A BRIEF HISTORY
OF
MEMS MARKET GROWTH

A compilation of company, milestones, products, category, share, trend, and predictions

MEMS Central Foundations of MEMS

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MEMS is a growing field. This article aims to document the growth of the size of MEMS market. It is a fact-based account of major market information and events relevant to the field of MEMS. Some events (such as the emergence and growth of Google) can serve as a parallel comparison.

Market research companies such as Yole and iSuppli did wonderful jobs of tallying the market sizes. Here, I take liberty to collect public available numbers/graphs and compile them in one document. One can see snap shots of the market by reading these market research reports (typically the cost is prohibitive for individuals and academia). The benefit of this article is to add a historical perspective and expand such market research data with deeper analysis/observation.

In this article, I peg some of the MEMS industry numbers with respect to two companies: Google, which has no MEMS business, and HP, which has a large operation that including a strong MEMS component.

1947

First transistor is invented at AT&T Bell Laboratory.

1969

First time a word "Hello" was sent from UCLA to MIT via ARPA-NET, the precursor of Internet. ARPA is the precursor of DARPA, the Defense Advanced Research Program Agency of the US military. Why was the military interested in inventing the internet? It was initially pitched as a way to allow US-based satellite stations to communicate with each other in the unlikely event of a nuclear attack. The genie has been released from the bottle.

1992

The Mosaic web browser was first introduces at the University of Illinois.

1995

Sergey Brin and Larry Page met at Stanford.

1998

Microsoft annual revenue = $14.5B/year. When Bill Gates was asked what he feared the most, he answered "Someone starting new at a garage somewhere". Gates' worries are warranted. The company Google was founded in that year.

In 1999, Agilent is spun out of Hewlett Packard (HP). HP is a company that manufactures scientific instruments, computers, and certainly printers. The instrument part was spun into Agilent, a separate company. (According to CNNmoney, for the first half of fiscal 1999, HP reported a profit of $1.9 billion, or $1.80 per share, on $24.4 billion in revenue, compared to first-half 1998 earnings of $1.6 billion, or $1.51 per share, on $23.9 billion in revenue.) (Keep in mind, revenue is how much money a company collects from its customers. "Profit" is actually more meaningful. It is the revenue minus the cost of doing business. In Wall Street lingo, "profit" is called "earning". However, profit data, especially for a division among a large company, is rarely public available).

2001

Apple introduced iPod to the world this year. The product uses touch sensing interface cleverly. It also ushered in the era of personal consumer electronics. The iPhone would be introduced six years later, around January 2007. The iPhone release is paralleled by another product, the Nintendo Wii, in November 2006 (on time for the Christmas season).

Ironically, despite the introduction of iPod, whoever foresaw the explosive growth of personal consumer electronics trend in 2001 would still be considered a genius today. (People at InvenSense and ST Microelectronics certainly did.)

2004

That year, Texas Instruments, with the key product of Digital Light Processor (DLP), took the first place among all MEMS companies in terms of revenues. **HP**, which manufactures ink jet printer heads, is the second.

According to ComputerWeekly.com, HP revenue in the quarter ended 31 July 2004 rose to $18.89b, up 9% from $17.35b in Q3 last year. Net income came in at $586m for the quarter, compared to $297m a year ago. If we assume that the revenue is even for each quarter, HP's total revenue for the year would be around $73b. This makes the MEMS printer-head business roughly 1/100 of the total revenue of the company.

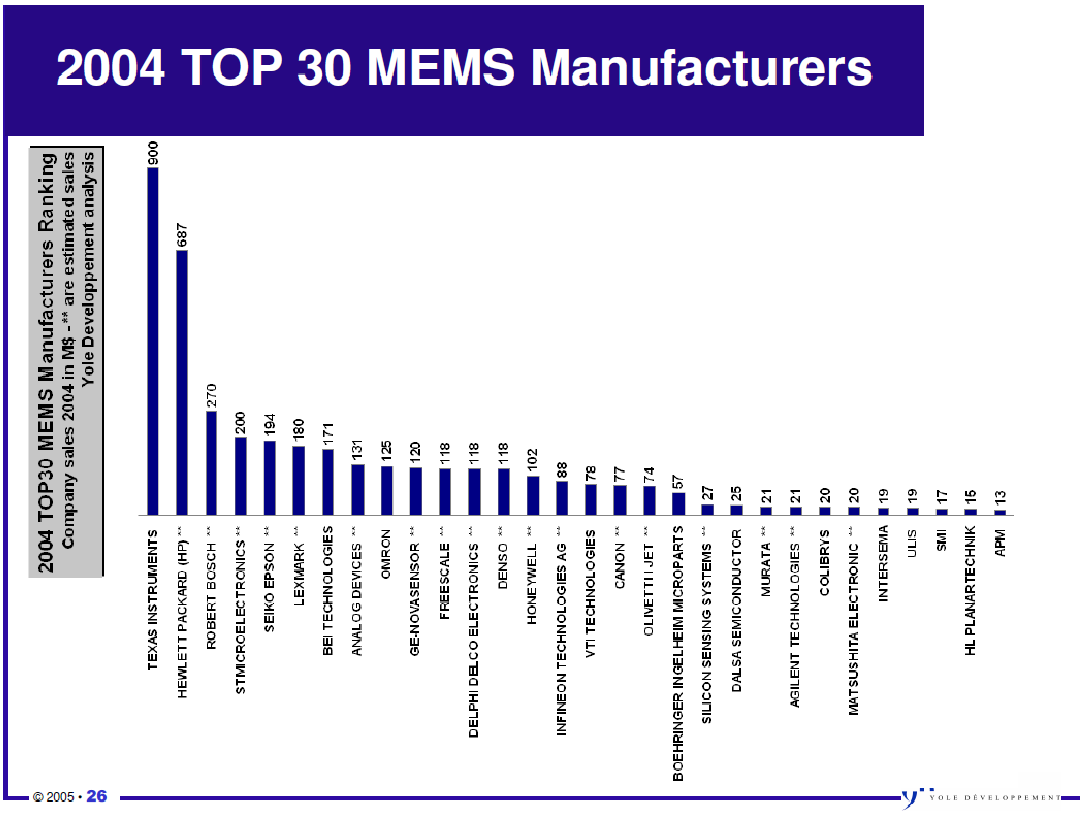


Figure 1: MEMS top 30 company revenue, 2004. (Source: Public data from Yole Development, a market research agency.)

