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Contents

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Status of the MEMS Industry: Evolution or MEMS Markets and of the Industrial Infrastructure

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Abstract: The MEMS markets in 2006 reached US$ 5.8 B and we can estimate that the 2011 MEMS markets will reach more than US $ 10.7 B, with very diverse growth rate depending on the devices and the applications: silicon microphone and RF MEMS are the fastest growing applications but the existing applications like ink jet head and pressure sensors are still growing at a rate of 4 % per year at least.

The industrial infrastructure is changing, with more and more companies going to 8'' manufacturing facilities and the strong growth of the MEMS foundry business.

MEMS business is changing for more structured industry and high volume production.

Keywords: MEMS markets, MEMS Industry, MEMS

1. Evolution of the MEMS Markets

The MEMS markets in 2006 reached US$ 5.8 B, see Fig. 1 and 2 for a detailed analysis. Concerning the future, we can estimate that the 2011 MEMS markets will reach more than US $ 10.7 B, with very diverse growth rate depending on the devices and the applications: silicon microphone and RF MEMS are the fastest growing applications (see Fig. 2). These devices will more and more impact the consumer applications (mobile phone, DSC…) but are also finding industrial, medical and security applications.

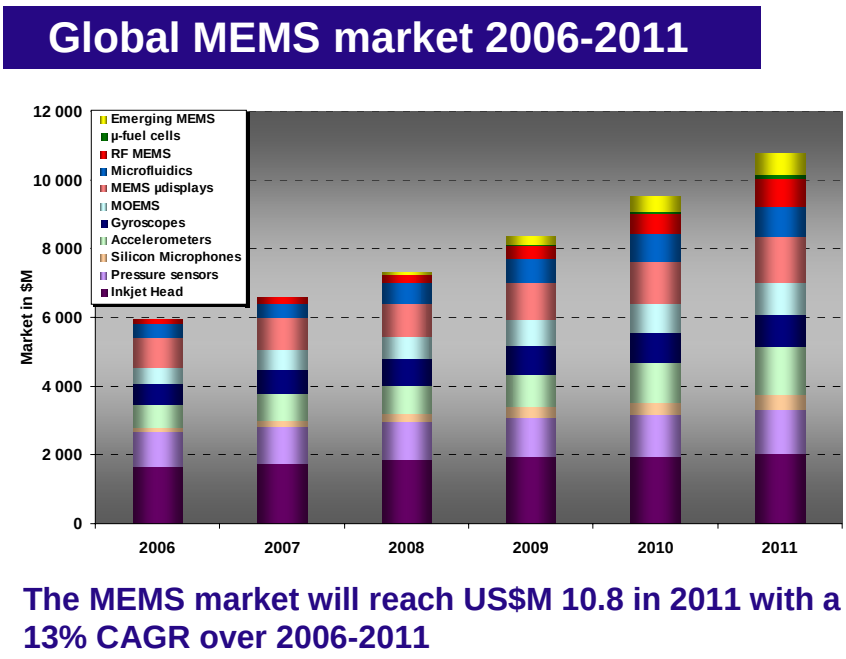

Fig. 1. Evolution of the MEMS markets (Source Yole Développement).

	2006	2007	2008	2009	2010	2011	2006-2011 CAGR
Inkjet Head	1 663	1 735	1 872	1 949	1 963	2 042	4%
Pressure sensors	1 028	1 103	1 093	1 147	1 208	1 275	4%
Silicon Microphones	117	169	245	309	365	442	31%
Accelerometers	652	779	815	936	1 158	1 403	17%
Gyroscopes	616	713	795	853	881	918	8%
MOEMS	466	563	615	741	835	949	15%
MEMS µdisplays	886	939	986	1 081	1 226	1 336	9%
Microfluidics	397	415	595	716	796	856	17%
RF MEMS	127	159	230	370	603	829	45%
µ-fuel cells	0	0	1	26	65	104	153%
Emerging MEMS	0	0	50	238	431	628	263%
Total	5 951	6 574	7 298	8 366	9 533	10 783	13%

Fig. 2. MEMS markets figures (Source Yole Développement).

Ink jet head and pressure sensors have limited growth (around 4 %) due to the maturity of the market. The price pressure is very high and is limiting the growth of these applications.

Inertial sensors (accelerometers and gyroscopes) are finding their growth both in the automotive and consumer markets. Here also, price pressure is very high and the growth in number of units is much stronger.

Optical MEMS are finding a lot of new applications and we are also expecting strong growth rate. IR image sensors are very promising devices with incredible growth at the moment.

