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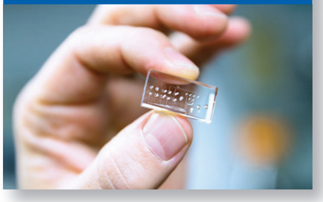

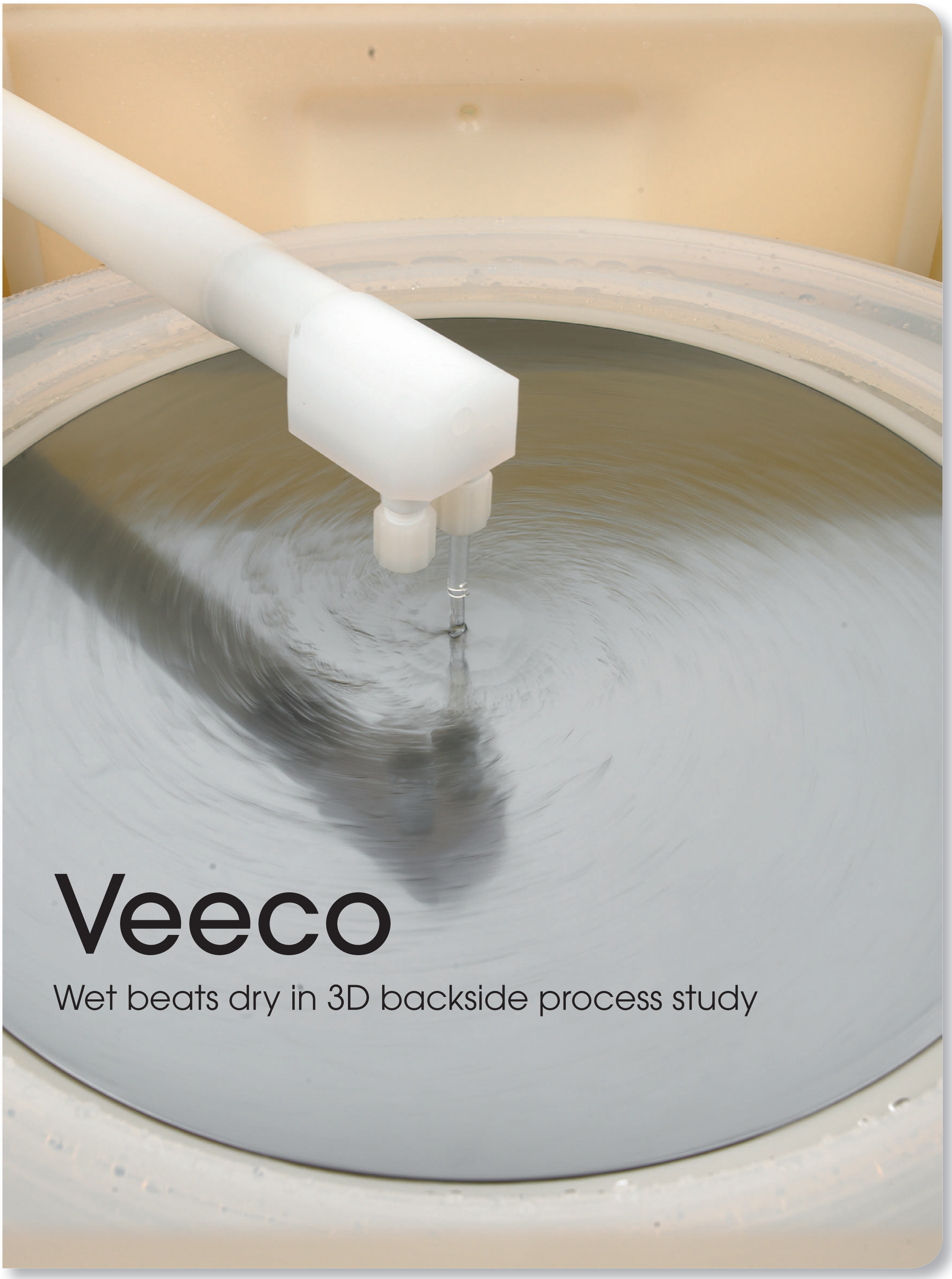

Veeco

