Commercialization Potential for Nano: Lessons from MEMS

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Micro (MEMS) to Nano: Quotes of Note

- Over 50 years of MEMS research
  - Pressure sensor: 1954
- When will Nanotechnology become commercialized?

"it's déjà vu all over again"

Market Projections: Nano

- US government estimate:
  - $1 trillion by 2015
  - US GDP, 2003: $10 trillion
  - US GDP, 2015 projection: $15 trillion

Market Projections: MEMS

- MEMS projections variable
  - 1998: $34B by 2002 (NEXUS)
  - 2000: $30B by 2004 (R Grace)
  - 2002: $8-15B by 2004
  - 2004: $10B by 2008
- Actual
  - 2003: $5.3B

Time to Market for MEMS products

Product	Discovery	Product Intro	Full Comm'ln	TTM (yrs)
Pressure/flow sensors	1954	1960	1990	36
Accelerometers	1974	1985	1998	24
Micro-nozzles	1972	1984	1998	26
DMD	1977	1986	1996	19
Optical devices	1980	1986	2004	24
Biochemical systems	1980	1986	2004	24

MEMS: Barriers to Growth

- Workforce
  - Lack of trained engineers and technicians
  - Technology and market-knowledgeable
- Manufacturing
  - Multiple processes; non-standard (bonding, etching, 3-D structures)
  - Multiple materials (ceramic, plastic, metal, silicone, silicon…)
  - Lack of process-independent design tools
- Product
  - Specialized, expensive packaging for 3-D devices
  - Application specific (ie automotive vs medical)
  - Multi-domain (electro/chemical/mechanical/optical)
- Market
  - Diverse and fragmented
  - Is "new" necessary?

Is the opportunity ripe for start-ups in Nanotech?

- Startup companies
  - $386M in venture funding, 2002 (2%)
  - Nanosys: 2001 start-up, IPO 2004 @ $500M
  - Vague product plans, but 200+ patents
- Japan: 1 of 3 industrial firms with nano R&D
  - NEC holds fundamental nanotube patent
- IP: IBM had most nano-related patents, 2003
  - In top 10: IBM, Micron, 3M, Canon, UC
- Products
  - GM: nanocomposite resins
  - Levi's: water-resistant nanoparticles in pants

MEMS: the corporate landscape

- VC funding in H1'04 exceeds 2003 by 33%
- Top 20 MEMS producers
  - 90% revenues; 90% units shipped
  - 12 large semicon & multinationals; 8 start-ups
  - HP (inkjet printheads), TI (DMD), GE (sensors)
  - 3 applications = 70% MEMS market
- Of 230 companies tracked, <50% generated multi-$M revenues
- After 50 years…..

Digital MicroMirror (DMD)

- Major investment (est. $1B) and development time (R&D ’77, patent ’86, product ’96)
- 10 years to profitable production
- At least 10 years behind projections
  - Market: long time to adoption
  - Manufacturing: yield issues
- Semiconductor-like drivers: volume production, yield, process efficiencies
- Large margin, small volume (1.5M devices since 1996)
- ROI?

Inkjet printheads

- Large margin, high volume = true “killer app”
  - Estimate: 30M units yearly
- A component, not a product!

MEMS Biomedical Application Case History

- Venture funded microfluidics start-up
  - Commanding IP position in field
  - First product application: low-cost, high-volume medical test
  - MEMS offers faster, easier solution
- Market reaction: so what?
  - No clinical benefit over status quo
- Lack of customer value proposition
  - No current clinical applications
  - Alternatives: high-value tests are low volume; lesser need for technological advance

MEMS Biomedical Application Case History, cont'd

- Market still a "tools" vs "product" market
- Solution: research applications: research, prototyping, custom product development
  - Gain early insight into emerging market, opportunities
  - Integration into customer/partner development process
- Customer profile suited for emerging technology
  - "fault-tolerant" – don't have to be 100%
  - "leading view" into customer-driven problems
  - Need it <u>now</u> and will pay
  - Can develop underlying technology on-the-job: science, technology, operations, reliability, …
  - Service income is immediate while product focus develops

Another Lesson, from Biotech

- Corporate strategy is the 3 R's
  - **R**esearch contracts: a service business to validate, develop technology
    - Provides expertise to customer
  - **R**oyalties: via licenses from partners as technology is applied
    - Solves customer problem
  - **R**evenue: from product sales
    - Addresses market opportunity

Closing quote:

"nano is very similar to MEMS, but in different ways"