The new emerging applications (like microfuel cell, silicon oscillator, energy harvesting devices… which represent a zero value at the moment) will reach within 5 years 7 % of the MEMS business. This is the fastest growing application and the fuel for new innovation in the MEMS industry. A lot of new devices are under development and will impact the market within 3 years.

All in all, we can say that the MEMS markets are growing and are impacting more and more applications, from high end security systems to consumer last gadget. But the strong increase of the consumer applications is pushing the changes of the manufacturing infrastructure.

The Fig. 3 is providing the 2004, 2005 and 2006 sales of the TOP30 MEMS manufacturers worldwide.

		Sales			
	Société	2004	2005	2006	AGR 06/05
1	TEXAS INSTRUMENTS*	850	780	883	13%
2	HEWLETT PACKARD*	687	750	820	9%
3	ROBERT BOSCH *	260	325	375	15%
4	LEXMARK *	201	230	313	36%
5	SEIKO EPSON *	194	199	231	16%
6	STMICROELECTRONICS*	200	200	220	10%
7	CANON *	161	184	214	16%
8	FREESCALE	157	182	210	15%
9	ANALOG DEVICES *	131	133,6	170,0	27%
10	DENSO *	118	135	170	26%
11	GE INFRASTRUCTURE SENSING *	120	132	152	15%
12	SYSTRON DONNER (SDA - SDI)*	171	190	141	-26%
13	HONEYWELL *	102	117	120	3%
14	DELPHI DELCO ELECTRONICS *	116	116	116	0%
15	INFINEON TECH. * (incl. Sensonor)	77	88	101	15%
16	OLIVETTI I JET*	78	96	96	0%
17	VTI TECHNOLOGIES	62	89,8	88	-2%
18	PANASONIC (MEI - MEW)*	20	80	88	10%
19	BOEHRINGER INGELHEIM MICROPARTS*	54,6	49	85	73%
20	FORMFACTOR	36	47	68	45%
21	CONTINENTAL AUTOMOTIVE *	40	50	64	28%
22	KNOWLES ACOUTICS *	35	41	59	44%
23	MSI (including HL Planartechnik)*	12,4	13,8	55	299%
24	MURATA *	21	47	53	13%
25	AVAGO TECHNOLOGIES *	21	24	50	108%
26	OMRON	125	130	50	-62%
27	SILICON SENSING SYSTEMS *	32,4	35	43	23%
28	ULIS*	18	26,4	37,7	43%
29	COLIBRYS*	19	25	30	20%
30	KIONIX	0	18	26	44%

Fig. 3. TOP30 MEMS manufacturers' sales.

The market drivers are the automotive industry and 2 specific applications (ink jet heads and projection systems) which are providing the strong growth of the market. The consumer applications is explaining the growth of several companies (STM, Avago Technologies, Knowles Acoustics…) with important new business linked to mobile phone applications and the game industry, but the contribution to the total MEMS sales is still limited. More will come in 2007 and 2008. In addition, the price level (and the price pressure) is very strong: hundreds of million units at few 10 s cts each is only a few 10 s million $ business…

The major changes in the industry are the following (see Fig. 4):

- The cumulative sales of the TOP30 MEMS manufacturers has increased from BUS$ 4.5 in 2005 to BUS$ 5.2 in 2006, representing more than 88 % of the total MEMS sales (and more than 20 % increase in total). So the TOP30 MEMS companies are growing faster compared to the MEMS markets;
- The minimum sales grew from MUS$ 15 to MUS$ 26, with several new companies entering the field (and several companies exiting the TOP30, see below);

The top 6 MEMS manufacturers have not changed:

- Texas Instruments micro mirror business is growing again and is more important than the 2004 sales which was a very strong year already;
- HP has increased its sales of ink jet head (higher growth compared to the market) due to the introduction of new ink jet printer families (the Scalable Printing Technology and the Edgeline family), which have been well accepted by the market;
- Bosch is again the world leader for MEMS sensors, with an impressive 15 % growth (despite a strong decrease of the device price estimated at least at 6 %); sales in the non automotive fields have just started and the contribution in 2006 sales is limited. We expect a much stronger impact in 2007 at least in the number of devices sold;
- Lexmark and Seiko Epson are also growing faster compared to the ink jet head market, with strong labeling business for Lexmark (agreement with Dell);
- STMicroelectronics MEMS activities are now linked to ink jet head (contract manufacturing for several ink jet printer companies, including HP) with the start of the sales of the 3D accelerometer in volume for Nintendo. We estimated that the non ink jet head business of STM contributed to approximately MUS$ 20 in 2006, with more to come in 2007.

