SEMICON, PACKAGING & ASSEMBLY REPORT
October 2007

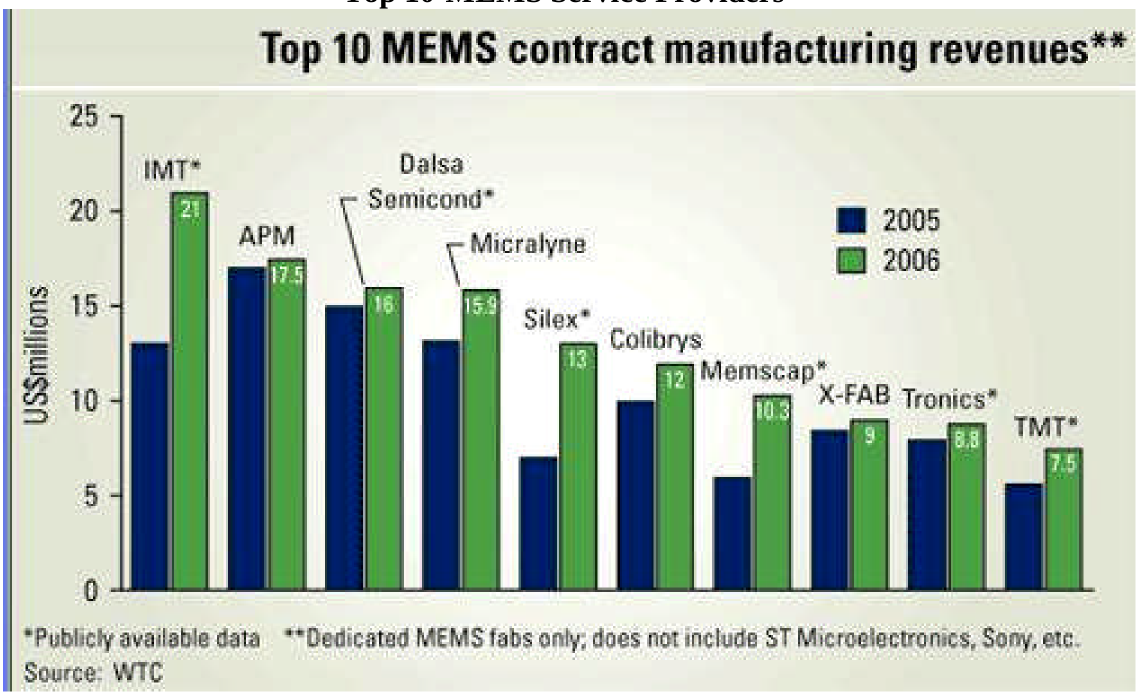
From Ken Gilleo - Ken@ET-Trends.com

ET TRENDS

BUSINESS & MARKET NEWS

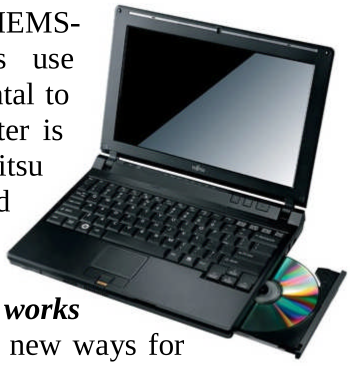
MEMS Momentum - The MEMS industry has made substantial progress in the past few years and the infrastructure is being built out. The top revenue-generating contract foundry, Innovative Micro Technology (IMT), grew 50% from 2005 to 2006. IMT helped advance wafer-level packaging (WLP) for MEMS and has extensive experience in the design, prototyping, process development, and high-volume manufacturing of a wide range of products and applications such as biometrics, biotechnology, imaging, metrology, inertial measurement, optoelectronics, sensing, microfluidics, RF switching, and switch arrays. They can handle a variety of materials like metals, magnetic, polymers, etc. Predictions are that increasing business for contract MEMS manufacturers will continue. Tronics (France) is also extending MEMS services and recently made its second expansion in the past year, adding new space and tools to improve its characterization, assembly, packaging, and testing capabilities. The expansion aims to strengthen design-to-manufacture services and to support the supply chain for customers' unique MEMS devices. Last spring, the company added competencies for MEMS design and electronic interfacing of MEMS components and upgraded its production facility to 150-mm wafer technology [***MEMS has not present need to move to 300-mm, or even 200-mm, since devices are mostly discrete, non-integrated***].