A summary of some of these companies, their geographical locations, and their market sizes are provided below:

- Robert Bosch (Germany), automotive market, accelerometers, gyros, manifold pressure sensors
- ST Micro (Italy-France), accelerometers, gyros
- Seiko Epson (Japan): ink jet printer heads
  Lexmark (US), formerly IBM printer business, makes printers and printer heads.
  BEI Technologies (US, California): gyros, more specifically quartz gyros. BEI is in the aerospace industry, hence the California location.
  Analog Devices (US, Boston area): automotive market, accelerometers based on surface micromachining.
- Freescale (US, Arizona and Chicago): automotive market. Former micro division of Motorola.
- Delphi (US), automotive sensors.

More details can be found in the MEMS-links section.

In that year, the company Google's revenue=$3.2b, w/ profit of $400M. Also this year, Facebook is founded (in January 2004). Youtube was founded in February 2005. These

events unleases people's appetite for what is called Web 2.0. In 2006, the person YOU would become the person of the year.

2005

The number of cellphone applications for MEMS microphones doubled between 2005 and 2006 to reach 20% of mobile phones manufactured, according to The Information Network.

2006

According to the following graph, the landscape of MEMS companies and revenues did not change significantly still. The most noticeable feature is the growth of Canon. It seems to take some market share away from HP. Companies that focus on consumer electronics, such as Knowles Acoustics (microphone) starts to show up on the map. Nov 14, 2006, Knowles sold 300 million MEMS microphones.

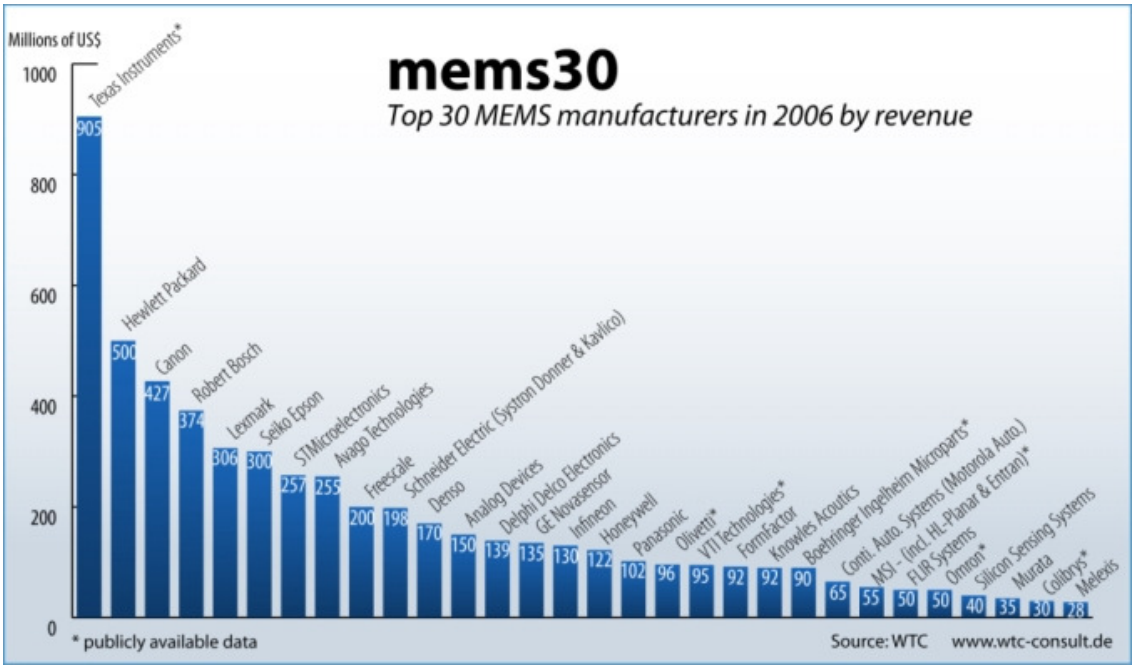


Figure 2: MEMS top 30, according to 2006 revenue. HP suddenly gives us a lot of revenue to Canon.

The iPhone was introduced around January 2007. The iPhone release is paralleled by another product, the Nintendo Wii, in November 2006 (for the Christmas season). These event would surely change the MEMS revenue landscape, as you will see later.

HP's second-quarter revenue was $22b, making the total yearly revenue around $80b still. This is according to HP investor relations published source. Also according to the report, details about the Imaging and Printing Group can be found. It says:

Imaging and Printing Group (IPG) revenue grew 5% year-over-year to $6.7 billion. On a year-over-year basis, supplies revenue grew 10%, commercial hardware revenue grew 4% and consumer hardware revenue declined 8%. Momentum in key growth initiatives continued, with color laser printer shipments and printer-based MFP shipments up 38% and 44% year-over-year, respectively. HP Indigo Press printed page volume grew 42% over the prior year period. Operating profit was $1.0 billion, or 15.5% of revenue, up from a profit of $814 million, or 12.7% of revenue, in the prior year period.

By this estimate, the HP imaging group's yearly revenue is around $28b, and the profit is around $4b for the year. The MEMS printer head business appears to contribute 1/50 of HP imaging group's revenue.