Wet beats dry in 3D backside process study

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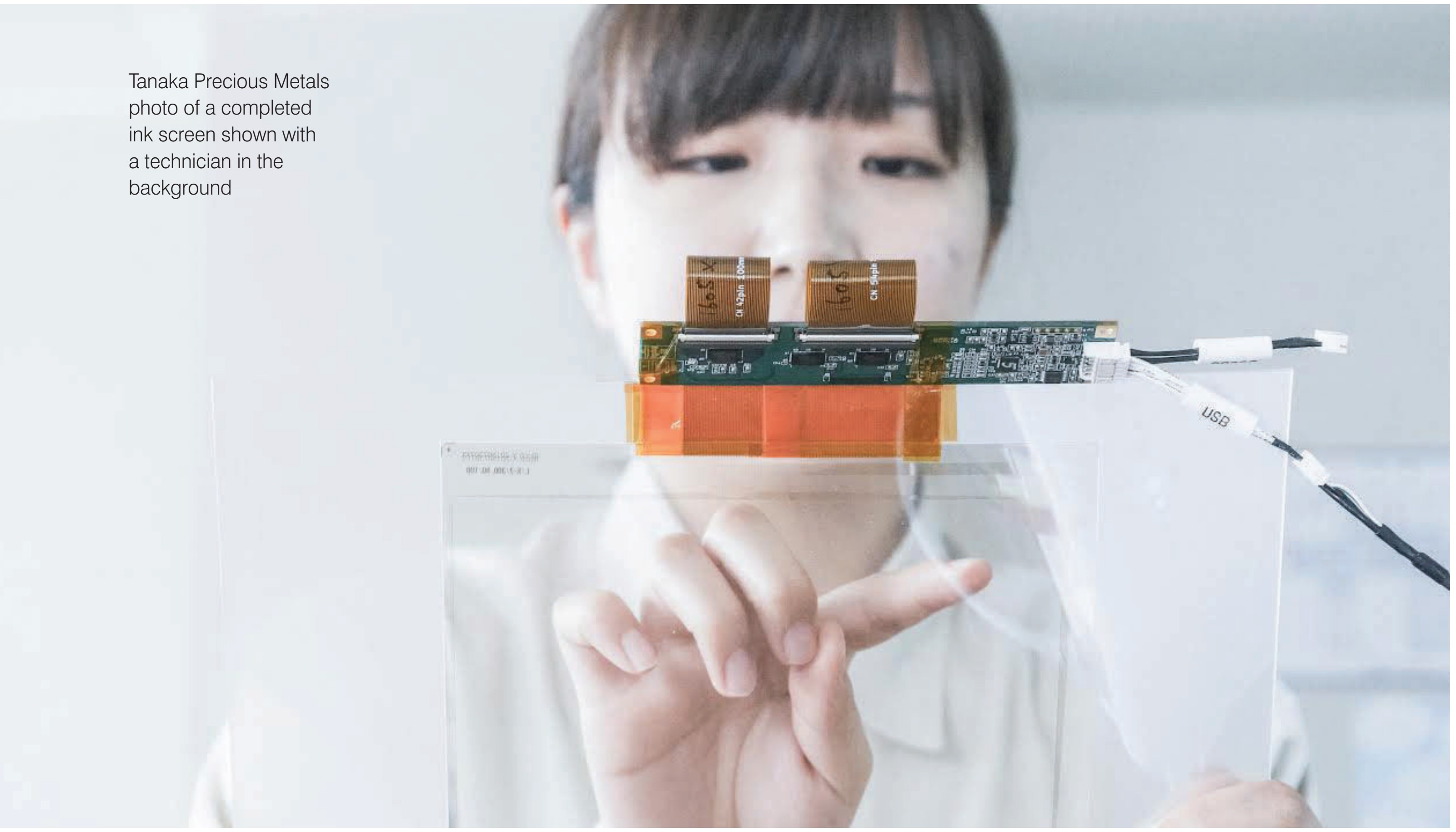