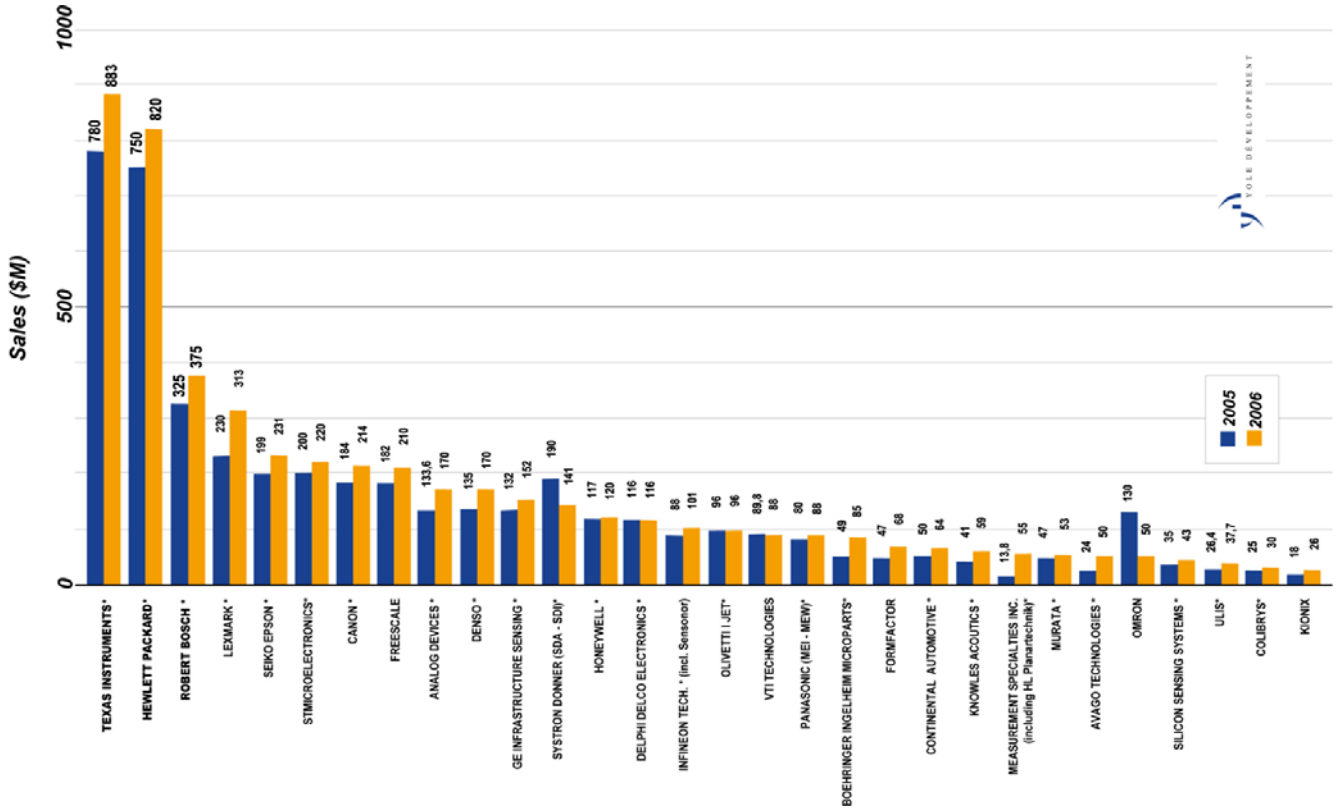

Fig. 4. MEMS manufacturers ranking.

Eight MEMS manufacturers are now above MUS$ 200, compared to 6 last year: the new entrants are Canon (ink jet head manufacturing) and Freescale (strong growth of their automotive business).

Eighteen companies have sales below MUS$ 200 and above MUS$ 50 (linked to automotive and medical applications mainly) and four have sales below MUS$ 50 and above MUS$ 25 (sensor manufacturers mainly).

It is important to remember that more than 300 companies have MEMS sales below MUS$ 26 worldwide. As a key fact of the fragmentation of the MEMS industry, the last company in the TOP50 MEMS manufacturers has sales of MUS$ 6, which means most of the MEMS manufacturers are producing few hundreds or thousand of wafers every year, mainly for their own use in their systems.

2. Evolution of the Industry Infrastructure

It is one of the major evolutions of the MEMS industry YOLE Développement has highlighted: the new MEMS companies are fabless. These new companies (like Invensense, SiTime, DelfMEMS, Wispry, Qualcomm MEMS, Kavendish Kinetics…) are using external partners in order to have access to die and sell devices to their customers.

