

IR Sensor Chip 8x1
(Courtesy of Omron Electronic
Components LLC)

"First of these products to surpass the \$100 million mark will likely be MEMS oscillators," predicts Yole Développement.

Emerging MEMS: Leading suppliers say MEMS oscillators, picoprojectors and tunable RF are finally ready to take off

Leading suppliers say the time has at last come for MEMS oscillators, picoprojectors, and tunable RF to break through to the next level. Yole Développement thinks they may be right this time, with each of these markets now on track to pass the \$100 million -- though it may still take two to four more years.

Maturing MEMS technology, maturing customer acceptance of MEMS technology, and the burgeoning market for smart phones seeking differentiated value, may start to push some long-emerging MEMS devices into real commercial volume markets over the next few years.

Yole Développement expects the total market for emerging MEMS devices to nearly double over the next two years, from ~\$445 million this year to some \$950 million in 2014, and to see 42% CAGR for the next five years to reach \$2.8 billion. First of

these products to surpass the \$100 million mark will likely be MEMS oscillators, which we expect will reach that milestone in about 2014, followed by micromirrors for picoprojectors and autofocus devices in about 2015, and RF switches and variable capacitors by around 2016. Like the MEMS market in general, a major proportion of the rest of the emerging MEMS market consists of a widely diverse range of products in very small volumes, and we see growth potential in these newer products too, such as thermal sensors, audio speakers and force-sensitive sensors.

MEMS'

Trends

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Suppliers of these devices say this growth is of course in large part enabled by improved technology that brings performance up to expectations, but also in part from market forces trending in their favor, from the enabling infrastructure of easily accessible video content for pico projectors, to the LTE generation's dynamic frequency adjustment issues that may require tunable RF components. Now the key issues may move on to the business basics of marketing and distribution.

SiTime turns focus to designers' needs to grow MEMS oscillator sales to next level

SiTime plans a sharper focus on making designers' jobs easier with more applications support, speedier delivery of custom devices, and a stepped up effort to educate users on the performance and resilience advantages of MEMS oscillators. A partnership with established timing supplier Vectron should help reach more of its high-end customers. And lower power devices in development for the mobile phone market could finally turn the small size of the MEMS devices to competitive advantage.

"The game is changing from manufacturing to marketing," says SiTime VP of marketing Piyush Sevalia. "If every designer in the world just knew that MEMS was such a compelling alternative, they'd all use it.... Now it's a matter of who has the best market reach and who executes best on channel push, and pull with new technology."

"More phones with the projectors are expected in the next six months," reports Frank Moizio, Texas Instruments.

It's perhaps a sign of maturity of the MEMS timing segment that growth now comes down to business basics of marketing and distribution. Over the last seven years, SiTime has mastered the manufacturability, overcome resistance to MEMS technology, then drastically improved the technology to meet performance requirements for more demanding markets, improving jitter by 300X to 0.5ps in five years, and frequency stability 250x to 0.1ppm. The company recently made a listing of the top 10 XO oscillator suppliers, with some 3% market share, and says it has shipped 120M units to date to 800 customers, as sales doubled last year. Still, total Yole

Développement estimates revenues remained under \$20 million for 2011 in this \$6 billion market.

So in addition to developing technology for mobile and very high-end telecommunication applications, SiTime is investing in campaigns to get out the word about better MEMS product performance and resilience, based on data from a stepped up testing program. It's offering online tools for engineers to figure out the parameters for their designs, with online ordering and shipment of custom samples within 48 hours, with more such service improvements planned to come.

MEMS small size will likely become a competitive advantage going forward. It hasn't been so yet, as customers have typically preferred their MEMS devices in the same size packages as the traditional quartz devices for easy drop in replacement and interchangeability.

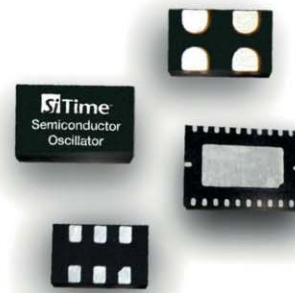
But the mobile phone makers will care about size, once MEMS can bring down power consumption enough for that market. "Look for an announcement in the next six months," says Sevalia. "Then MEMS will start to shine for its smaller size and enhanced feature integration."

Other users in the mobile segment have at least increased their trust in the reliability of MEMS enough to convert most orders to the smallest quartz package size available as the security backstop, even though actually replacing the MEMS with quartz in that size

package would be much more expensive. The coming influx of other MEMS timing suppliers could also ease users' concerns with alternative supply of the smaller devices.

TI reports more picoprojectors coming in next few months

Leading micromirror supplier Texas Instruments argues that improved technology, and the wide availability of easily accessible content are finally making the pico projector a compelling option. Now more real products that consumers can see in phones and retailers may start to spur demand.