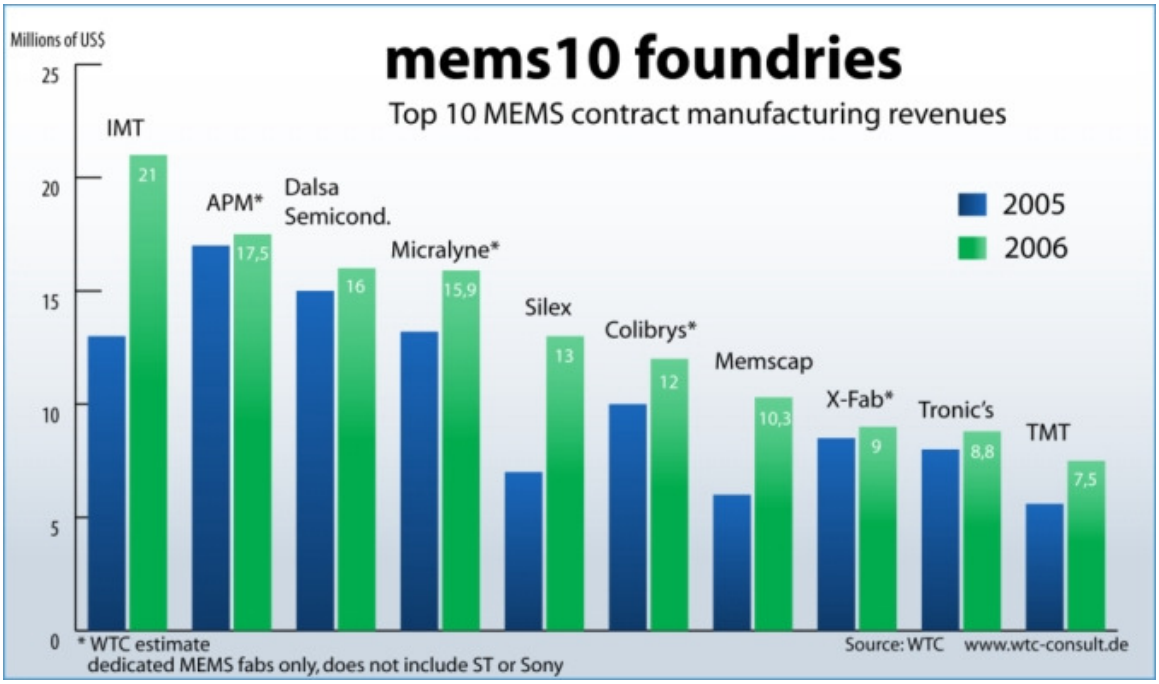


Figure 3: Top 10 MEMS Foundries, 2006.

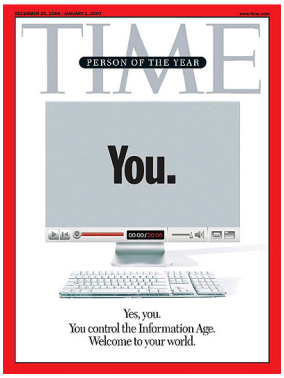


Figure 4: The Time Man of the Year of 2006 is the mobile and connected YOU. To make YOU, you must have computers, mobility, cameras, and portable electronics.

2007

Global revenue for MEMS device in cell phone = $299M
Global market of MEMS accelerometers for CE (consumer electronics) devices = $947.7 M
ST Micro accelerometer revenue = $29M
MEMS market for automotives = $ 1.6B

HP earned $850 M from inkjet printer head business, beating TI to top the MEMS revenue chart.

TI's MEMS revenue droped 10% from 2006 to 2007, as DLP came under heavy pressure, perhaps from large screen LCD manufacturers, personal home large screen TV. TI tried very hard to use DLP in back projection large screen TVs. However, it seems that the LCD large screen TV holds a dominant position. According to a New York Times article on January 26, 2009,

> Texas Instruments announced across-the-board losses and employee layoffs on Monday. One of the areas hardest hit was the division that creates the DLP technology used in most rear-projection TVs. Revenue in that group, which also includes calculators and microprocessors, dropped 30 percent and profit dropped 70 percent. Within the last few months, several DLP division executives, seeing the writing on the wall, have left TI. TI said it would lay off 1,800 people across divisions and accept voluntary retirements from 1,600 more. Given the state of the rear-projection business, the results are not surprising. The company had already ceded ground to flat-panel TV technology in every size below 55 inches, and with new, more efficient LCD manufacturing facilities opening in about two years, it's likely that except for the very biggest supersize TVs and front projectors, everyone will be buying a flat TV using either LCD or plasma technology.

Google revenue=$16.6b, with profit of $3b.

2008

2008 is a watershed year for consumer electronics. The growth of consumer electronics introduced new energy into the MEMS market.

ST Micro accelerometer revenue=$220M

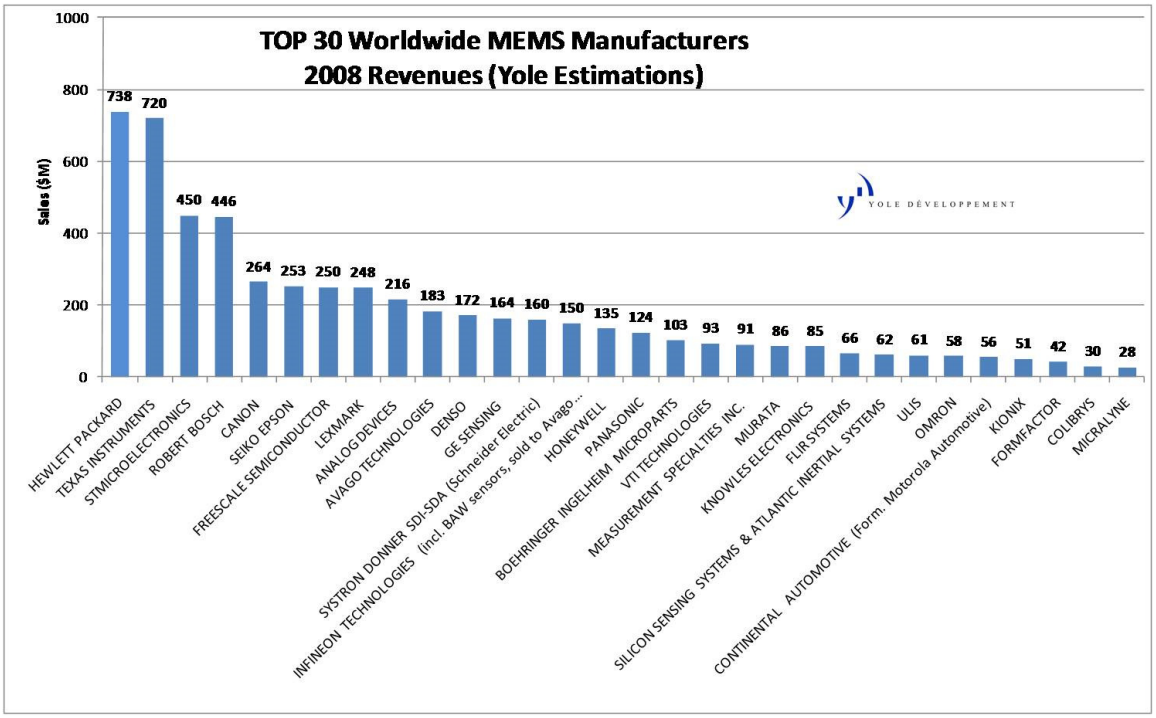


Figure 5: Yole development top 30 MEMS companies.