But this assessment is not exactly right: all these companies have strong team of process engineering, at least at the beginning of the company and all of them are investing in development and production equipment, which is quite unusual for a fabless company.

In fact, all these new MEMS companies are fab-light: due to the heterogeneity of the MEMS industry, these companies have to help their manufacturing partners to develop and stabilized a viable process (for from end and back end processing) and have to invest in process development and equipment. Once the process is established and viable, it is then transferred to a foundry.

For example, SiTime has developed its processes with SVTC and is now using Jazz Semiconductor as a manufacturing partner.

The necessity to have a fab-light strategy is impacting heavily the MEMS industry in 2 different ways:

- The development time for a new device is in the range of 2 to 4 years, which is a very long time for start-up companies (and their investors). Very few investors are able to wait 4 years before having a product on the table, ready for commercialization. This timing is much faster compared to what the MEMS industry has seen in the past (15 years of R&D for TI, 12 years of R&D for Knowles Acoustics…) but it is still a problem for the whole industry. Several start-ups do not have enough capital to take into account this long time of development and do not find the right funding structure for their project.
- Each new MEMS company has to find the right engineering team, with highly skilled persons and track records in bringing MEMS from idea to real production, which is not that simple due to the lack of such skilled individuals.

These 2 issues of the MEMS fab-light start-up are delaying the development of the companies, which need more money, more time, bigger and diversified team in order to be up and running. Several companies have had such problems in the past: Discera, Wispry… have all announced years ago that they were close to production but each time, they needed 3 years more in order to solve the process engineering issues. Other companies like SiTime, LVL Sensors, InvenSense… have made a great job with product introduction in a 2 years timeframe.

The MEMS industry will be really mature when these problems will be solved. That means the industry as a whole has to break the **"MEMS law: one product, one process"** (by the way, this concept has been invented by YOLE Développement in 2003). The growth of several MEMS foundry like IMT, Micralyne, Silex… is certainly a part of the answer: step by step, they will standardized the processes they are offering to their customers. But there is very few process compatibility between these different players.

This fact could pave the way for a new entrant, taking the big part of the MEMS foundry business by proposing solutions to this "Fab-light" problem and really breaking the "MEMS law".

According to the Taiwanese Institute for Economic Research, the integrated IC foundry business represented approximately 10 % of the total IC market in 2006. The four main players (TSMC, UMC, Chartered Semiconductor and SMIC) had together a market share of 84 % and TSMC alone dominated more than 50 % of the business in 2006.

The picture is quite different if we look at the MEMS foundry business. The following table (Fig. 5) provides YOLE Développement's analysis of the MEMS foundry business in 2006:

2006 ranking		2005	2006	Growth 06/05
1	STMicroelectronics	$198,0	$200,0	1%
2	IMT	$14,0	$21,0	50%
3	Sony	$15,0	$20,0	33%
4	APM	$15,0	$17,0	13%
5	Micralyne	$14,0	$17,0	21%
6	Dalsa Semiconductor	$15,2	$16,2	7%
7	ELMOS-SMI	$10,5	$14,0	33%
8	Memstech	$13,0	$13,5	4%
9	Colibrys	$12,5	$13,5	8%
10	Silex	$6,7	$13,1	96%
11	Memscap	$6,0	$10,3	72%
12	Tronic' Microsystems	$7,4	$8,7	18%

Fig. 5. Ranking of MEMS contract manufacturers (Source: Yole Développement).

Approximately 25 companies provide MEMS foundry services worldwide, with total revenues of US $400 million. The growth rate in 2006 compared to 2005 is 35 %, after a 40 % growth in 2005. IT is the leader in the independent MEMS foundry areas.

At YOLE Développement, we are forecasting the MEMS foundry growth rate to remain at the same level for 2007 and 2008 as the first trends gathered for 2007 sales indicate a possible 40% growth rate for the year.

Comparing MEMS foundry sales to MEMS product sales in 2006 (which represents US $5.9 billion), 7 % of the MEMS product market is manufactured by MEMS foundries, a much lower rate compared to the semiconductor industry.

The main reason for this difference is the diversity of MEMS processes and the existence of the "MEMS law: one product one process". That is, few standard processes today are able to capture the majority of the market.

3. Looking to the Future, Let's Imagine the MEMS Foundry Business in 2016

In 2016, we expect the MEMS market to generate approximately US $20 billion in revenue based on a 2006-2016 13% compound annual growth rate (see Fig. 1).

We also predict that the "MEMS law: one product one process" will be solved, resulting in the evolution to a more mature industry.