Tanaka Precious Metals photo of a completed ink screen shown with a technician in the background

Anxiously anticipating big opportunities

A relatively flat semiconductor market in 2016 has led to more consolidations and longings for the advent of IoT devices to impact the global chip marketplace. Mark Andrews technical editor at Silicon Semiconductor discusses.

THE SILICON semiconductor equipment market in 2016 remains relatively flat while chip revenue continues on a slight downward track, according to the SEMI trade organization. At SEMICON West and subsequent industry events, hopes for strong growth are pinned to new internet of things (IoT) device sales in 2017 and beyond.

Semiconductor manufacturers find themselves in another recovery year in which uneven global economic news keeps downward pressure on silicon IC prices as well as the tools that make them. The SEMI group expects by the time we close the 2016 books, fab equipment for wafer processing, test, assembly and packaging may see about 1 percent annualized growth compared to 2015, which was off substantially compared to more robust sales in 2014.

While Taiwanese fabs are expected to retain the top-spot in new equipment investments this year, more that USD $9 billion, they will be followed closely by China at nearly $6.5 billion and Korea at about $6.1 billion. China leads in terms of fab equipment investment, up more than 30% compared to last year. Non-traditional semiconductor markets—areas outside Europe, North America and Asia—contributed a whopping 59 percent increase this year. Although small compared to the deep-pocket spending elsewhere, the so-called Rest of the World (RoW) spending hints that non-traditional semiconductor manufacturing centers are looking to gain a share of the IoT growth potential

With so much riding on expected growth of IoT spending— connected 'smart devices' of every imaginable shape and function, why isn't the market already churning along at a robust pace? According to Future Horizons founder and CEO Malcolm Penn during his autumn industry forecast seminar in London (September), current revenue levels have little to do with IoT prospects. Penn said the far-from-stellar chip market performance can find its roots in the lackluster global economic recovery that has stymied investors of every stripe. Penn said he believes that because the industry is now driven by a relatively few high-volume chipmakers (4 to 5 depending on who is counting,) as a group they do not throw money into the fray until economic trends move solidly upward.

Penn pointed out that ICs are now an inescapable part of a global economy. Whether good or bad, this means that equipment and device-level sales performance ties closely to worldwide economic conditions. This global influencer status helped buoy semiconductor markets for economies during the worst days of the Great Recession. But during a period some call 'economic malaise,' it swings the other direction when emerging economies trim spending, energy sectors trend lower, wars engulf some regions and major political events (like the upcoming US presidential election) make headlines.

Poor growth has also led to semiconductor industry consolidation (USD $100 billion in 2015,) which further tends to dull enthusiasms for risk-taking. While consolidation slowed to half the 2015 rate this year, Penn's forecasts for 2017 chip sales range widely between nearly 3 percent positive to the possibility of backsliding as much as 3 percent if worse-case scenarios play out.

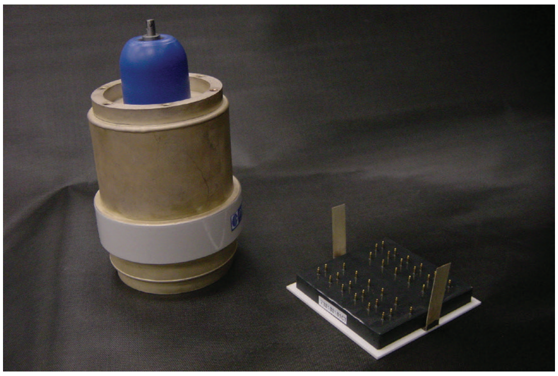
Semiconductor sales have long been driven by major waves of technological innovation such as the ascendency of personal computing and smartphones. Market watchers are now awaiting a third wave—universal device connectivity through the IoT. But IoT is in its relative infancy, so its influence is small compared to other electronics mainstays. IC Insights (in their September updated market report,) projects IoT related sales will finish at about USD $18 billion in 2016; they forecast this growing to $26.9 billion per year by 2019. The entire semiconductor chip sales market should be about USD $335.6 billion this year. IoT's potential is clear.