Top 10-MEMS Service Providers

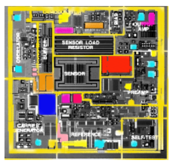


MEMS, NANOELECTRONICS and MOLECULAR ELECTRONICS

Nearly all **MEMS start-ups are fabless** and use existing foundries. ***The only exceptions are companies with pre-existing foundries that decide to make MEMS products, as either OEMs, or foundry service providers. But the idea of a one-stop-shop is still emerging.*** A MEMS developer may parcel out manufacturing tasks to different contractors, who may sub-contract some services to others. As an example, fabless MEMS developer SiTime uses Jazz Semiconductor to fabricate its MEMS silicon oscillator. But it works with SVTC Technologies, a development foundry, to transfer its 4-in. and 6-in. wafer designs to 8-in. wafers for manufacturing. Taiwan Semiconductor Manufacturing Co. (TSMC) makes the oscillator's resonator component and its signal-conditioning ASIC.



Why is MEMS on the Move? - The Nintendo Wii uses a MEMS-enabled motion controller and Apple iPhones use accelerometers to change the display from horizontal to vertical. ST Microelectronics' 3-axis accelerometer is the enabling force within Nintendo's Wii. Fujitsu laptops use a MEMS sensors to park the hard drive (this is a 3-axis device; motion graphs can be displayed) and also a MEMS microphone [***I have this MEMS-enabled laptop and MEMS works well***]. These are a few examples of how MEMS is creating new ways for people to interact with electronic devices. They illustrate the continued expansion of MEMS technology from its beginnings in the automotive and industrial markets to applications that include energy harvesting, wireless communications, "smart homes," and biomedical. The MEMS market was worth $5.8-billion in 2006 and will grow to $10.7-billion by 2011 per Yole. The leading MEMS application, inkjet heads, is followed closely by sensors for airbag deployment and tire inflation monitoring. Texas Instruments (TI) makes Digital Light Processing (DLP) MEMS for computer displays as well as for digital projection. Wicht Technologie Consulting says that TI was the top MEMS manufacturer in 2006, with $905-million in revenues. TI has reportedly shipped more than 10-million DLP sub-systems since 1996.



Analog Devices says it has shipped more than **250-million MEMS accelerometers** for automotive, consumer, and industrial applications. **VTI** Technologies reports sales of more than 25-million MEMS structures per year, and the company claims more than 50% market share in automotive low-G sensors and medical cardiac rhythm management (CRM). Robert **Bosch** GmbH, which many consider the leader in MEMS sensors, has an annual output of more than 130-million of the units. The key to the recent growth acceleration is cost. At less than $1 each, MEMS devices are becoming cost-competitive for mass-market consumer electronics. Also, MEMS meet demands for flexible, reliable sensors for consumer products, known for increasingly rapid design-to-deliver cycles.

MEMS devices are successfully replacing both off-the-shelf semiconductors and custom ASICs in applications in which those other two options were once dominant. Expect continued strong growth in accelerometer-based motion sensing for consumer and automotive applications and in combination accel-gyro units for a new generation of accurate, blur-free, global positioning systems and gesture-based navigation. There will be significant growth in silicon microphones that are shipping in the millions in mobile phones and PC laptops. RF-MEMS are also gaining ground as companies such as WiSpry offer products to "create revolutionary wireless architectures enabled by the cost-effective integration of reconfigurable RF front-ends in cellular phones." RF MEMS offer advantages over conventional (mechanical and semiconductor) technologies, such as low loss; high isolation; linearity; and large, fast, and reliable bandwidth.

MEMS is also penetrating wireless networks: MOEMS, or optical-MEMS, is expected to grow, recovering from slow growth in previous years as more telecom companies, including British Telecom and Verizon, are investing in fiber-optic networks. MEMS are increasingly used in biomedical applications, too, for instance in wireless systems that enable disease detection. MicroCHIPS Inc. is working to revolutionize the way drugs are delivered and monitored. Fuel-cell technology and vibration-based energy harvesting are among the emerging technologies for people around the world who are thinking green and creating a market for smart homes and buildings. General Electric (GE) Sensing is successfully selling and using MEMS devices that claim considerable energy efficiency and reliability. GE Sensing said that MEMS is a core technology for many of the critical sensing applications-from fuel transmission to distribution [GE Energy Oil and Gas] to actual power generation, control, and conservation. Source: Small Times.