	2007	2008
Bosch	457	429
Denso	220	200
Freescale	196	191
Sensata	140	142
Infineon	123	130
Schneider Electric (SDA & Kavlico)	150	127
Analog Devices	94	87
VTI	86	79
Panasonic Industrial Work	75	76
Delphi	88	72

Figure 6: Automotive MEMS Vendors sales.

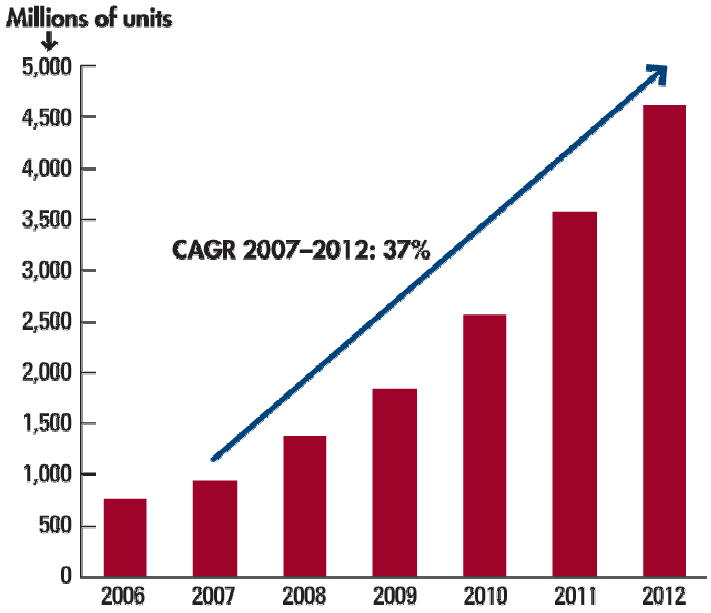


Figure 7.: Expansion in applications of MEMS in consumer and mobile space.

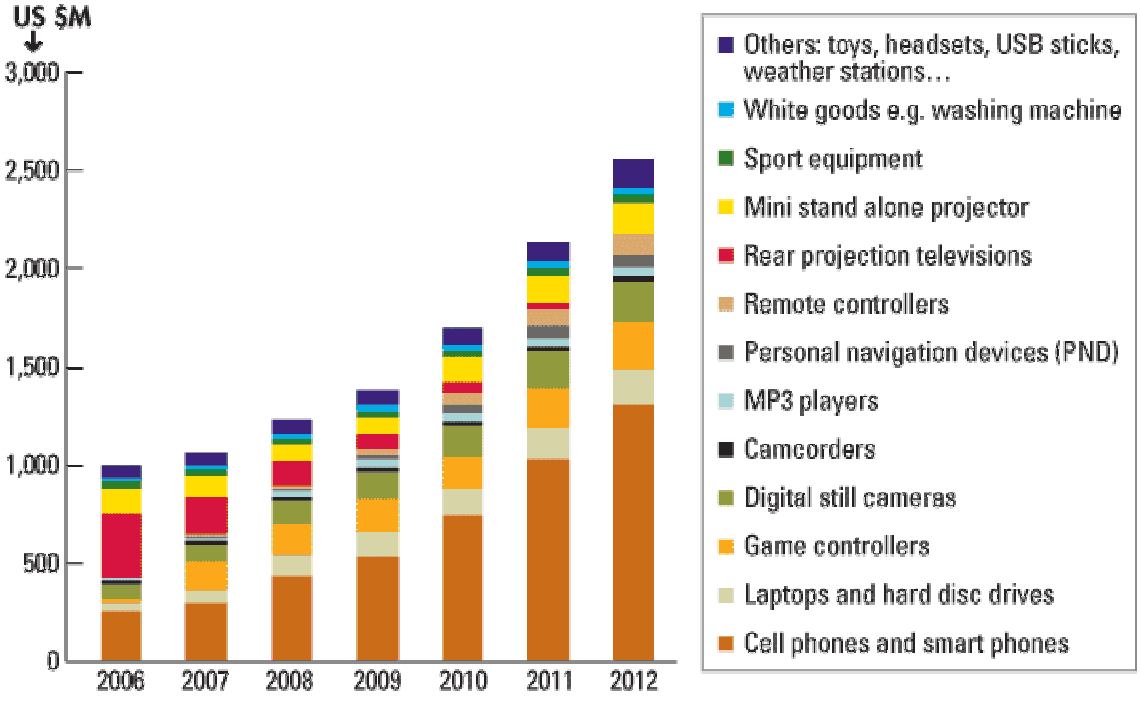


Figure 8: Consumer and mobile MEMS products.

