also envisioned for gyro, RF resonator, micro energy source…

DLP chips: the exception of high volume and high price

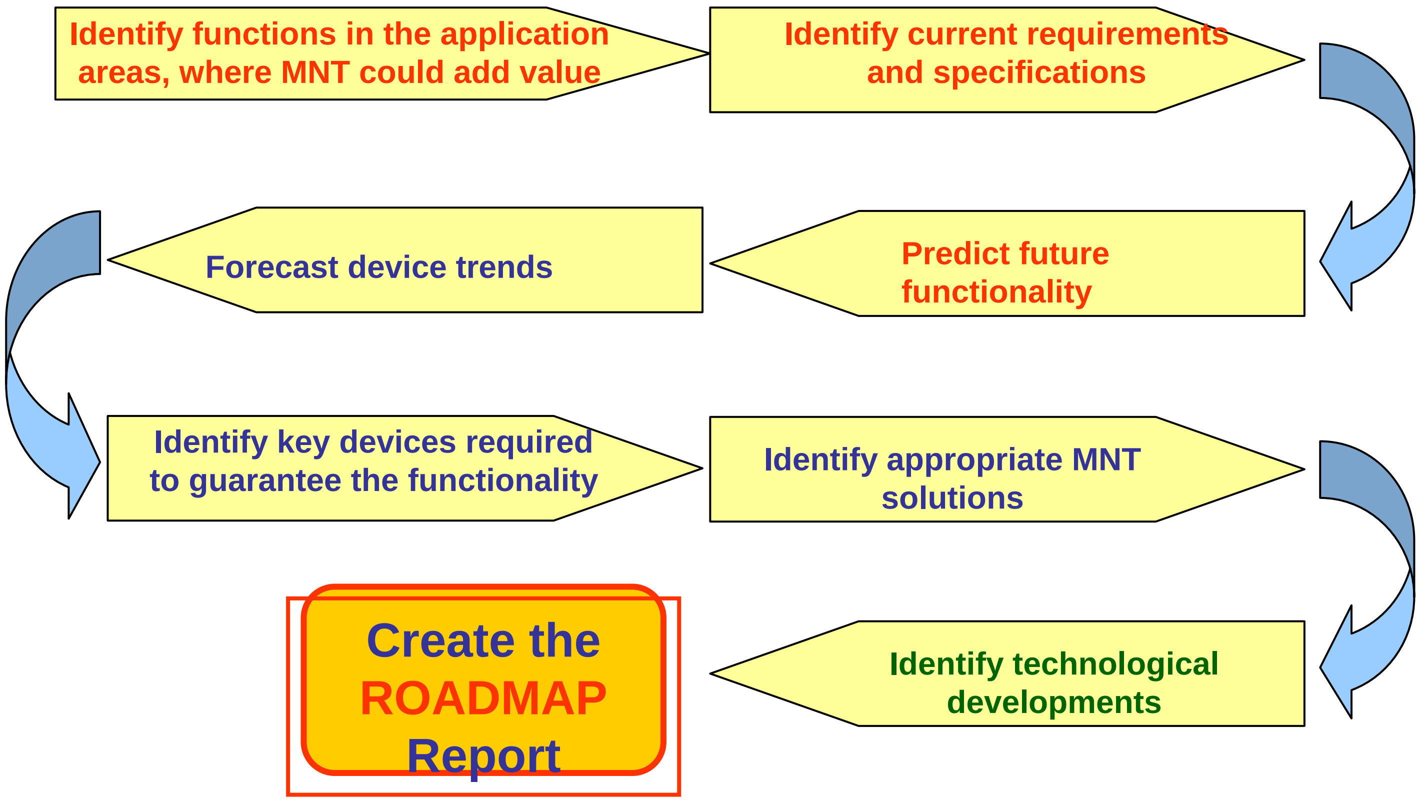
- ASP US$ 400 in 2004, estimated US$ 190 in 2009
- Sub $1000 Rear Projection TV (RPTV) expected mid-2006
- Plan for 40% reduction of BOM at TI. Simplified MEMS structure, less layers to reduce cost.

Conclusion: The MEMS/MST market 2004-2009

- The MEMS/MST market volume was worth $ 12bn in 2004. It is expected to reach $25 in 2009 bn. The growth is still rapid: 16% CAGR in value in 2004–2009.
- Consumer electronics will drive the market growth in the next 4 years.
- 14 out of 26 MEMS/MST products are expected to have > $100m markets in 2009
- Completely new products in 2009 will include micro fuel cells, MEMS memories, chip coolers, liquid lenses for cell phone zoom