InvenSense, another fabless MEMS producer, prefers to develop its own packaging and process technologies, design tools, and then turn them over to a fab to manufacture the company's MEMS gyroscopes. This allows the manufacture of virtually any bulk-silicon MEMS device and signal-conditioning electronics on nearly any CMOS platform. From a MEMS designer's perspective, a fabrication partner must be able to accommodate design tweaks, use new materials, and handle specialized process equipment and/or steps if needed. Another important issue is the amount of foundry time availability in the event of the need for additional design iterations-which is often tied to the size of the order. A designer must be sure that the contract foundry will not prioritize customers that have larger orders. Another service some foundries offer is computer-based simulation. MEMS-specific analysis, modeling, and simulation applications are available from companies such as Coventor and IntelliSense Software. Recently, both firms have worked with a new vendor, SoftMEMS, to develop add-on MEMS capabilities for standard electronics-design automation (EDA) software; and SoftMEMS has unveiled MEMS Xplorer (for Unix and HP platforms) and MEMS Pro (for Linux PC platforms). IMT provides simulation services using Ansys software, while some of the software providers themselves, including ESI Group, offer simulation services. Source: Small Times.

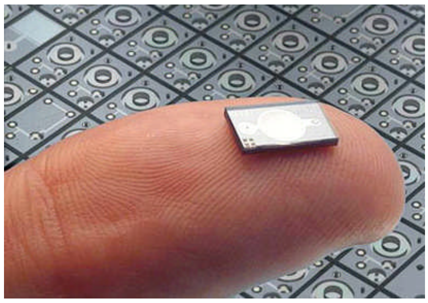
More MEMS Mics - Infineon will cooperate with microphone vendor Hosiden in developing MEMS-based microphones. The Japanese company is particularly interested in miniaturization and ruggedness using MEMS technology. Infineon will provide its semiconductor and MEMS expertise to the Hosiden which develops and produces microphones for cellphones, notebook PCs, digital still cameras and automotive navigation systems. Hosiden intends to benefit from the MEMS technology in that MEMS-based microphones are smaller and more rugged than conventional types. In particular, MEMS microphones exhibits higher heat resistance, withstanding temperatures of up to 260°C. Thus, they can be soldered directly onto a standard printed circuit board which makes them a good candidate for use in fully automated production lines. MEMS microphones also can be integrated with a microcontroller and software to enable designers or users to determine the acoustic characteristics of the microphone, an Infineon spokesperson explained. Source: EETimes.

VTI TECHNOLOGIES

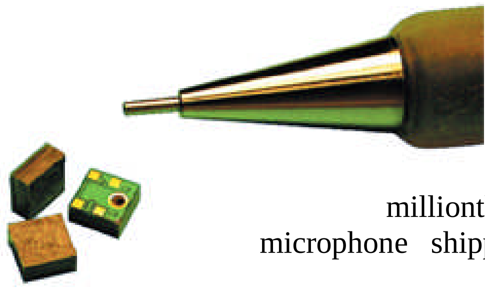
Chip-on-MEMS - ***Only a few MEMS chips have integrated electronics, like Analog Devices' iMEMS accelerometers. Many products use other chips to supply whatever is missing. Most MEMS chips are currently joined to separate CMOS ASICs after separate wafers are diced.*** But a new technique called Chip-on-MEMS bonds ASIC dice atop an entire MEMS wafer before dicing, according to developer VTI Technologies. Chip-on-MEMS is a radical step [***not really***] away from conventional packaging according to VTI (Finland), a manufacturer of MEMS accelerometers and pressure sensors for the automotive market. Even the final testing and calibration are wafer-scale processes. Besides the benefit of wafer-scale calibration and testing, VTI Technologies also claims that Chip-on-MEMS will enable them to make much thinner chips. VTI has demonstrated a combined MEMS-ASIC measuring 4 mm2 but just 1-mm thick. Typical MEMS chips bonded to ASICs are between 2- and 5-mm thick.