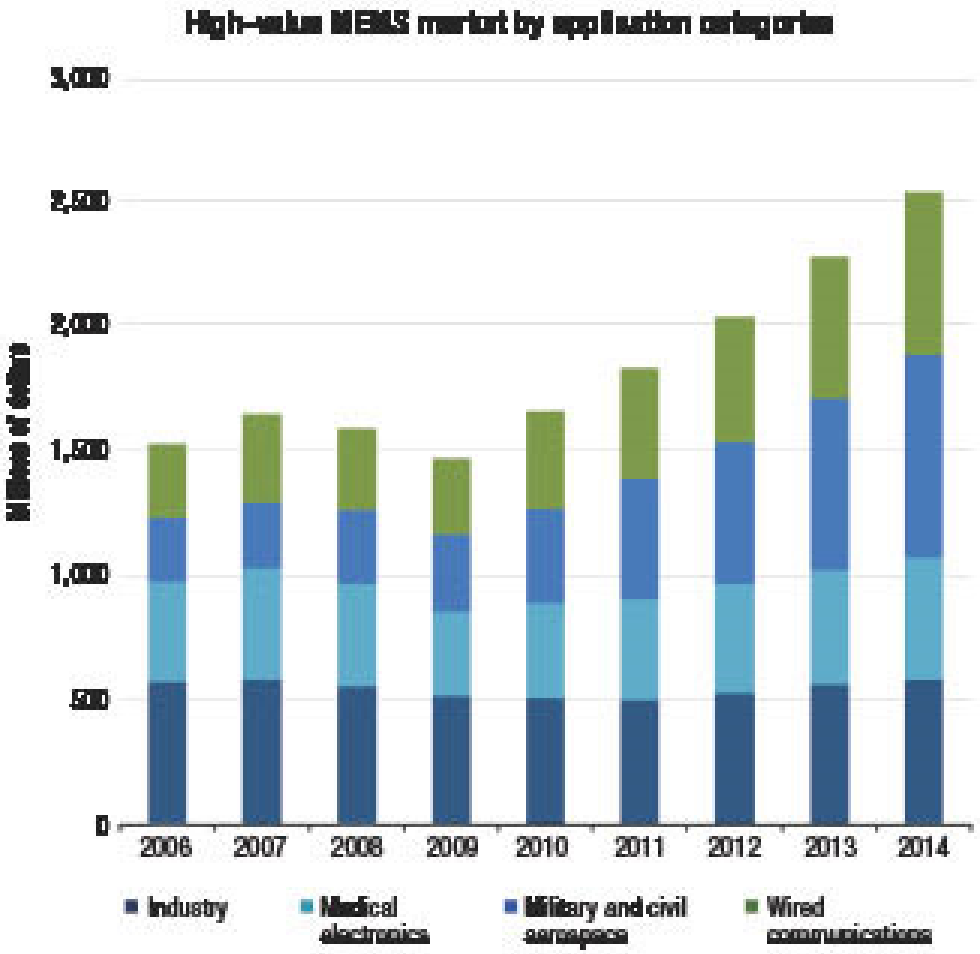


Figure 9: High volume MEMS market by categories: Industry, Medical Electronics, Military and Civil, Wired communications.

The trend of fables processing is growing. Fabless companies do not manufacture its own products. It simply design a MEMS product, and send the job elsewhere. According to the following figure, one can see that HP, Lexmark and Analog Devices all have strong fables components. Lexmark appears to be entirely sourcing the production part out.

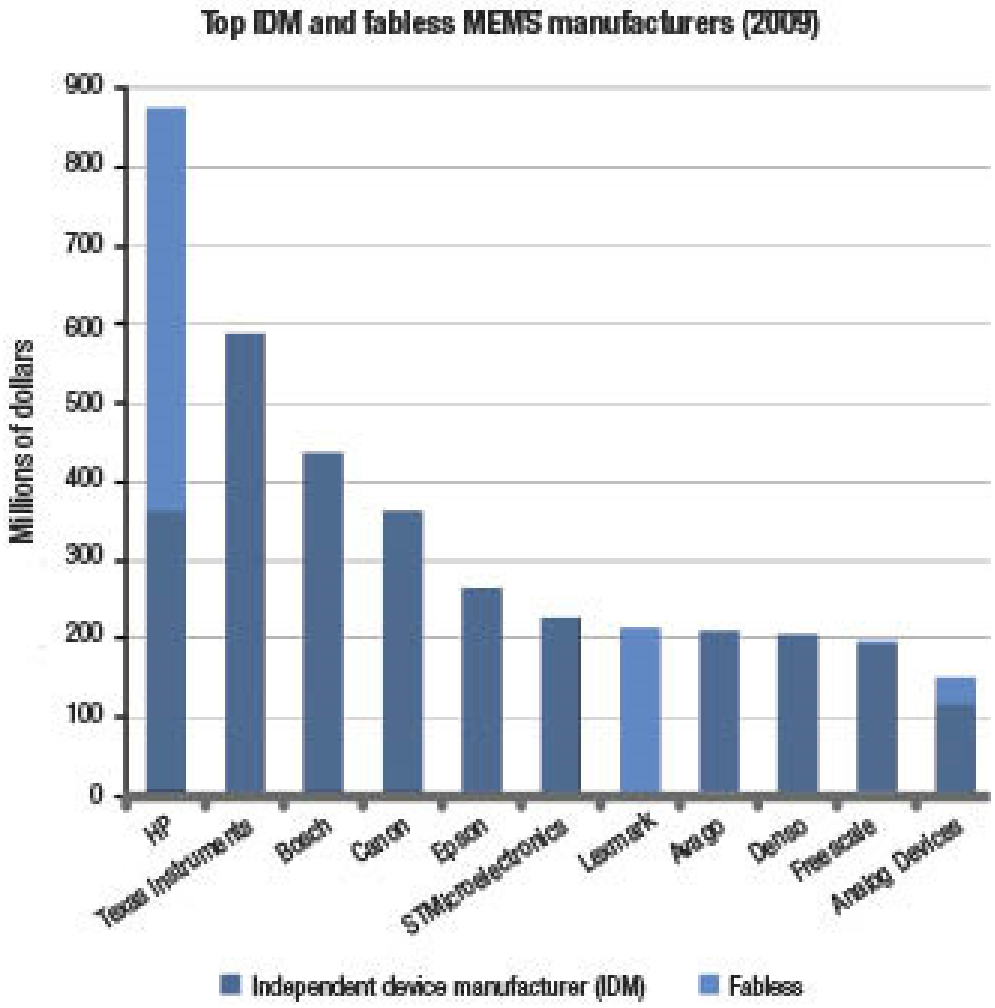


Figure 10: MEMS producers in perhaps 2008. HP was able to beat both Canon and TI.