Completely new MEMS/MST = $250m in 2009

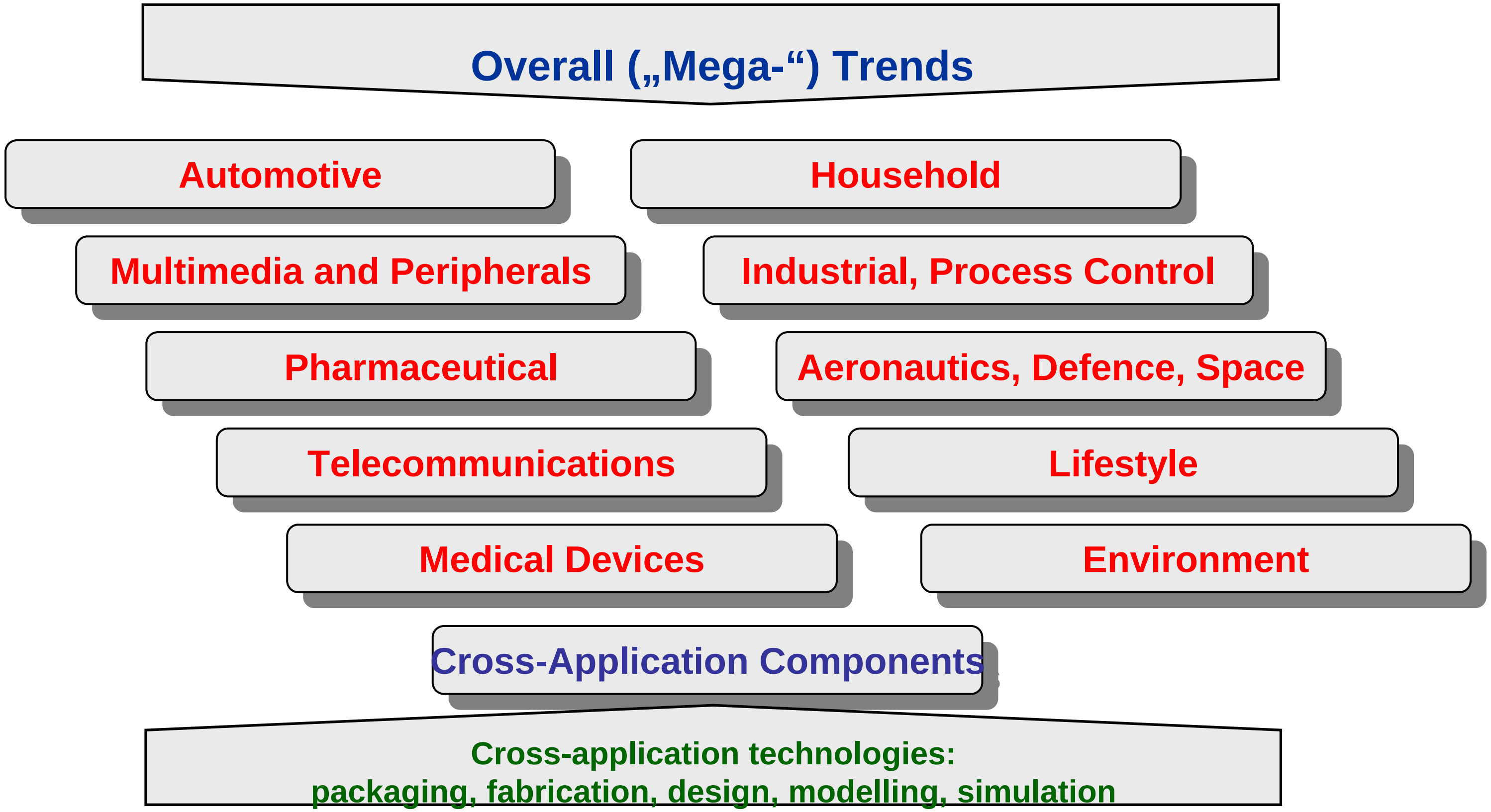
Other Reports: NEXUS Roadmap



Methodology of the NEXUS Roadmap

Source: NEXUS Association, 2003

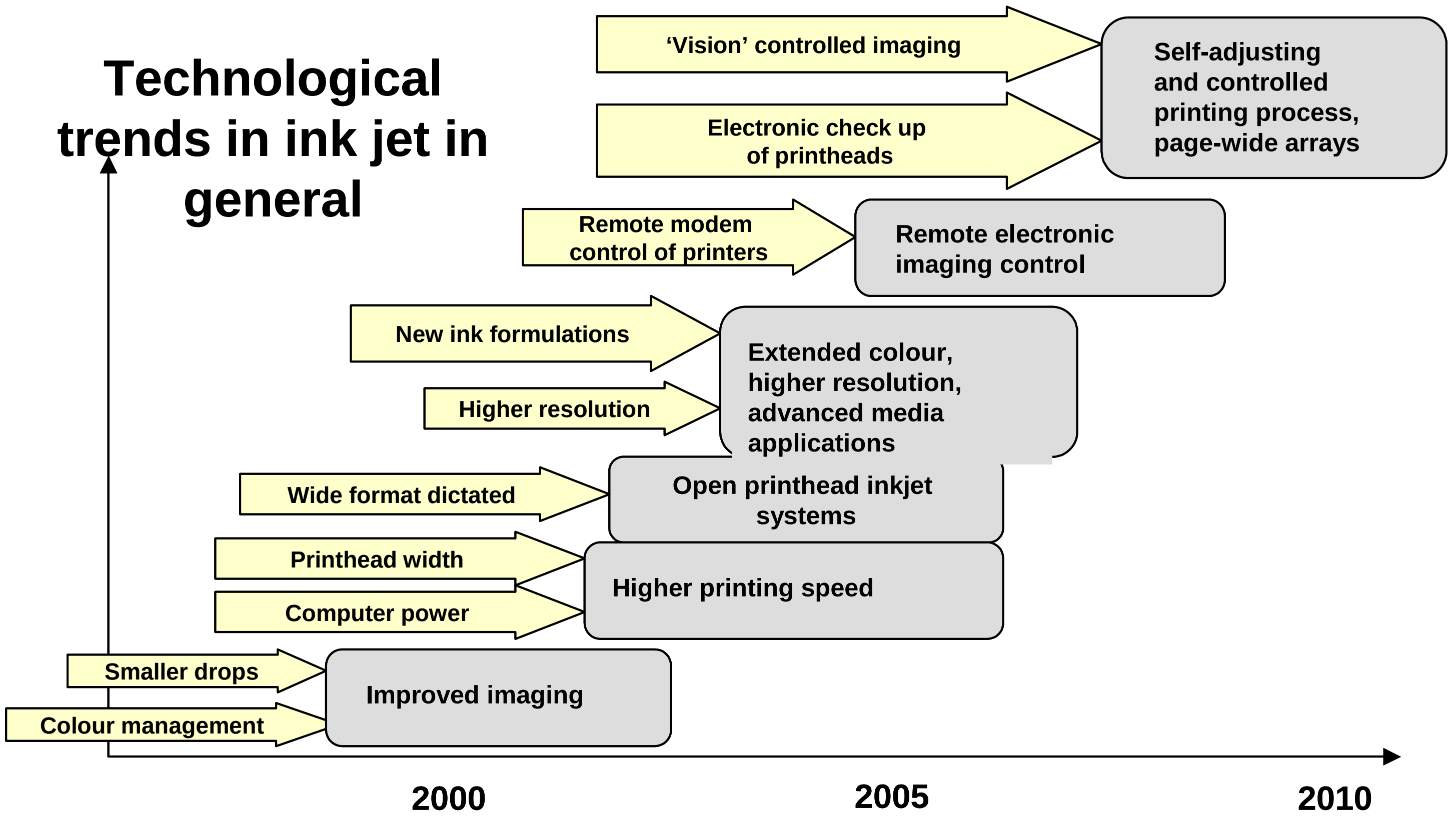
Other Reports: NEXUS Roadmap



NEXUS Roadmap: Application Domains