Eventually, VTI claims it will be able to produce Chip-on-MEMS dice one-third the thickness of today's thinnest dice. The chip-on-MEMS process works by first testing the MEMS wafer, then placing extra-thin ASIC dice face down on the MEMS wafer in known-good locations. Then 300-micron solder balls are dropped on the ASIC, which was flip-chipped with solder bumps. Finally, an underfill isolates the ASIC from the MEMS for passivation and increased reliability. Final testing can then be performed at the wafer scale before dicing the combined chip-on-MEMS device. Next, VTI said it is looking to stack multiple ASICs atop its MEMS wafers for producing 3D stacks of very complex circuitry. VTI said it hopes its technique will enable stacks of multiple 20-micron-thick ASICs to be integrated atop MEMS wafers at a much lower cost than competing 3D techniques. The company is also seeking to advance to technique to allow high-volume manufacturing. [***This looks like a Motorola concept for their OptoBuss. They piggybacked a flip chip onto a larger chip and the two devices were linked by light. Cookson Electronics supplied transparent underfill***]. Source: EETimes.

Motion Sensors - STMicroelectronics, one of the world's leading manufacturers of MEMS devices, introduced a new generation of 3-axis linear accelerometers. The versatile, low-power MEMS sensors provide complete output flexibility and embedded smart features, meeting the exploding demand for miniaturized motion-sensing solutions in the consumer and industrial markets. ST's new 3-axis motion sensors represent a significant step forward in the product's miniaturization. Developed in-house, the 3x3x0.9mm plastic package effectively addresses the space and weight constraints of portable electronic devices. The LIS331 accelerometers deliver high performance at low power consumption and their ultra-compact robust design provides very high immunity to vibration and shock survivability up to 10,000g. ST's 'nano' motion sensors are suitable for a wide range of low-g applications in the consumer and industrial markets, including motion user interfaces in mobile and gaming devices, free-fall detection for hard-disk data protection, and vibration monitoring and compensation in white-goods appliances. ST's LIS331DL integrates a standard SPI/I2C digital interface and a host of smart embedded features, including click and double-click recognition, wake-up and motion detection, high-pass filters, and two dedicated highly programmable interrupt lines.



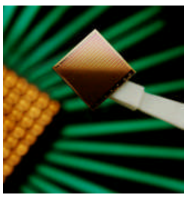
Click and double-click recognition allows manufacturers to associate simple tapping gestures with user commands, such as turning a portable device ON or OFF, opening a document, browsing an application menu, or muting a ringing mobile phone without taking it from the pocket. The configurable high-pass filters can be turned on to enable motion- activated functions and vibration monitoring regardless of whether the end product is tilted or placed upside down at the moment of measurement. Two separate, highly programmable interrupt signals enable immediate notification of motion detection and click/double-click events, giving manufacturers more freedom and flexibility in their design and applications. The consumer and industrial markets are hungry for flexible and reliable motion sensors that enable novel and friendly user interfaces and features. Leading manufacturing technology with an 8-inch MEMS high-volume production line and complete supply chain control, enable us to reduce unit costs and accelerate both the expansion of current applications and the development of new MEMS markets." The MEMS market is one of the most exciting segments of the semiconductor industry, forecast to grow at around 50% over the next five years, heading towards $10-billion by 2010. Source: ST Micro.



Microphones - Akustica pioneered system-on-chip acoustic systems by combining on- board electronics with MEMS microphones on the same chip. Everyone else uses a 2-chip system [as far as I know]. They shipped their two-millionth digital microphone. Akustica's two-millionth microphone shipped just three months after its one-millionth microphone. Akustica had reached the one-million mark 15 months after the launch of its first digital microphone, the award-winning AKU2000. Strong market demand for high-quality voice input in mobile PCs has led Akustica to introduce three more digital microphones and rapidly ramp overall production to satisfy customer demand. Akustica's CMOS microelectromechanical systems (MEMS) microphones can be manufactured in any CMOS foundry, leveraging the high-volume capabilities, quality and economies of scale of the global semiconductor market. This is the fundamental reason why Akustica has been able to ramp its production rate so quickly. By making our microphones in standard CMOS foundries, Akustica can scale manufacturing with unprecedented speed and quality. This allows our customers to integrate a new, differentiating technology into a wider array of products, accommodating the compressed design-to-delivery cycles of PCs and consumer electronics. Akustica's "milestone microphone" went to computer-maker Fujitsu which has designed Akustica's products into its LifeBook® notebooks and convertible tablet PCs. Source: Earthtimes.