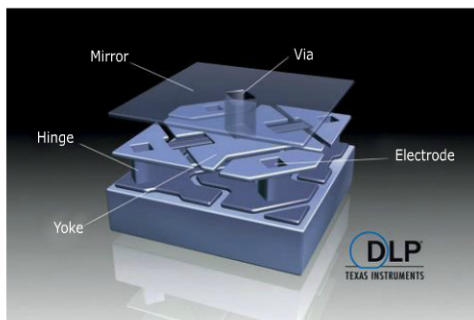
Oscillators in plastic package
(Courtesy of SiTime)

Samsung's svelt Galaxy Beam pico projector phone out in multiple world markets is a major start. More phones with the projectors are expected in the next six months, and major retailers will stock multiple phone-accessory projectors by the Christmas season, reports Frank Moizio, TI business manager for DLP pico displays, arguing that this visibility will draw consumers. "Once you actually use the phone with the picoprojector, you really see its value," says Moizio, ticking off how he recently used his new Samsung Galaxy Beam phone for giving small group presentations, sharing pictures from events, and easily showing his parents his talks on YouTube.

The technology may at last be ready for prime time. On the MEMS side, major progress had been made in driving down the size of the DLP pixels, from the 10-12µm for TVs down to 7.5µm, to decrease the size of the array, reducing the power needed to drive the smaller mirrors, and allowing smaller die size, with simpler thermal management, to bring down costs. Major efforts have also gone into reducing the power usage of the rest of the chipset, and improving the efficiency of the LED illumination and the optics as well, to at last achieve enough brightness for good visibility with reasonable battery life and reasonable cost. The Samsung phone claims three-hour battery runtime for the 15 lm projector, at a price about that of other high-end smart phones, from ~\$500-\$550 alone down free on some contracts.

Besides the Samsung phone and others coming, Brookstone, Wal-Mart and Target are now stocking ~\$200 accessory picoprojectors that fit around the phone like a sleeve, and multiple products will reportedly be available in multiple retailers this holiday season. Small stand-alone projectors, both plug-in and battery-powered, have similarly improved in performance and availability.

"Demand for saving energy will drive adoption of low-cost, infrared noncontact thermal sensors,"
says Donna Sandfox,
Omron Electronic
Components LLC.



*DLP-chip-mirror-technical-architecture
(Courtesy of Texas Instruments)*

"These live in-store demos or seeing a friend use the device will really help people see the value," argues Moizio.

Also helpful is the wide array of content now available on consumers' smart phones and tablets that can easily be projected directly, or easily ported to a separate projector with an HDMI cable connection, for more comfortable viewing and sharing of television, movies and games in any setting. One might think that the larger and sharper displays on all these handheld devices would cut down demand for picoprojectors, but Moizio says, "Our experience is just the opposite. The 20-30 inch image is just much better, and the tablets make it easy to get content to the projected display."

WiSpry says LTE should catalyze market pull for tunable RF

WiSpry argues that LTE will finally drive demand for RF MEMS devices. "It's become very clear over the last 3-6 months that the market has caught up with the solution we can provide," says Jeff Hilbert, president and founder. He notes that 3G phones had problems that antenna tuners could solve, but with the LTE generation tunability starts to become more essential—and LTE handset units will reach some 75-100 million units this year, 250-300 million next.

At the same time that even thinner phones mean less volume available for antennas, many more frequency bands and higher data rates make their job more demanding. Handset makers are also now looking to temporarily aggregate different channels to create one fatter channel for high-bandwidth on-demand data downloads, and this need for dynamic frequency flexibility brings much more interest in tunable components.

"In the last quarter I've had as many people ask about carrier aggregation as about antenna tuning in general," says Hilbert. "With LTE the technology is becoming essential. I'm bullish we'll finally get out of the full-production-soon stage. ...The sector is gearing up for the real deployment wave this time around."

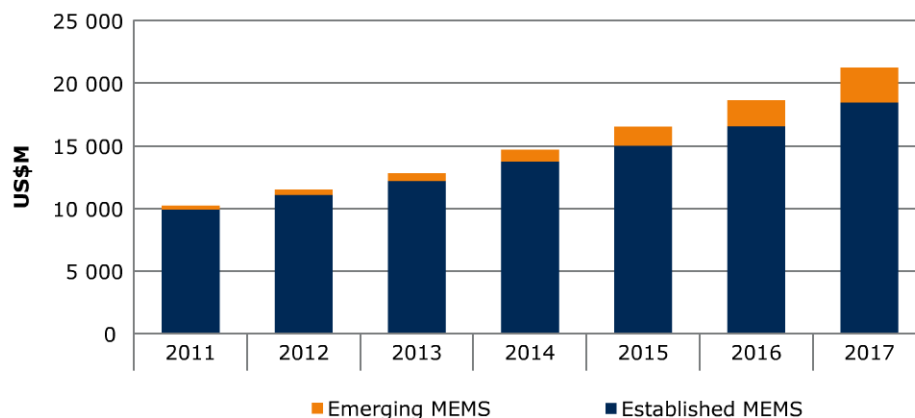
Though WiSpry has been shipping its RF MEMS devices in volume for multiple phones, customers have remained reluctant to add a new component and its cost, when network connection problems weren't of as much driving interest to consumers as things like display quality and applications. And customers needed more support to integrate an entirely new kind of device. "The number one lesson we have learned is the big gap between having a working MEMS and selling a working product," says Hilbert, noting the need for collateral, reference designs, development kits, applications support and the like.