Source: NEXUS Association, 2003

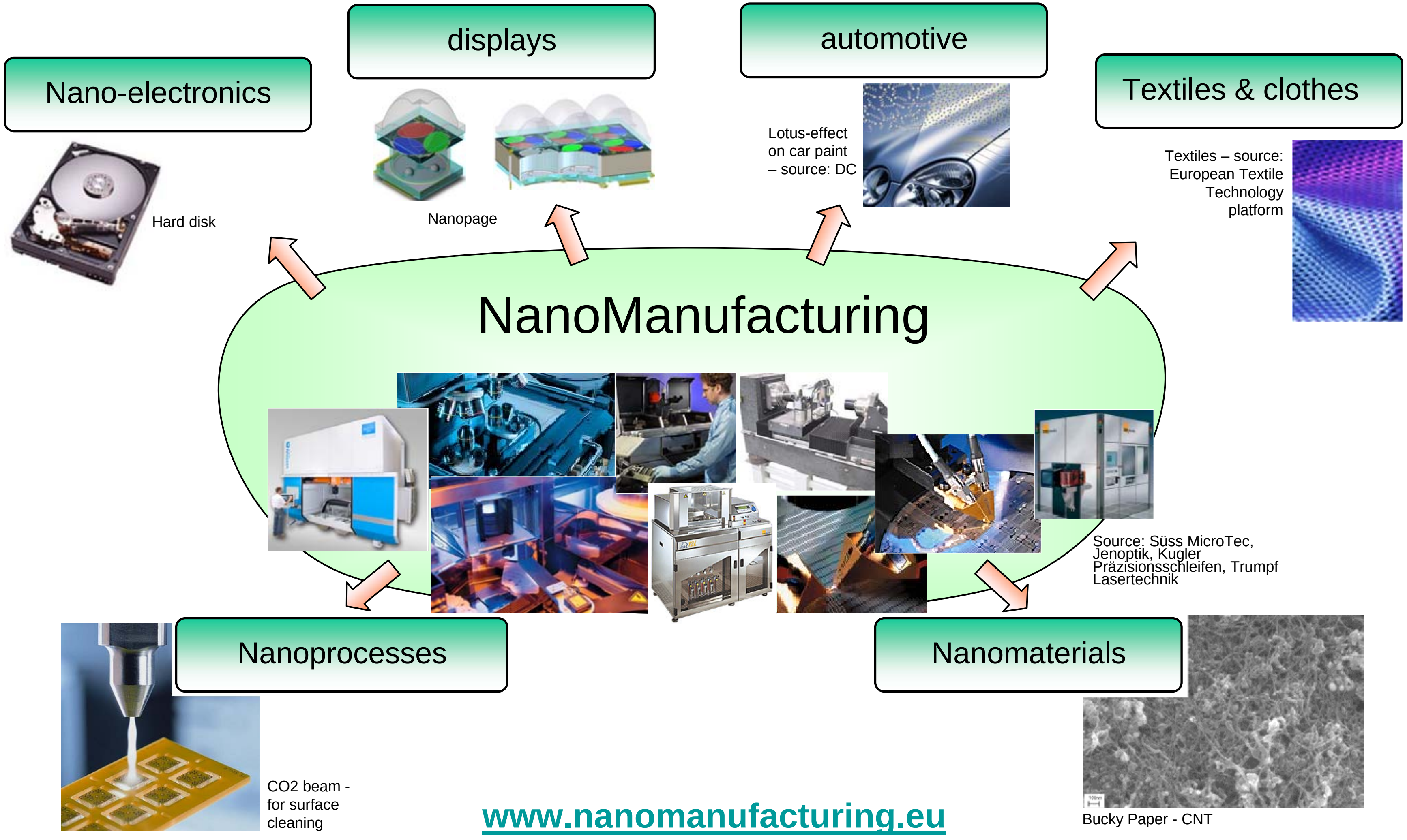
Other Reports: NEXUS Roadmap



NEXUS Roadmap Example: Ink Jet

Source: NEXUS Association, 2003

MINAM –
EC Technology Platform on NanoManufacturing



www.nanomanufacturing.eu

Part 2:

Company Developments – From Foundry to Component Supplier ?