Reno Sub-Systems show one of their complete systems. Although replacements for legacy devices need to be the same size/footprint, new installations could be substantially smaller. All Reno RF power systems are more stable, much faster and perform with very little reflected power compared to legacy solutions.

Exhibitors at recent SEMICON West and Intersolar events aren't waiting for 2017 to get excited. New ideas abounded, with many companies showcasing new approaches at these events and others in third quarter across the semiconductor supply chain.

Leti, a CEA institute, led-off with its next-generation 3D network on a chip (3D-NoC) that researchers in Grenoble, France said substantially boosts performance while reducing energy consumption. An earlier generation of the 3D design premiered as a demonstrator project early in 2016. The updated design is called IntAct, which means ACTive INTerposer, playing-off the fact that Leti's design places active components inside a silicon interposer whereas competing 3D designs frequently utilize solid silicon without embedded actives. There are two essentially different approaches to achieve 3D benefits. The first uses stacked chips relying on interconnections to speed signal processing. In the second, chips are designed with vertical structures to increase density. The Leti design is essentially a chip stack, but with a difference.

Let's differentiator is placing active components like electrical pathways inside the interposer; they have plans for future designs using optical connections. In its latest demonstration project, Leti showed chip-



An EVC matching network component from Reno Sub-Systems (left) is compared to its counterpart in a traditional plasma system.

A portion of KLA-Tencor's new inspection portfolio

to-chip data transmission speeds-in the hundreds of megabits per second (M/bs) in a chip measuring just 40 μm x 40 μm. Along with high speed processing, the new design needs 20 times less energy for data transmission than chips on electronic circuit boards. Leti indicated that their new IP is compatible with standard remote direct memory access-type software used for data transmission as well as virtual-server migration applications.

The wafer inspection and process control leaders at KLA-Tencor announced six new products for advanced defect inspection and review at SEMICON West followed by a suite of three new reticle inspection systems. All new products focus on devices at the 10nm node and below.

KLA-Tencor's new inspection and review products include the 3900 Series (previously referred to as a 'Gen 5' product); the 2930 Series broadband plasma optical inspectors; the Puma 9980 laser scanning inspector; the CIRCL 5 all-surface inspection cluster; the Surfscan SP5XP unpatterned wafer inspector and the eDR7280™ e-beam review and classification tool. KLA said these new systems employ a range of innovative technologies to form a comprehensive wafer inspection solution that enables discovery and control of yield-critical defects at all stages of IC manufacturing.

KLA Tencor's new reticle inspection device family.

KLA pointed to performance advantages in all of its new systems such as decreasing time for the delivery of usable data, eliminating nuisance defect reports as much as 4x, and continually tightening control mechanisms. The new tools also utilize improved algorithms for better identification, classification and signature ID with no throughput loss. VP for Customer Engagement Mark Shirey called out the new 3900 and 2930 inspectors as examples of what the entire suite could offer. In the case of these new patterned wafer inspectors they achieved a "…sweet spot for yield enhancement. An entire wafer of 10nm devices can be scanned in an hour, so throughput is the real value along with high reliability at that speed. This makes (the tools) indispensable for accelerating ramp."

KLA-Tencor followed its SEMICON West announcements with three new reticle inspectors to address 10nm and below mask technologies: the Teron 640, Teron SL655 and Reticle Decision Center (RDC). The company described all three systems as enabling present and next-generation mask designs by more efficiently identifying lithographically significant and severe yield-damaging defects.

