

MEMS Equipment and Materials Markets and Opportunities

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ABSTRACT

The MEMS/Microsystem industry is at an inflection point. Consumer application demands are expanding markets, increasing volumes and driving the adoption of CMOS-compatible manufacturing technologies. The future of MEMS is not one of niche applications and small volumes, but rather high volume consumer and automotive applications. MEMS devices are increasingly displacing components for a variety of applications, expanding MEMS markets. And, at the heart of it all is innovation in MEMS manufacturing and materials technologies.

Keywords: MEMS, MEMS-CMOS integration, MEMS equipment, MEMS materials, Microsystems/MST

OVERVIEW

MEMS—micro electromechanical systems—are devices combining mechanical structures such as sensors, actuators or resonators with microelectronics in one integrated system. While MEMS are not new, historically these devices had limited applicability due to high cost and low production volumes. Innovations in manufacturing technologies and materials are resulting in high production volumes and lower costs allowing broader applicability.

Figure 1 shows the MEMS supply chain, with approximately \$1.2 billion of MEMS equipment and materials expected to enable \$72 billion of MEMS systems in 2008. MEMS systems incorporate MEMS devices and include products such as automobile airbag systems, display systems and inkjet cartridges. Systems are expected to grow at a compound annual growth rate (CAGR) of 15% over the next few years, while devices grow at 13%, equipment at 6% and materials at 15%.

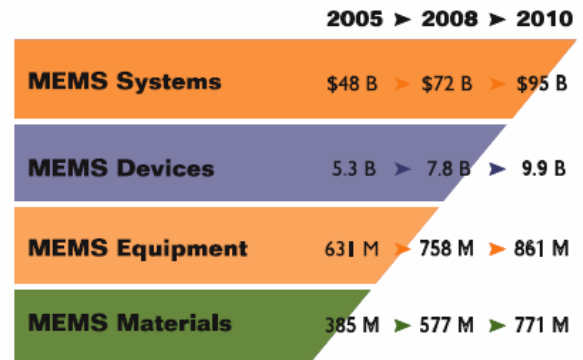


Figure 1: The MEMS Supply Chain.

The MEMS industry is highly fragmented, with numerous device manufacturers worldwide in many application fields. Several start-ups and medium-sized companies participate in the industry. As shown in Table I, optical MEMS are the largest segment, followed by inkjet heads and pressure sensors respectively. However, the fastest growing segments are microphones, RF MEMS and accelerometers, driven by consumer applications. Micro fuel cells are expected to be commercialized in 2008 and experience very strong growth. Approximately 50% of MEMS devices by value are produced in North America, followed by Japan with approximately 20% and Europe with just over 15%.

MEMS Device Market	2008 Market	CAGR (%)
MOEMS (includes DMD)	2,348	20
Inkjet Heads	1,881	6
Pressure Sensors	1,172	7
Gyroscopes	808	11
Microfluidics	629	16
Accelerometers	550	17
Silicon Microphones	259	44
RF MEMS	199	26
Micro Fuel Cells	2	80
Total	\$7,848M	13%

Table I: Global MEMS Device Markets and Forecasts.

MEMS-CMOS INTEGRATION

Top chip manufacturers and foundries have taken notice of the growth in MEMS, and all of them maintain MEMS development programs or products today. MEMS-CMOS integration is viewed as an opportunity for differentiation. Key differences between CMOS devices and MEMS remain. For example, mobile ions and metals do not pose manufacturing issues for MEMS but are detrimental to CMOS devices, while defects on the back-side of the wafer are problematic for MEMS but not a significant issue for CMOS. There are three different manufacturing approaches to address these differences when integrating MEMS and CMOS, including pre-CMOS, intra-CMOS and post-CMOS, with the best choice application dependent.

EQUIPMENT AND MATERIALS

Innovation in MEMS-CMOS integration has resulted in high volume manufacturing capabilities and lower costs. However, further innovation is required for assembly & packaging and testing of MEMS devices and systems, creating opportunities for equipment and materials suppliers.

MEMS Manufacturing Equipment

Older generation semiconductor manufacturing equipment has commonly been used for MEMS devices, often with some customization required for specific devices. Over the past several years, MEMS requirements have demanded some new classes of manufacturing equipment, such as wafer bonding and increasingly test, providing new markets for equipment suppliers. Higher volume requirements of MEMS devices for consumer applications is causing a migration to 200 mm wafers, and increasing aspect ratios have created the need for deep reactive ion etch (DRIE) tools.

The MEMS equipment market totaled just over \$750 million in 2008. Test, etch (both wet and dry) and assembly & packaging represent the largest MEMS equipment markets, making up approximately 50 percent of the total, while the fastest growing segments include etch, driven by DRIE, bonding and test, assembly & packaging, as summarized in Table 2.

MEMS Equipment Market	2008 Market	CAGR (%)
Test	161	7
Etch	112	13
Assembly & Packaging	80	7
Deposition	73	2
Lithography	73	5
Inspection & Measurement	38	3
Bonding	36	10
Thermal Processing	22	2
Wafer Clean	11	2
Other Front End	37	6
R&D Equipment	115	6
Total	\$758M	6%

Table 2: Global MEMS Equipment Markets and Forecasts.

MEMS Materials

Semiconductor materials have also commonly been used to manufacture MEMS devices, with a few exceptions, particularly in some of the substrate materials as well as some of the etching and cleaning chemistries. Hermetic packages, mostly ceramic, have been the dominant package form, but here too, innovations in packaging materials are allowing new capabilities.

The MEMS materials market totaled just over \$575 million in 2008. Substrates (silicon, silicon-on-insulator, quartz, glass and polymer) and photomasks are the largest MEMS materials markets, making up 90 percent of the total, while the fastest growing segments include packaging coatings and CMP slurries & pads, driven by smaller form factors, as summarized in Table 3.

MEMS Materials Market	2008 Market	CAGR (%)
Substrates	414	17
Photomasks	107	9
Gases	17	17
Photoresist & Ancillaries	15	17
Wet Etchants	12	5
CMP Slurries & Pads	6	20
Other Wet Chemicals	4	5
Packaging Coatings	1	50
Other Materials	1	14
Total	\$577M	15%

Table 3: Global MEMS Materials Markets and Forecasts.

OUTLOOK

MEMS markets and applications are experiencing strong growth, driven by consumer markets. Manufacturing and materials innovations have enabled high volume, lower cost MEMS devices, but further innovation is required in MEMS assembly & packaging and test. Moving forward, MEMS-CMOS integration will increase, creating a host of new applications and likely more opportunities for innovation in MEMS manufacturing and materials.

Acknowledgements

All of the data contained in this article are from the comprehensive market research report, *Global MEMS Markets and Opportunities* that was published August 2006 by Yole Developpement and SEMI. The report will be updated in June 2007.

For more information and to access or purchase the report, please visit semi.org/mems or yole.fr.