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Dec-07

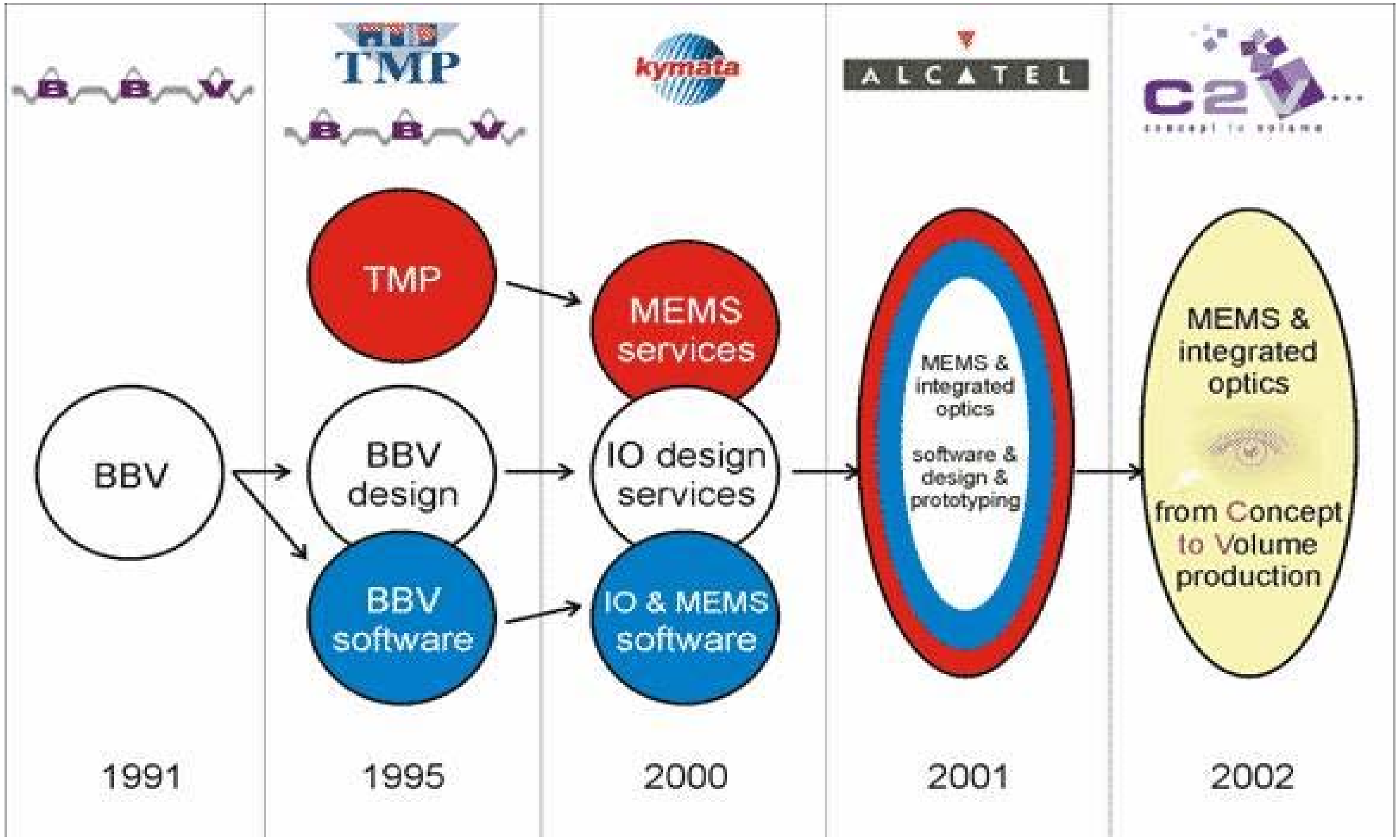
Company Developments: MEMSCAP

- Spin-off from TIMA (Grenoble) with software tools
- IPO 2001: Towards components for optical telecoms and wireless communication; build own fab
- 2001/2002: Economic downturn… breakdown of telecoms business
  - → Foundry services: acquisition of former MCNC/Cronos fab from JDSU
  - → Acquisition of sensor business unit from Sensonor
  - → Other acquisitions…
  - → Spin-off SoftMEMS
  - → Consolidation and move towards systems: skin station

Company Developments: Colibrys

- Spin-off from CSEM Neuchatel
- Initial business: Foundry
- Moving towards components:
  - Movement detection in Harsh environments
  - High reliability - Attractive margin
- Acquisition of Applied MEMS (US)
- Establishing partnerships: Packaging, etc.

Company Development - C2V



Source: C2V – Concept to Volume B.V., The Netherlands

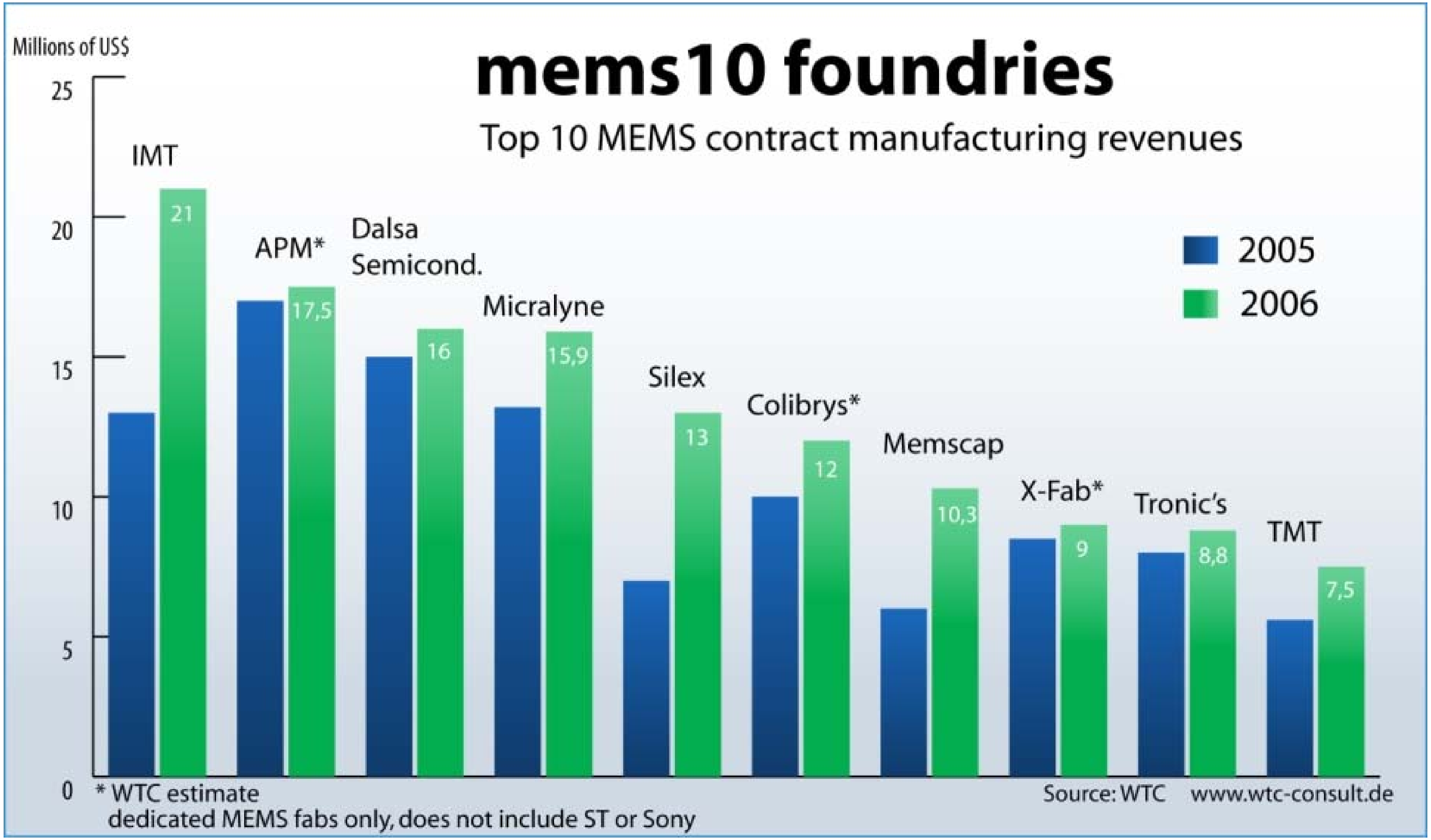
- HL Planar – from foundry/processing services to sensor products
- Boehringer Microparts - now mainly serving the pharmaceutical industry
- Bosch Sensortec launched to address Consumer Market