<u>TECHNOLOGY FOREFRONT</u>

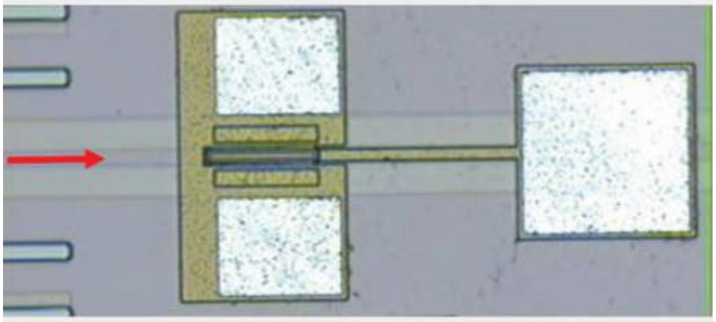
Thermoelectric Bumps for Flip Chips - Nextreme Inc. (RTP, NC) claims to have a nanotech heat management process for flip-chips. The technology embeds a thermoelectric **cooler into each bump**, or copper pillar that can either help cool chips, or can be used in reverse to generate energy from waste heat. Nextreme's thermal copper pillar technology studs the backside of flip-chips with solder bumps that not only make an electrical connection, but also help transfer heat out of the chip. The copper pillars are made thermally active by incorporating a proprietary nanoscale thermoelectric thin film into each bump. When current passes through the bumps, one end of the thermoelectrically active structure cools faster than the other, creating a thermal differential that cools chips faster. The process also works in reverse so that temperature differentials can be harnessed to generate small amounts of energy for power scavenging applications. Nextreme claims that a temperature difference of 60oC can be generated across a 60-micron-high pillar by running a current through it, enabling a maximum power-pumping capability of 150-watts per square centimeter, 10-times more than the 15 watts per square centimeter typical of flip-chips today. For power-generation applications, the same temperature differential can generate more than 3 watts per square centimeter, or about 10-mw of power per bump. Nextreme's proprietary thin film enables an embedded thermoelectric cooler (eTEC) to harness the Seebeck Effect, whereby electricity is generated from a temperature differential, which induces a difference in the Fermi energy across the thermoelectric material, yielding a voltage potential that can drive a current. The process is currently in reliability testing and will be in pilot production by the end of 2007. Applications include microprocessors, display drivers, radio-frequency discretes, watch chips, smartcards and mixed-signal devices. Source: EE Times



Intel Photonics Triple-Play - Their new light detector means all three core components of telecom networks can now be built in silicon. Researchers at Intel recently announced a silicon-based light detector that, by all measures, is better than those made of materials that are more expensive. It can detect flashes of light at a rate of 40-gigabits per second, while most of today's fiber-optic networks operate at 10-gb/s. The new detector is also more efficient and produces a cleaner signal than other detectors that operate at the same speed. Since detectors made of silicon have the potential to be manufactured on large silicon wafers, through standard processing techniques, researchers could produce detectors that are hundreds of times less expensive than those used in today's networks, which are made of materials such as indium gallium arsenide. Already, Intel has demonstrated a silicon-based laser and a silicon modulator, a device that encodes data onto light that operate at 40-gb/s. The goal is to combine all three devices on a single silicon chip. That chip would be cheap, since it could be made using manufacturing processes well honed by the microchip industry. If implemented in existing fiber-optic networks, inexpensive photonic chips could drastically reduce the cost of Internet bandwidth. Built into computers, they could move and transmit data at much greater speeds.