Google revenue=$21.8b, with profit of $4b. (97% from advertising)

2009

Global accelerometer in cell phone = $220M

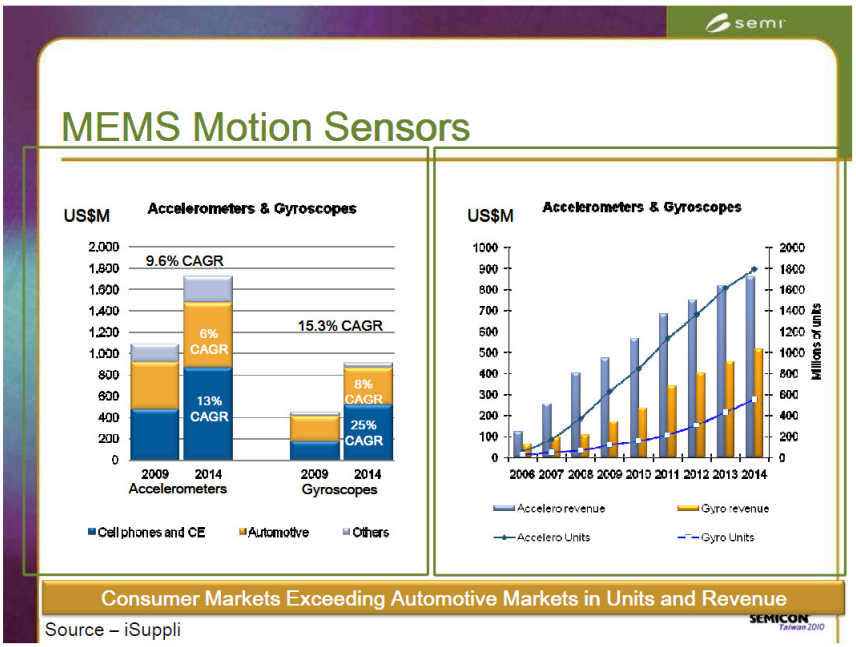


Figure 11: Market analysis by iSuppli.

Market Forecast by Device Application

- High growth segments : Accelerometers, Gyroscopes, Microfluidics
- Emerging segments : RF MEMS, Si Microphones, MOEMS, Microbolometers

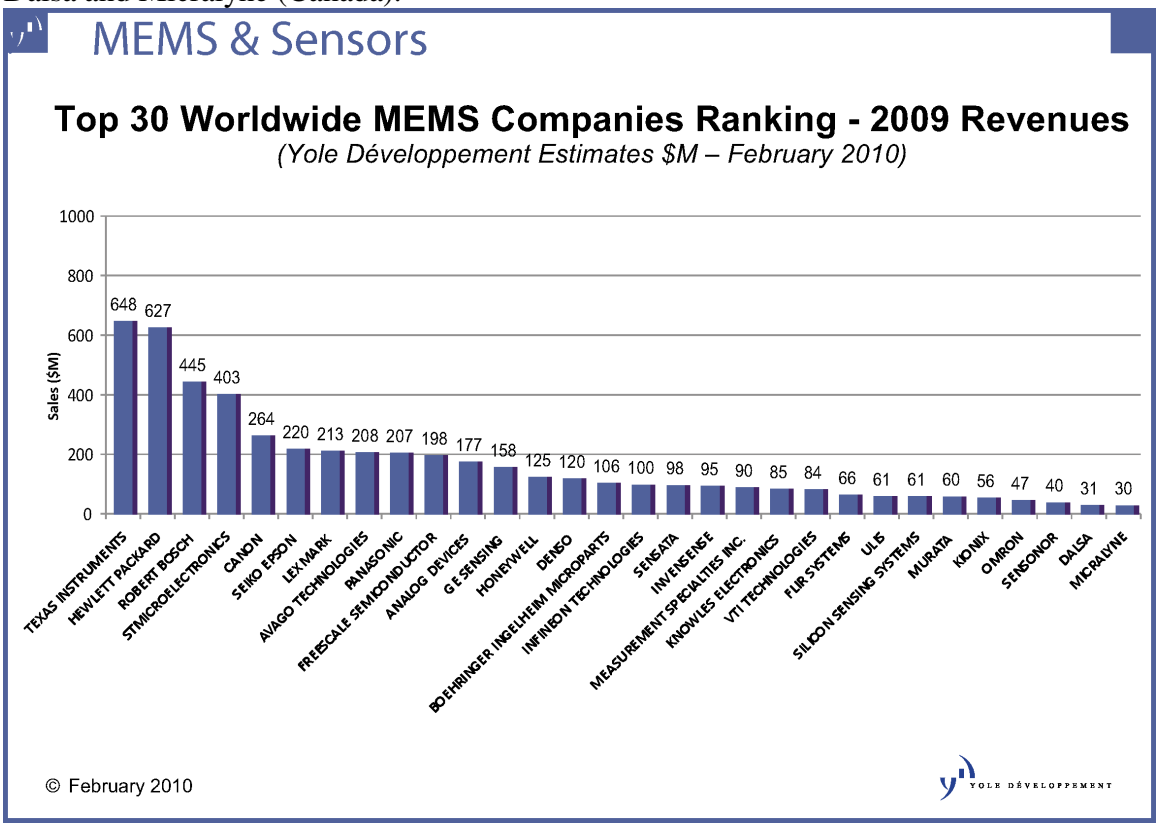
	2007	2008	2009	2010	2011	2012	08'-12' CAGR	09'-12' CAGR
Total MEMS Market	7,002	6,833	6,893	7,969	9,874	13,202	18%	24%
IJ Heads	1,867	1,658	1,462	1,610	1,820	2,327	9%	17%
Pressure Sensors	1,116	1,046	990	1,041	1,141	1,314	6%	10%
Accelerometers	883	893	940	1,122	1,377	1,747	18%	23%
Microfluids	677	787	898	1,052	1,546	1,947	25%	29%
Gyroscopes	814	833	841	945	1,100	1,474	15%	21%
Microdisplays	804	699	658	746	1,007	1,495	21%	31%
RF MEMS	250	261	314	499	748	1,154	45%	54%
MOEMS	188	198	244	270	272	369	17%	15%
Microbolometers	161	187	228	254	301	356	17%	16%
Si Microphones	117	135	159	193	238	325	25%	27%
Micro tops & Probes	125	127	113	134	155	166	7%	14%
Micro Fuel Cells	0	1	26	65	104	448	360%	158%
Emerging MEMS (autof	0	8	20	38	65	80	78%	59%

Source:Yole, 200910

Figure 12: Market analysis by Yole.

Here is market information of top performing MEMS companies. As one can see, TI's revenue is not at the earlier $900M anymore, and Canon's distance to HP has increased again. ST nearly rivals Bosch. The consumer electronics (cell phone) has made the following companies large: Avago (Cell phone high frequency components), Sensata,

InvenSense, Knowles, Kionix. Two foundry companies actually made into the top 30: Dalsa and Micralyne (Canada).



September 3, 2009, Knowles SiSonic sold 1 billion device.