If we can extrapolate what has happened in the semiconductor industry:

- Approximately 10 % of overall semiconductor business is in the hands of foundries;
- One foundry (TSMC) has 50% market share, reducing the size of the other players (UMC, SMIC, etc.).

If we apply this ratio to the MEMS industry in 2016, the results are surprising:

- 10 % of the MEMS business will be in the hands of MEMS foundries, meaning a US $2 billion industry (compared to a US $400 million market today);
- One player will have 50 % of the market, resulting in one US $1 billion MEMS foundry.

The question remains, who will be able to build a US $1billion MEMS foundry company in the next 10 years? And in order to do this, will MEMS manufacturing processes have to be standardized? This dream may not seem possible today but the semiconductor industry achieved this goal 15 years ago while many people were skeptical about the viability of the semiconductor foundry business model.

Following the semiconductor example, we hope that the dream of building a US $1B MEMS foundry will turn into a reality!

MEMS business is growing and changing. YOLE Développement is day after day looking at the evolution of the MEMS markets and industry and reporting these evolutions in our publications Micronews, the online news provider i-Micronews and in our reports. With its strong involvement in MEMS industrial business (we are making more than 1 500 industrial contacts every year linked to MEMS business), YOLE Développement is leading the way in the analysis of MEMS markets worldwide.

Sensors & Transducers Journal

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726- 5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually.

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Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

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- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

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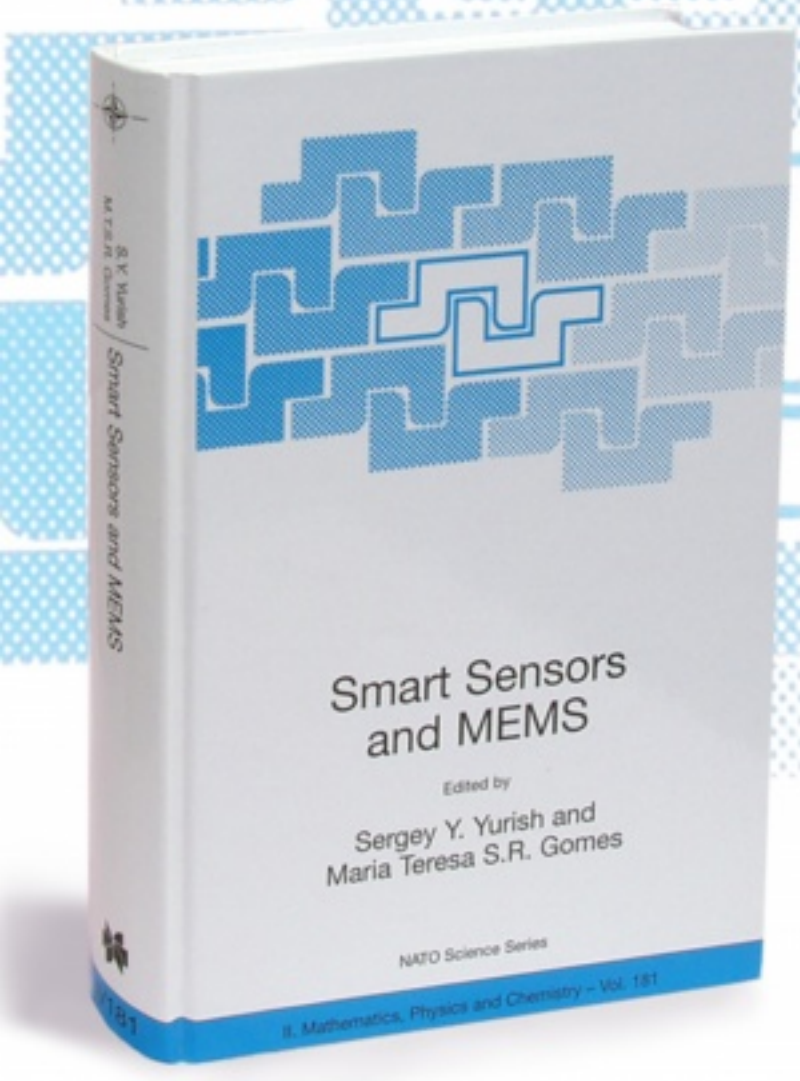

Smart Sensors and MEMS

Edited by

Sergey Y. Yurish and
Maria Teresa S.R. Gomes

The book provides an unique collection of contributions on latest achievements in sensors area and technologies that have made by eleven internationally recognized leading experts ...and gives an excellent opportunity to provide a systematic, in-depth treatment of the new and rapidly developing field of smart sensors and MEMS.

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