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Power semi testing goes wafer scale

By R. Colin Johnson

Cascade Microtech Inc. today will field a characterization system that it says can shave weeks off the power semiconductor development cycle. The Tesla probe station allows power semiconductors to be safely tested on the wafer, before the wafer is diced and the chips packaged.

Power semiconductors are notoriously difficult to probe. Because the devices require high current and high voltages, and because the wafers are thin and difficult to hold down with a wafer chuck, probing can pose a danger to both the test instruments and the engineers who deploy them. Thus, manufacturers of power semiconductors—from discretes to systems-on-chip—have had to test the devices as packaged chips. And one source described traditional power device test equipment and procedures, respectively, as jury-rigged and ad hoc.

"The common problem with testing power device wafers has been that when you blow up a device, it can send power surges into your probe," said Cali Sartor, senior program manager for Tesla at Cascade Microtech (Beaverton, Ore.). "They can propagate all the way back up the line, potentially damaging your multi-thousand-dollar instruments; plus the blown device can arc to adjacent devices."

An infrared-light curtain surrounds the Tesla probe to prevent electrocution of operators when the probe is carrying high-voltage signals. Any disruption of the light curtain shuts down the system. Further, all the mechanical and electrical components have been beefed up and validated for up to 3,000 volts and 60 amps.

"Today, test engineers spend an enormous percentage of their time jury-rigging fixtures and designing ad hoc test procedures," said Douglas Raymond, vice president of measurement and instrumentation at market watcher Frost & Sullivan. "Tesla gives them the opportunity to concentrate on characterization rather than on test procedures."

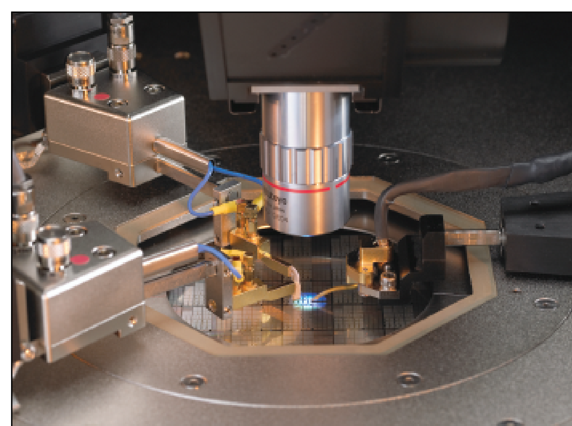
Freescale Semiconductor's SmartMOS Technology Center is a beta site for Cascade's new probe station. "Tesla will have a huge effect on our productivity," said Edouard de Fresart, power device section manager at the center. "It will reduce the hassle of packaging devices before we characterize them."

Power everywhere

Frost & Sullivan and fellow market watcher Yole Development (Lyon, France) both peg today's power semiconductor industry at about $25 billion, and both predict growth to more than $30 billion by 2009. "All the new consumer devices, from handheld PCs to mobile GPS to iPods, have to deal with power semiconductors," said Raymond. "You are going to see continued growth in that marketplace, because power semiconductors are needed to drive all the widgets and gadgets."

According to Cascade's Sartor, testing of such devices today requires a detour from the normal design cycle, as engineers remove a "split"—a multidice section of the wafer—send it out for packaging and then test the packaged chips in specially constructed fixtures. The process can take weeks. With Tesla, Sartor claimed, "one beta site EE said he has been able to test multiple devices still on the wafer in a single day."

Cascade based Tesla on its Summit 12000 series wafer probe station. Thus the system "can be used for both regular and power semiconductors," said Raymond of Frost & Sullivan. "In the morning, the test engineer could be doing tests on mixed-signal, RF, microwave and high-frequency semiconductors; then in the afternoon he might do tests on high-voltage, high-current power devices."



Cascade's Tesla probe places wafers in a sunken microchamber to provide an electrically shielded test environment.

Tesla includes a hands-free digital imaging system and relocates all the control panels outside the light curtain so that the engineer can manipulate a sequence of power devices on the wafer through automated test routines.

"We also had to develop a thermal chuck" that could accommodate testing of ruggedized power devices, said Sartor. "And we had to figure out how to safely handle such very thin wafers," often with vertical device structures.

Tesla's wafer chuck has a proprietary, chemically functionalized gold top surface that has been optimized for low contact resistance. The gold chuck electrode can connect to all the power devices that use the backside of the wafer as an electrode.

Tesla also uses a proprietary probe, for which the basic innovation is a multifingered tip that distributes the current across the fingers. While the probe diameter is oversized, so as to draw heat up from the device under test, each tip finger is very small and does not leave marks on the wafer pads after testing.

The high-voltage probe provides a triaxial measurement. Proprietary insulating materials enable a precision measurement to be performed at very low leakage currents, while still handling up to 1,100 V triaxial and up to 3,000 V coaxial.

The probe station sits on an anti-vibration table and has a microscope mount, a thermal controller and a chiller system both for characterizing temperature ranges and for keeping the wafer at a constant temperature during test. While power devices are typically fabricated on 6-inch wafers, the tester can accommodate wafers up to 8 inches in diameter. The wafer itself is placed in a sunken microchamber that provides an electrically shielded test environment. The system can also be used to test shards and discrete devices.

Software supplied with the Tesla probe station automatically performs the most common tests for power devices, according to Cascade. ■

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