In the fourth quarter (Q4) of 2009, HP reported revenue of $30b on its investor website. This makes their yearly revenue around $120b. The imaging group pulled in $4.3b of revenue. This makes the overall revenue for the year for the Imaging Group approximately $16b.

According to Google investor relations, Google's full year revenue is $23b.

2010

Global accelerometer in cell phone = $426M

Global MEMS in cell phones: $821 M.

24% unit growth predicted, until 2015.

Global MEMS sales: $8B

However, 2010 is the year that most MEMS companies starts to taste the other end of success – competition. The large CE market brings price competition. For example:

A 3-axis accelerometer that cost $3 in 2007 now sells for only $0.65, almost a five-fold plunge

A 2-axis gyro is $1.80, almost a 10X drop. These falling prices have spurred major market growth. “It’s crazy but it does open up new markets of tens of millions of units, in a big leveraging effect,”.

By 9/2010， ST has sold over 850 million accelerometers and gyros cumulatively.

In comparison, Google’s revenue in 2010 is $29b, with the profit being $8.5b. (According to Wikipedia account of Google).

Automotive MEMS Sensor Market to Reach Record High in 2010
http://www.isuppli.com/MEMS-and-Sensors/News/Pages/Automotive-MEMS-Sensor-Market-to-Reach-Record-High-in-2010.aspx

Marking a new high point for the industry, shipments of automotive MEMS sensors will reach 662.3 million units in 2010, up a robust 32.1 percent from 501.2 million units in 2009. The projected year-end levels—including the replenishment of inventory pipelines that were depleted during the recession of 2009—will exceed even the pre-crisis high point in 2007 of 640 million sensors, iSuppli data research shows.

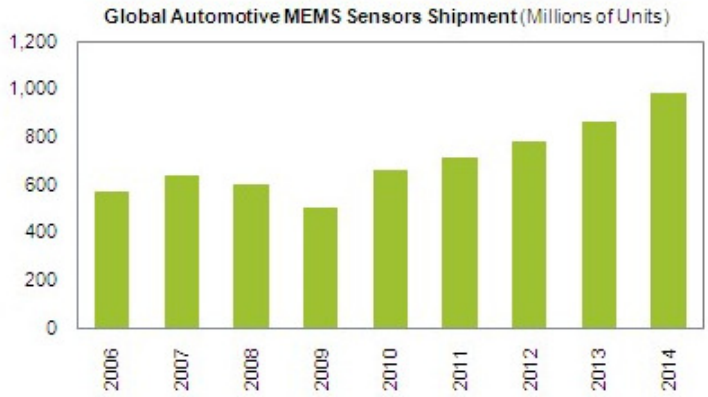


Figure 13: Global automotive MEMS shipment. Note the dip caused by the 2008 recession.

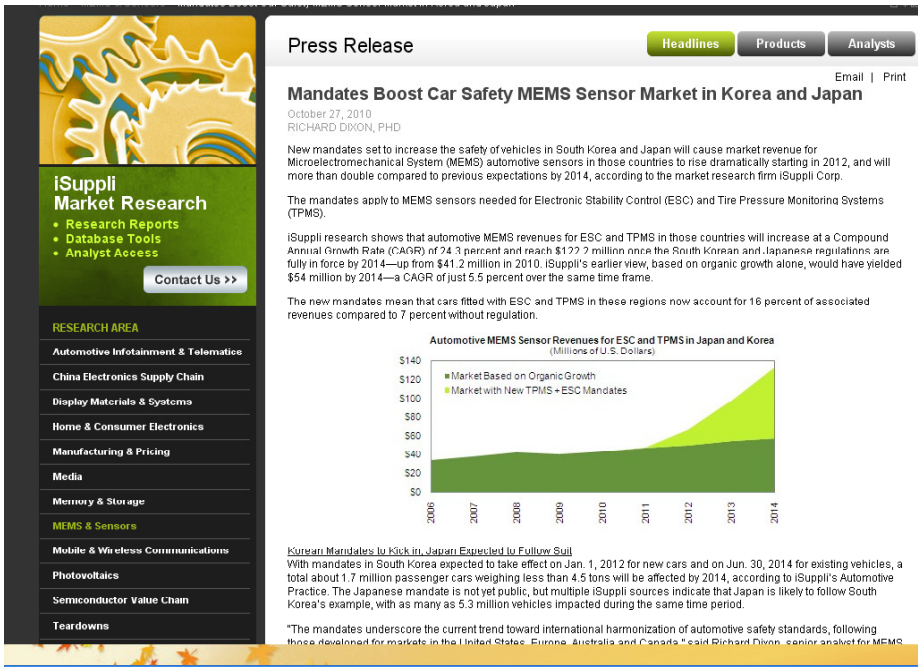


Figure 14: Asian country mandates (similar to the one introduced in US around 1990s) causes new surge of MEMS.

Figure 15: The global MEMS industry size seems to be comparable to the global display driver IC industry.

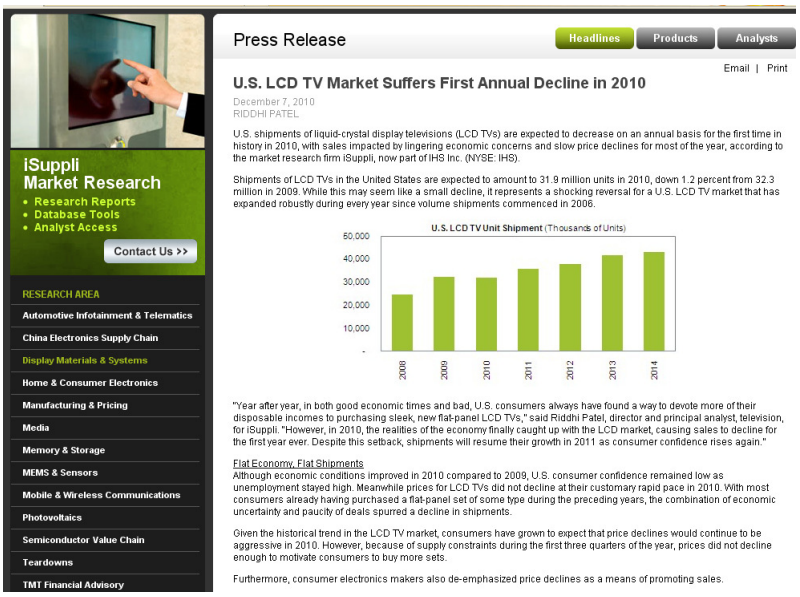


Figure 16: Is the LCD market finally saturating? if so, what is coming next?