New foundries launched:

- Microfluidic Chip Shop

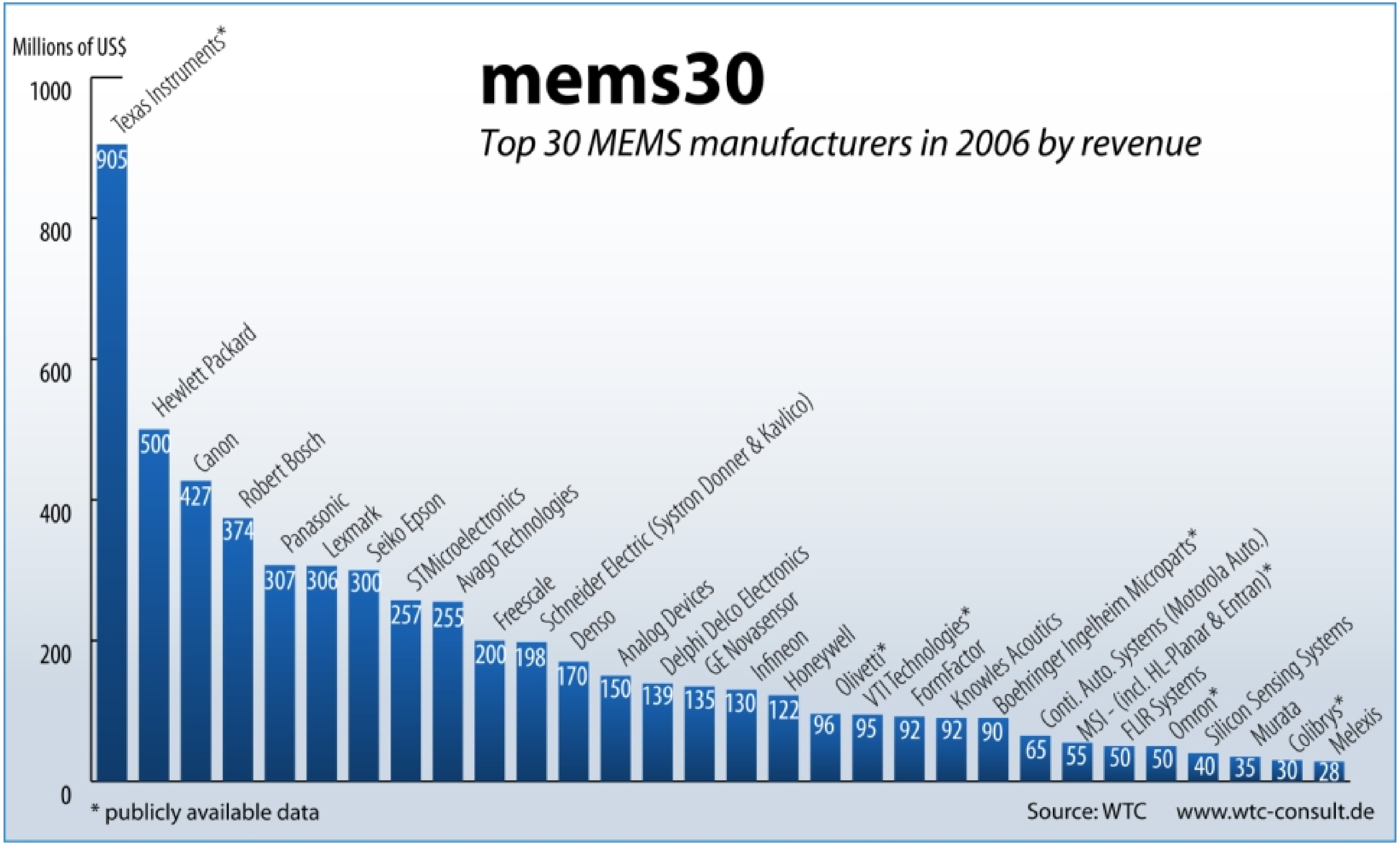
... plus many spin-offs from institutes...

Top 10 MEMS Foundries - worldwide



Source: WTC - Wicht Technology Consulting, 2007

Top 30 MEMS Manufacturers - worldwide



Source: WTC - Wicht Technology Consulting, 2007

Climbing the MNT Supply Chain ?