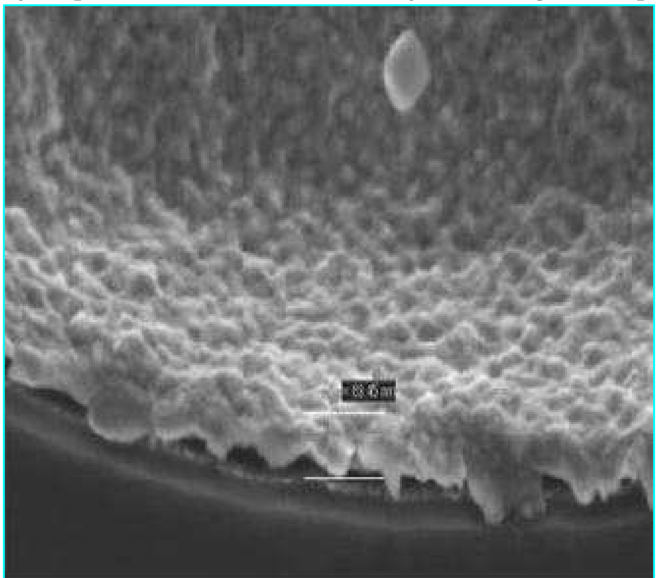
Intel's silicon detectors use the same basic principles that many other light detectors do. When photons strike a traditional detector, they produce pairs of electrons and "holes." (A hole is the absence of an electron where one would be expected; it can be thought of as a positively charged particle.) A voltage is applied across the detector, pushing the negatively charged electrons one way, and the positively charged holes the other way. The resulting electrical current provides a measure of the amount of light the detector collected. For detectors made of gallium arsenide and indium gallium arsenide, the process is straightforward: both of those materials easily produce electron-hole pairs when photons with a certain energy pass through them. Silicon, however, doesn't react to light in the same way. So in their new device, Paniccia and his team decided to use silicon as a waveguide, a sort of channel that collects and holds light. On top of the waveguide, the researchers grew layers of germanium, a material that does create electron-hole pairs when struck by photons. It's the germanium that does the actual detecting: as light passes through the silicon waveguide, part of it sneaks into the germanium and produces an electric current. Some of today's silicon devices actually include small amounts of germanium, so using existing manufacturing processes to deposit the material isn't necessarily difficult. What is difficult is depositing it in uniform layers on top of silicon. The distance between the atoms in a crystal of germanium is different from the distance between the atoms in a crystal of silicon. Combining the two produces strains and cracks, which could cause problems in an electronic device. The Intel researchers focused on developing a process that minimizes the strain on the materials near the part of the device that detects light. Many of the details are proprietary, but the team experimented with a number of variations in the materials' growth conditions. In the end, the researchers found an ideal combination of temperature and other factors that sweep defects out to the edge of the detector, where they don't impede performance. The team's next major hurdle is to develop processes for integrating the detector and other silicon devices on a single chip. Intel doesn't expect integration to pose any major challenges, but it could take a while to complete a system. While all three of the silicon photonic devices work well in the lab, when they're subjected to quality-control testing, problems could arise. Estimate for commercialization for integrated silicon photonics is within about five years. Source: Technology Review 2007. *[Photo:*

Light passes through a silicon waveguide (bottom) to a strip of germanium that lays between two aluminum pads (white squares, center). Voltage is applied to the pads to turn the detector on and off. The current passing through a third aluminum pad (white square, top) indicates how much light has struck the detector].



THROUGH SILICON VIA (TSV) TECHNOLOGY

Electrografting Process for TSV- A new technique called electrografting has been developed Alchimer (Massy, France) that could provide a cost-effective solution to replace standard physical vapor deposition (PVD) for copper seed layers. The company says it ensures extendibility of copper metallization to aspect ratios >10:1 by enabling electrochemical deposition on virtually any diffusion barrier material (tantalum, TaN, titanium, TiN, tungsten, ruthenium layers deposited by PVD, MOCVD or atomic layer deposition {ALD]). The company is targeting high-aspect-ratio through-silicon vias (TSVs) needed for 3-D integration, as well as conventional dual-damascene interconnects. They claim that existing copper PVD techniques could run into limitations with aspect ratios in the 5:1 to 8:1 range, in terms of their ability to provide continuous seed layers with good step coverage and acceptable cost-of-ownership. They also claim that PVD had the same problem for high-aspect-ratio tantalum- and titanium-based diffusion barrier deposition, but the higher surface mobility of tantalum and titanium atoms should allow better step coverage. Electrografting is a wet coating process invented in the 1990s at CEA-Leti (Grenoble, France) to make strongly adherent vinylic polymer layers as anti-corrosion coatings for nuclear applications. It is a two-step process, where a small current (a few µA-cm2) initiates a transient chemical bond formed at the surface of the substrate. The amount of current determines the grafting density; everything is controlled by the current.