EV Group (EVG) announced significant additions to its metrology and wafer bonding tool line-ups, including the EVG50 automated metrology system. The new

EVG50 is designed to support increasingly stringent manufacturing requirements for advanced packaging, MEMS and photonics applications. It complements the company's versatile EVG40NT measurement system, which has become an industry standard for bond overlay inspection. The EVG50 performs high-resolution non-destructive multi-layer thickness and topography measurements, as well as void detection in both bonded wafer stacks and in lithographic photoresists. The system measures down to two microns in layer thickness, and can inspect up to one million points, achieving throughputs (with 300 mm substrates) of up to 55 wafers per hour. The EVG50's high throughput and unparalleled accuracy and repeatability, even at ultra-high resolutions, enables cost-effective, 100-percent inspection of production wafers, resulting in improved process control.

EVG has also expanded its line of wafer bonding solutions with two new ComBond modules designed for automated high-vacuum wafer bonding in high volume production environments producing such as the latest MEMS devices. The products include a new vacuum bond alignment module that provides sub-micron face-to-face alignment accuracy, which is essential for wafer-level MEMS packaging. EVG also announced a new bake module that performs critical process steps with what they describe as outstanding bond quality and performance of encapsulated MEMS devices. The tools use a modular approach to augment production lines and enable greater levels of accuracy. EVG's latest innovations add new capabilities, such as bonding at room temperature through the ComBond Activation Module (CAM) designed to bond temperature sensitive materials.

In discussing the new capabilities, EVG VP and general manager of North America, David Kirsch, said that the company's ability to control or eliminate oxidization of metal layers is especially appreciated by customers working with aluminum. EVG uses a preheating step prior to bonding, and that offering these benefits all under vacuum is a significant advantage. "The new products fill a void that has existed in the industry—to create bonds without oxidization with extreme accuracy under vacuum. Offering this in a modular system greatly enhances customer advantages," he noted.

EVG's new tools also can provide vacuum encapsulation, which is increasingly needed for certain MEMS devices in order to reduce power consumption caused by parasitic drag, reduce convection heat transfer, or prevent oxide corrosion. Maintaining the required vacuum level for the entire wafer bonding process has been a key challenge for ramping these devices into high-volume production.

New innovations were also announced by 3D Micromac, with a focus on their micoDICE system that leverages thermal laser separation techniques. 3D Micromac calls their adaptation TLS-Dicing; this has been productized in their microDICE system, a high throughput platform designed specifically for hard and brittle wafer substrates, thin wafers at high risk for breakage, new packaging technologies and smaller devices on larger substrates. A material perfect for the new laser technology is silicon carbide (SiC) with a rating of 9.2 on the Mohs scale, the company said.

3D Micromac shows a close up from inside its new MicroDICE thermal laser separation system that is ideal for hard/ brittle substrates such as SiC wafers.

At the heart of 3D Micromac's new microDICE system is their new ultraviolet laser in combination with microbursts of deionized water that seamlessly cleave a wafer into individual devices. Unlike diamond embedded saw blades that create a wide kerf as they singulate devices, or other laser approaches that can ablate wafer surfaces, the TLS-Dicing approach is fast (up to 200mm/s,) requires just one cleaving pass per 'street,' involves no tool wear and leaves a virtually perfect side wall.

3D Micromac's semiconductor market development manager, Hans-Ulrich Zuhlke (PhD) noted that the only consumable product, '…is water. No saw blades, no particle contamination. It is clean and very quick."