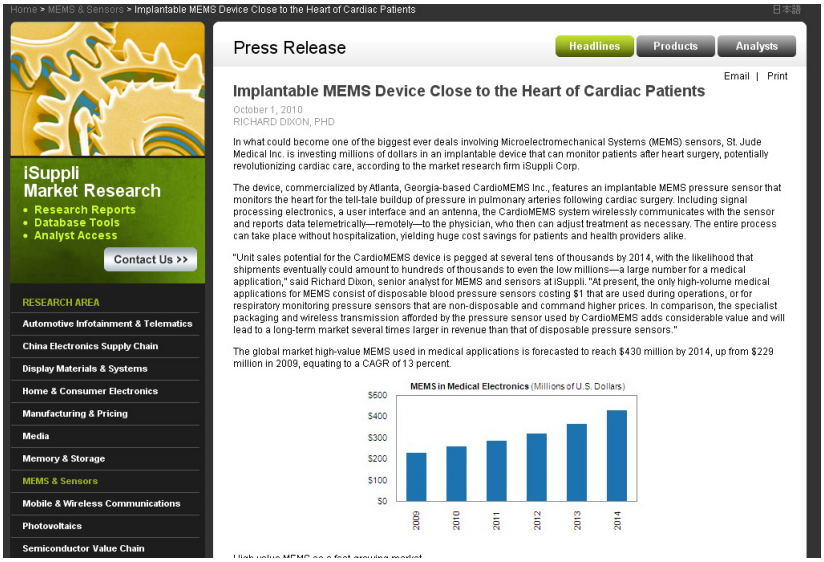


Figure 17: One bright spot of MEMS in 2010 is the market success of CardioMEMS.

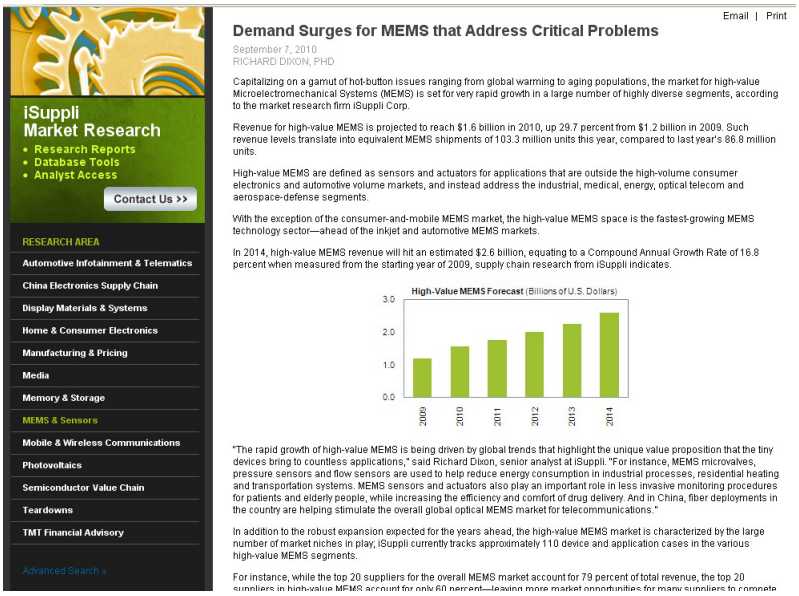


Figure 18: It is projected that NON-consumer-electronics related MEMS continues to grow at an annual rate of around 17%.

2011

Here are some key predictions:

- Global accelerometer sale increase by >10% year
- Global MEMS in cell phones: close to $1B. Up more than 20% from 2010.
- 24% unit growth of MEMS is predicted, until 2015.

The share price, market capitalization, PE/ratio, and earning per share of some major companies on December 1, 2011 are listed below. The size of Google and HP is misleading if you only read the share prices and market capitalization information. HP still makes far more revenue than Google. The market capitalization is also related to how many shares are there on the market. HP, being a much older company, has about 10 times shares floating on Nasdaq than Google.

Company (stock symbol)	Share price ($)	Market cap ($)	PE ratio	Earning per share ($)
Google (GOOG)	610	200 billion	21	29
HP (HPQ)	28	56 billion	8.5	3.32
Texas Instr (TXN)	30	34 billion	12	2.4
Analog Devices (ADI)	34	10.4 billion	12	2.81
Cepheid	34	2.2 billion	437	0.08
Groupon (GRPN)	18	11.48 billion	N/A	-2.17
Apple (AAPL)	385	358 billion	14	28
Nanosphere	1.66	0.072 billion	N/A	-1.01

The PE ratio, which is called the Price Earning ratio, is the ratio of a company's share price divided by per-share profit. A high PE ratio indicate "hotness" of the company. Traditional companies may be large but have low PE ratios.

2012

Global revenue for MEMS device in cell phone expected = $1.3B

Projected global MEMS revenue: $13.4B

24% unit growth predicted, until 2015.

2013

Global market of MEMS accelerometers for CE devices = $1.7B

Figure 19: MEMS accelerometer market, iSuppli.

2014-2015

24% unit growth predicted, until 2015. This kind of growth is even attracting traditional IC companies to enter the MEMS market, by integrating MEMS with IC.

Below are excerpts from market forecast reports made by Yole and iSuppli. Note that Yole seems to report higher numbers compared with iSuppli. However, this discrepancy seems to be consistent across all years.

MEMS, as the technology is known to those less inclined to tongue-twisters, is expected to grow from $8 billion in sales in 2010 to $16.4 billion by 2015, according to Yole Développement, a market research firm based in Lyon, France. The forecast reflects a

compound annual growth rate (CAGR) of about 15 percent.

Meanwhile, iSuppli Corp., a market research firm based in El Segundo, Calif., forecasts MEMS device sales to climb from more than $6 billion this year to about $10 billion in 2014, representing a CAGR of 11.6 percent. And it's possible that growth rate could continue through 2020, bringing the MEMS market to more than $20 billion, said Jeremie Bouchaud, iSuppli's director and principal analyst for MEMS and sensors.

I hope you enjoy reading this article. Cheers!

MEMS Central