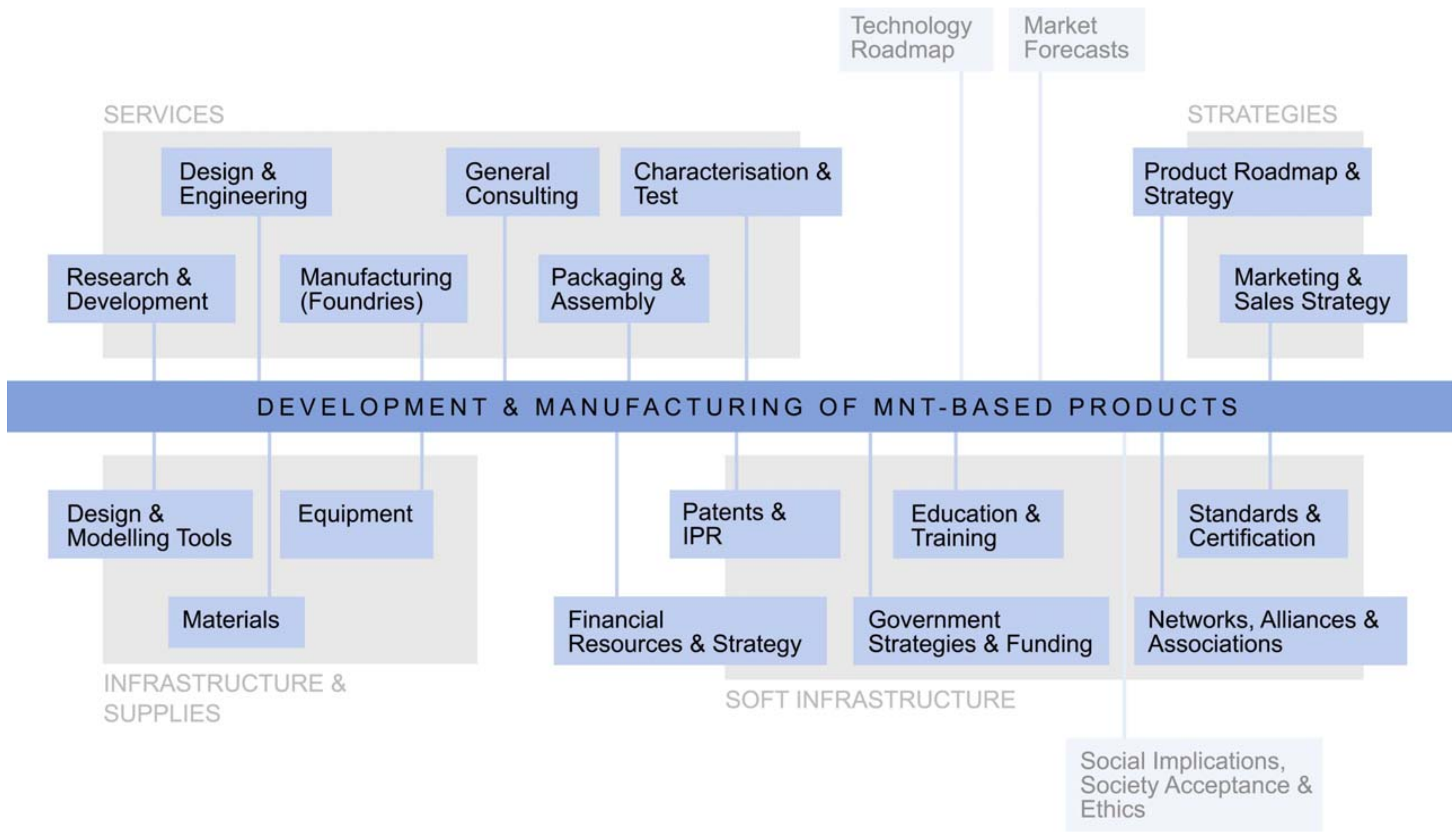
From foundry business model to component supplier:

- higher margin on MEMS-based components compared to MEMS wafers.
- difficulty for the customer to get access to packaging and assembly technology without a close link to the front-end process

→ Offering integrated manufacturing services... components... subsystems...

- But Competing with your foundry service customer ?

A micro nano manufacturing strategy needs to look at the complete supply chain…



Supply Chain for MNT-based Products
Source: enablingMNT Review Series, 2003/2007

A micro nano manufacturing strategy needs to look at the complete supply chain…

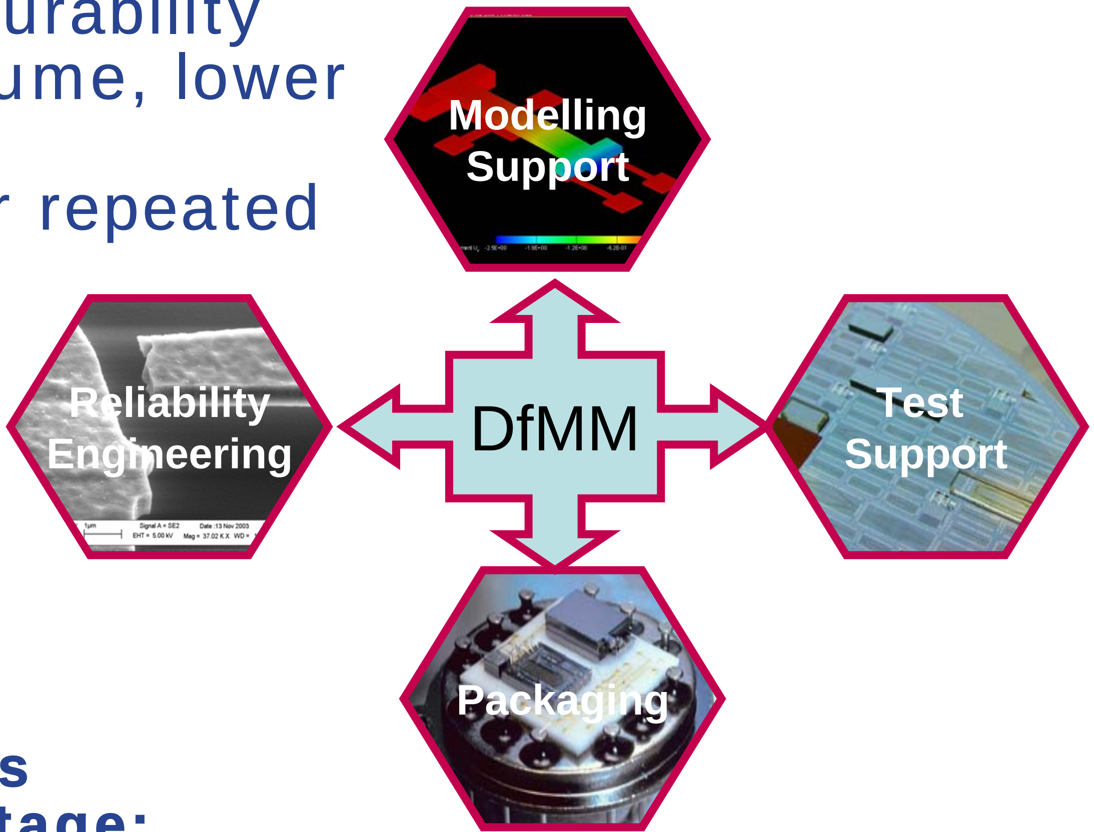
Objectives:

- Improve manufacturability (faster route to volume, lower cost)
- Keep IPR ready for repeated usage

Develop a „Design for Micro Nano Manufacture" Strategy:

Consider manufacturing issues early in the design stage:

- reliability, packaging, test, yield, etc.