The feasibility of the process was demonstrated with a 5-µm-wide, 25-µm-deep via, with a TiN barrier layer deposited in collaboration with IMEC. As shown in the photo, the conformal copper layer at the bottom of the via is ~50 nm thick. Process time was 5 min.

The second step is chemical propagation/polymerization; the kinetics is driven by the composition of the bath and doesn't require any current. This transient chemisorbed radical deactivates or transfers its charge to another monomer that is in the solution, and this propagation of polymerization continues. The thicknesses of the layers are fixed by the bath composition. The propagation is known as electrografting because, at that time, it was the first-known reaction electro-initiated that was creating a metal-carbon bond, grafting precursors on the surface. In addition to vinylic polymer, the company has found several other classes of polymers that work well for first electro-initiated step, including diazonium. For example, disproportionation can be used for copper layers, and protonation can be used for laying down polymers on metals. Tautomerization and organometallic complex cleavage are other examples. The main advantage of the technique is conformal step coverage. The feasibility of the process was demonstrated with a 5-µm-wide, 25-µm-deep via, with a TiN barrier layer deposited in collaboration with IMEC (Leuven, Belgium). The feasibility of the process was demonstrated with a 5-µm-wide, 25-µm-deep via, with a TiN barrier layer deposited in collaboration with IMEC. The company also demonstrated good results on vias with even higher aspect ratios. Copper was deposited conformally on a 10:1 aspect ratio, 5-µm-wide, 50-µm-deep via, where the TiN barrier was deposited by TiN. Alchimer has also developed a completely electroless grafting method that it calls chemical grafting. "If you cannot change the surface potential by applying a voltage, and you have the ability to modify or create the right reactive species in the bath, then they will have the right potential in order to give or take electrons from the surface. Basically chemical grafting is the same as electrografting, but with the first electro-initiated step, the electron doesn't come from the surface, but does come from the fact that we put in the bath enough very active reactive species that are willing to take or give an electron from the surface." Source: SI.

PACKAGING

LED Packaging - Chang Wha Electromaterials (CWE), a packaging material and equipment distributor, will start LED packaging operations. They will also form a joint venture with flexible copper clad laminate (FCCL) maker ThinFlex for the development and manufacture of materials for LED packaging. Chang Wha has over 20 years experience in the semiconductor packaging sector and has decided to enter the LED packaging business. They see LEDs as being an important component for the panel industry in the future. Source: DigiTimes.

Wafer-Level Packaging - ISSYS (Integrated Sensing Systems) has received a Phase II SBR NSF grant. The 2-year project, titled "Wafer-Scale, Hermetic, Packaging of MEMS- Based Systems," is aimed towards development of a novel packaging method which will greatly simplify the packaging of MEMS and their associated electronics [***We petitioned NSF to provide MEMS packaging funding in 2000, so it sure took awhile***]. Practical hermetic integration of electronics and MEMS devices will allow the commercialization of a variety of MEMS-based products that are currently not possible due to high cost of manufacturing or packaging problems. ISSYS methods can be used for a wide variety of devices, in particular, for applications where the MEMS device needs to be in direct contact with the media and the electronics need to be isolated from the environment. ISSYS immediate products benefiting from this technology include intelligent catheters, and implantable intracranial pressure (ICP) monitors for traumatic brain injury (TBI) and intelligent shunts for hydrocephalus. Other potential applications include industrial, analytical, defense, safety, or biohazard detection applications. They plan to offer two packaging platforms, for both wired and wireless sensors, which will meet the need for a low-cost, robust manufacturing packaging solution. Source: Market Wire.

CONFERENCES

The IWLPC, co-sponsored by SMTA and Chip Scale Review, was held last month in San Jose. The conference expanded by about 20% over last year, but its still a modest event with about 200 attendees. A summary will follow shortly. IWLPC-2008 will also be in San Jose. Ken Gilleo will be the General Chair.