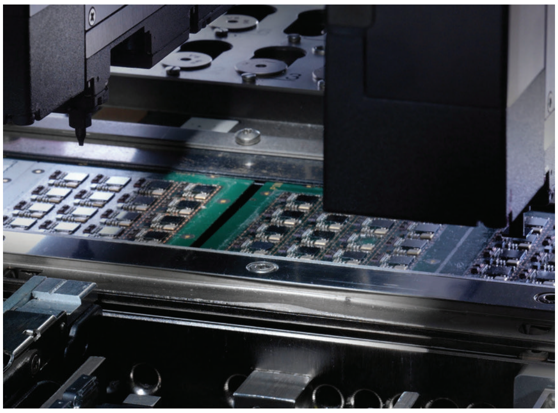
3D Micromac saw the opportunity to leverage its work with the Fraunhoffer IISB as a means for speeding the development of next-generation power devices and other product types that rely upon hard and brittle substrates, including SiC. "Using a conventional saw, a diamond blade cannot cut a six inch wafer without having to be changed prior to finishing. Sawing a wafer involves significant materials cost, damage and cleanup issues; our TLS technique has none of these concerns."

Another breakthrough was announced by Reno Sub-Systems, which specializes in radio frequency matching networks, RF power generators and gas

Kulicke and Soffa showing the K&S Hybrid 3 machine

delivery for semiconductor manufacturing. Mention Reno and people in the know talk about speed. The typical RF plasma setup for atomic layer etch (ALE) and atomic layer deposition (ALD) takes one to three seconds for completing RF match and gas stabilization. Once match and stabilization are complete, it takes 30 seconds to finish the entire process. That sounds fast until you consider Reno's approach: just 50 microseconds for RF match and gas stabilization, and 10 seconds for the overall process. Reno delivers speed, repeatability, and predictability as well as more precise control thanks to the company's solid-state design. What is the market? According to Reno, there are roughly 100,000 plasma systems in service across industry, a figure calculated by multiplying the number of RF systems shipped in the past two decades: about 9,000 to 10,000 each year. Given the growing significance of these units in semiconductor manufacturing, they estimate a compound annual growth rate (CAGR) of 5-7 percent. Dramatically improving cycle time while maintaining quality and consistency is huge for these markets as device geometries shrink and the importance of ALE and ALD increases.

Kulicke and Soffa also released new products that again establish the company as a leading resource for pick and place packaging requirements. The new K&S Hybrid line includes the Hybrid 3 and Hybrid 5; both are designed to place active and passive devices at the same time in the same machine in multi-chip modules, system in a package (SIP) modules, wafer level packages and flip-chip products. The new Hybrid 3 can deliver up to 99,000 applications per hour while the Hybrid 5 can output up to 165,000 modules per hour. The K&S vice president of wedge bond, capillary and blades business, Chan Pin Chong, said the benefit for customers is the combination of speed and the fact that the robot assembly units are interchangeable. Using a Hybrid, customers can complete various pick and place operations and then rapidly shift to entirely different devices between shifts or whenever needed.



K&S and shows a device attach taking place

"It saves space on the factory floor to have one machine that can perform two major operations," remarked Chan Pin. "Another aspect that customers enjoy is that there is no impact force delivered during pick and place. Components are constantly monitored, so we deliver 'first time right pick' with very high consistency. Every operation is constantly monitored, so yield is increased even further."

Tanaka Precious Metals also debuted an innovative solution to the development of touch screen and wearable electronics with its new SuPR-NaP (Surface Photo-Reactive Nano metal Printing) technology that uses silver nanoparticles and industrial screen printing techniques to create conductive films. The new technology's ultrafine wire widths are less than one micron across. Due to the precision possible with Tanaka's printing techniques along with its silver-based nano ink, the company believes it could have applications across semiconductor and solar industries. The challenge with current conductive inks and their incorporation into LCD, LED, OLED and other advanced screen types is the need for greater transparency and uniformly thin wires. Tanaka indicated that their new ink is 'virtually invisible' compared to legacy products. Tanaka expects sample distribution at full scale early in 2017 with a production ramp later in the year.

While 2016 remains a challenging year across the global semiconductor market, process technology, materials and device manufacturers are continuing their efforts to enhance competitiveness and ensure that the supply chain supports existing market needs and the prospects of a growing IoT marketplace. As the IoT market matures, manufacturers will be ready to support a changing semiconductor ecosystem with innovative solutions to improve control and efficiency while supporting growing consumer expectations.