DfMM Approach

Source: NoE Design for Micro & Nano Manufacture (PATENT-DfMM), 2004-2007

Further Information

Thanks to:

- **WTC – Wicht Technology Consulting: for their contributions (NEXUS and WTC Market data)**
- **enablingMNT – Henne van Heeren: for his contributions and feedback on business strategies and company developments**
- **PATENT-DfMM, NEXUS, MINOS, and Europractice for funding, contacts, and information…**

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NoE Design for Micro & Nano Manufacture (PATENT-DfMM)
www.patent-dfmm.org

www.nexus-mems.com

enablingMNT Industry Reviews:

- MST/MEMS Foundries
- MST/MEMS Design & Engineering Companies
- MST/MEMS Packaging & Assembly Providers
- Manufacturing Equipment for MST/MEMS (front-end and back-end)
- Nanomanufacturing Equipment
- Test & Measurement Services & Equipm.
- Processing Services
- MST/MEMS Activities in China

www.enablingMNT.com

Commercialising MNT

Denis Koltsov
Lancaster University

2 Oct 2007

Overview

- Models for nano business
- MNT entry points
- Intellectual property
- Product to Market Issues
- Societal dynamics of Nanotechnology

Commercial Activity

Types of Nano-business opportunities

Accidental Nanotech:

- These businesses just happen to fall under the definitions of nano, while doing their usual things. Eg. Production Carbon black for car tyres. (Low risk)

Evolutionary Nanotech:

- These businesses usually extend the conventional technologies down to nanometre scale seeking improvement in functionality. Eg. Microelectronics industry, Hard disk industry (The highest risk is in the continuity of that evolution)

Revolutionary Nanotech

- With revolutionary technology we move beyond products that have been around forever. Eg. Solid state memories, nanomedicine, nanoenergy (Higher risks and returns)

Disruptive Nanotech

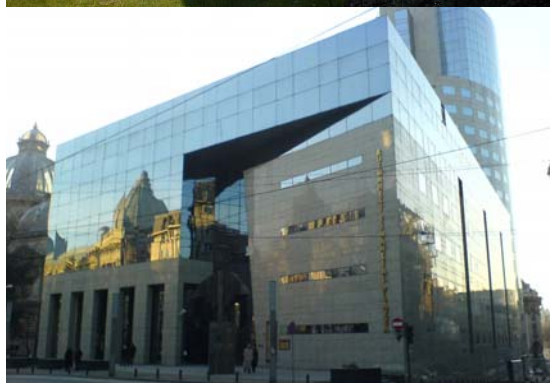
- Drexlian model with the whole of the world economy remade in a nanotech image. A bit of a fairytale. Eg. None (risk is immeasurable)

R & D Players

Types of Organisations in the MNT area

- Budget organisations:
  - Universities
  - Government institutes

- Self-sustained organisations
  - Research institutes
- Commercial structures



University start-up model

Features: Small, 1-5 people in size, low capital needed, usually run but the founders, usually has a patent or two, uses parent organisation for support and cheap infrastructure.

Activity: Express product development and customer acquisition.

Risks: That it will never make it through the death valley.

IP based model being open to attack from other IP holders and competing technologies.

Exit: Buy out by a large company

Second round VC funding and possibly IPO

Internal growth of a large company

Features: Size is varied, capital provided by the company, usually have a management structure in place, usually has a patent portfolio. Supply chains and customer base already exist from the parent company.

Activity: Varied (complimentary to the daughter company)

Risks: That the division would make a loss on its activity

Exit: Exit is not really needed, but the entity could be sold out to another company or span out with an injection of funding.

Government funded network or consortium

Features: This is a gathering of existing institutions and companies under one idea. The resulting network mimics intellectual or manufacturing supply chain. The deliverables are well-defined.

Activity: Provide services to wider community.

Risks: That the starting funding will run out before the network is self-sustaining. That the partners would not be able to form a working team

Exit: Get another round of government funding

Form a commercial, self-sustaining venture to continue the activity.

Where do we start?

How do we get into nanotech?

- Approach a non-competitor company already working in MNT
- Contact University/Research centre active in MNT
- Use consulting advice from MNT consultants
- Approach groups of institutions for one stop-shop help through networks and collaboration

Practical hurdles

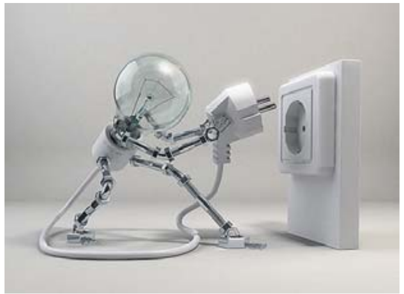
- Developing an application
- Finding suitable personnel
- Acquiring R&D equipment or outsourcing it elsewhere

Supply chains

- Regional, national and international collaborative networks (PATENT, INTEGRAM*plus*, CEMENT
- Networking events and clubs (such as “MNT Club UK”)

General points about IP

- Ideas have become the most important resource (real estate) of a modern technology venture
- The technology to be patented must pass 4 tests. It must be:
  1. Novel
  2. Useful
  3. Non-obvious
  4. Man-made (a mere discovery of natural phenomenon is not enough)



- Companies are treating IP as a business assets
- Only 5% of patents end up having any value and an even smaller proportion of those account for most of the income.

Intellectual Property

Nanotechnology Patenting trends

- Nearly exponential rise in Earliest priority filings
- US and Japan leading
- Severe backlog of unprocessed patents in national patent offices
- Gridlock of patents