In addition, competing semiconductor switch-based solutions made on GaAs or SOI didn't raise user concerns about MEMS manufacturability, and were somewhat easier to integrate, though Hilbert argues WiSpry's MEMS solution offers significantly better performance for more difficult applications.

The relatively larger size of a MEMS solution has also recently become more of a concern, but Hilbert argues that though the MEMS array is somewhat

2011-2017 MEMS markets

(Source: Status of the MEMS industry report, July 2012, Yole Développement)



larger than its semiconductor competitors, the actual area per amount of capacitance is about the same. WiSpry has also accelerated its roadmap to shrink its device, targeting products less than half the current size to come in the next two quarters, thanks to maximizing MEMS design re-use, a limited number of mask-level changes to create new floor plans and capacitor characteristics, and improvements in wafer-level encapsulation and packaging.

The company is also extending its tunable array platform to a wider portfolio of products, starting with on-demand filters and tunable antennas, and aiming next at tunable power amplifiers. It's sampling a tunable filter for LTE and CDMA low frequency bands which enables voice and data transmission over the two networks at the same time. When not needed, the filter can be tuned out of the bands, essentially switching it off to eliminate over 75% of its insertion loss.

"The market has truly arrived that will need antenna tuners--that was not the case a year ago," Hilbert argues. "It's clear to customers now that they have to pay more attention to the RF front-end and the antennas, or the rest of the gee-whiz apps aren't going to matter because they won't work be fast enough and won't work reliably....LTE will drive significant revenue growth in this sector in 2013, with multiple design wins from multiple customers."

Omron counts on demand for energy savings to drive sales of thermal sensors

Omron expects demand for saving energy will drive adoption of low-cost, infrared non-contact thermal sensors--the latest new MEMS device to go into mass production. It's offering the devices in modules on boards with microcontrollers and connectors for easy integration into building automation systems, to sense the presence of people in a room—even if they're not moving-- to adjust lights and temperature accordingly to save energy. The system reportedly measures the heat of an area with sensitivity of 1.4°C, to detect people ~4-6 meters away, without the high resolution of an uncooled microbolometer, but at a much lower cost.

The thermopile-based technology is related to that used in some Omron flow sensors, but with improved resolution, based on the difference in temperature between the hot junctions on dielectric and cold junctions on silicon of the polysilicon/aluminum thermocouple stack.

The array of 8 to 16 die is topped with a silicon lens to focus the radiation on the membrane.

Donna Sandfox, sensor and healthcare module product manager, says potential customers who've seen the demonstration device have been interested



*D6T thermalIR
(Courtesy of Omron Electronic Components LLC)*

in samples for a wider range of other applications as well, including turning off displays on computers and other appliances when no one is around. There's also interest in industrial monitoring applications, such as remotely watching for hot spots in equipment or checking the temperature of large containers of liquid.

Paula Doe for Yole Développement



Jeff Hilbert, President & Founder, Wispry

Jeff Hilbert is founder of the company, bringing over 35 years of executive management and technical experience, in a number of leading semiconductor and MEMS companies including LSI Logic, Compass Design Automation, AMCC, Motorola, Harris and Coventor. Hilbert holds a bachelor of science in chemical engineering from the University of Florida and master of science in computer science from Florida Institute of Technology.



Frank Moizio, Business Manager DLP Pico Projection, Texas Instruments

Frank Moizio has contributed to the team at Texas Instruments in both management and technical capacities for more than 20 years. He holds a BSEE from WPI and a MSEE from SMU. He earned his MBA from SMU's Cox School of Business. Mr. Moizio holds six patents in the areas of Digital Control and Digital Signal Processing.



Donna Sandfox, Product Manager for sensors and MEMS products, Omron Electronic Components LLC.

Her primary area of expertise is in MEMS Mass Flow Sensors. She also supports Omron's pressure, thermal IR, tilt/vibration and optical (photomicrosensors) sensors, as well as their RF MEMS Switch products. Donna received her bachelor's degree in mechanical engineering from Southern Illinois University and an MBA from Roosevelt University.



Piyush Sevalia, Executive Vice President, Marketing, SiTime

Piyush Sevalia has over 20 years of semiconductor industry experience. Prior to SiTime, Piyush was the Vice President of Marketing at Ikanos Communications (Nasdaq: IKAN). During his tenure at Ikanos, Piyush made significant contributions that drove the company's growth from a pre-revenue startup to a profitable, public company. Before Ikanos, Piyush spent over nine years at Cypress Semiconductor in positions of increasing responsibility. There, his key contributions included helping Cypress expand into wireless markets as well as defining and launching successful timing products that generated several hundred million dollars of revenue. Piyush earned Bachelor's and Master's degrees in Electrical Engineering from the University of Bombay and the University of Michigan respectively, and an MBA from the University of California, Berkeley.