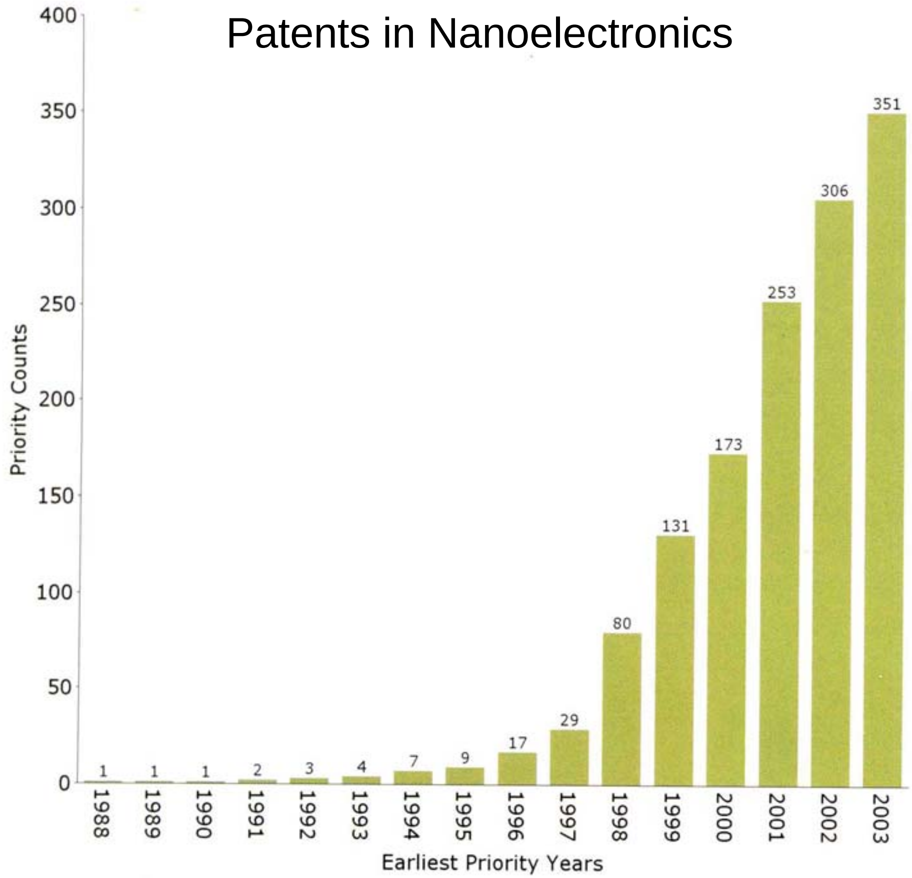


Figure 1: *Earliest Priority filings for nanoelectronics*

Source: *Computer Patent Annuities Limited Partnership/Marks & Clerk ©2006*

IP Gridlocks predicted

This leads to:

- Litigations
- Higher costs to the customer
- Slower technology development

Solution

- Software industry model (power balance). Turn the blind eye to IP abuse as long as it is mutual
- Indian model (not patenting anything at all and keeping it all as in-house secret)
- Speed-to-market model (Do not patent and just get the product out before the competition to capture the market)

Intellectual Property

To patent or not to patent – that is the question?

Benefits:

- Very useful for initial round of funding
- Allows some freedom to operate and develop technology

Patent fees:

- Basic Utility Patent Application Filing : ~$2k
- Patent attorney legal fees : ~$20k-30k
- Utility Patent Maintenance: ~$4k

What then?

- Patent licensing (quick return but low revenue)
- IP-to-product development (lengthy process that often requires VC funding but higher returns)

Startups

"in the end, the business is going to succeed or fail to a very large degree on the quality of its technical, marketing, financial, production, and general management, much more so than its IP"

Different business models for IP usage:

1. IP licensing house
2. Product development firm

Drawbacks of founding business on IP in nano:

- There is more than one way of doing things
- Time-bomb (someone will come up with a better solution at some point)

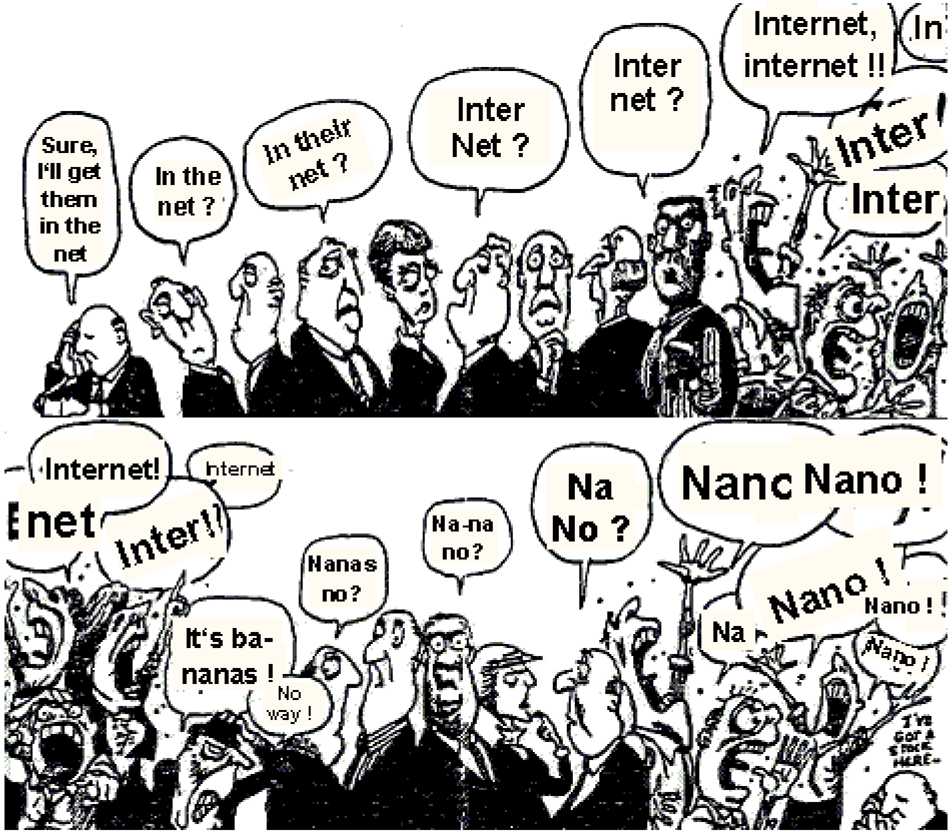
Product Development

"It is not the fact that it is Nano that makes a product attractive, but rather what that Nano can do in terms of extra functionality"

Main issues:

- Usually takes much longer to develop a working prototype.
- In case of medical applications one has to await medical trials results
- Design for manufacture (must be cheap and practical)
- Packaging (must be robust)
- Reliability (Functioning of devices under various conditions)
- Testability (inbuilt test for quality checks)

Nano or Nono ?


Sure, I'll get them in the net
In the net ?
In their net ?
Inter Net ?
Inter net ?
Internet, internet !!
Inter !
Inter
Internet!
Internet
Enet
Inter!!
Nanas no?
Na-na no?
Na No ?
Nano !
Nano !
Na
Nano !
Nano !
It's ba-nanas !
No way !

Little Nano PR problem

"Public perception is not a linear function of the quality of the technology or its safety"

- 90% of MNT is not harmful in any way, yet the last 10% of potentially harmful applications (based on nanoparticles) hijack 90% of time of the public debate.
- Need to engage the public debate and try to understand their concerns – after all they are your customers!

The End

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