DCG Systems

Technical Update

May 2009

In this issue...

News and Events

The following technical conference papers have been or will be published:

- "Full Dynamic Laser Stimulation Set Up and First Results," Deyine, et al. (THALES & CNES, DCG), IPFA 2009
- "RF Performance Increase allowing IC Timing Adjustments by use of Backside FIB Processing," Schlangen, et al. (Berlin Institute of Technoloy, DCG), IPFA 2009
- ""Enhanced wafer analysis using a combination of test, emission and software net tracing," Portune, et al. (DCG, ATMEL), IPFA 2009
- "Creation of Solid Immersion Lenses in Bulk Silicon Using Focused Ion Beam Backside Editing Techniques," Scholz, et al. (Berlin Univ. of Technology., DCG), ISTFA 2008
- "Advanced Methodologies for Backside Circuit Edit, "O'Donnell, et al. (Intel, DCG, Berlin Institute of Technology.), ISTFA 2008
- "Next Generation Laser Voltage Probing," Ng, et al. (DCG), ISTFA 2008
- "Yield enhancement using a combination of wafer level Failure Analysis and defect isolation software: case studies," Simon, et al. (ATMEL, DCG, Credence, Sector), ISTFA 2008
- "Comparison of laser voltage probing and mapping results in oversized and minimum size devices of 120 nm and 65 nm technology," Kindereit, et al. (Berlin Institute of Tech., NVIDIA, Fairchild Imaging, DCG), ESREF 2008

SLS Digital Lock-in Detection - Why do you need it?

Thermal Laser Stimulation (TLS) techniques are widely used for fault localization in complex submicron devices. These techniques are well suited for localizing electrical defects such as shorts, electromigration and resistive paths.

Two popular TLS techniques which use Static Laser Stimulation (SLS) are Thermally Induced Voltage Alteration (TIVA) and Optical Beam Induced Resistance Change (OBIRCH). (For more detail on these techniques, see Laser-based Analytical Techniques TIVA and OBIRCH).

The use of SLS involves powering up the device in a static condition while maintaining a constant voltage or constant current. By applying an external stimulus (such as a laser) to the device, perturbations to the device state can be associated with the position of the beam. This allows the analyst to pinpoint with a high degree of accuracy which areas of the device are most susceptible to failure.

While SLS has been effective for analyzing older technologies, it has started showing practical limitations when applied to CMOS technologies of 90nm and beyond due to the physical reduction of the structure dimension and the lack of sensitivity of the detection chain. The detection of subtle laser-stimulated changes in power consumption induced by TIVA and OBIRCH brings with it a significant amount of signal noise, thus making it difficult to discern the true signal from the background activity.

Lock-in to improve the signal-to-noise ratio

An effective way to compensate for the need for additional sensitivity on advanced technologies involves integrating a lock-in amplifier in the "resistance variation" detection chain. The goal is to modulate the laser intensity at a certain frequency, and then take advantage of this known frequency to perform lock-in amplification. The resulting lock-in amplitude image has a much higher Signal to Noise Ratio (SNR)

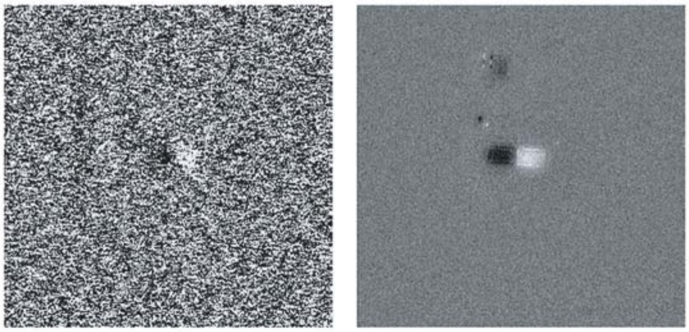


Figure 1: Images at same laser power without and with lock-in. Note the signficant improvement in signal-to-noise in the lock-in image.

when compared to the same image without lock-in, as illustrated in Figure 1.

An additional benefit of using the lock-in technique is that it allows TLS analysis to be performed using a lower laser power configuration, which is useful in order to minimize any potential damage induced by the laser on the device being analyzed.

TLS phase-shift signatures to identify the layer containing the defect

Another significant benefit of using lock-in is the ability to examine an additional characteristic of the TLS signature: the phase-shift between laser modulation and the induced modulated TLS signals. This phase-shift information gives an additional component of information on a structure being stimulated.

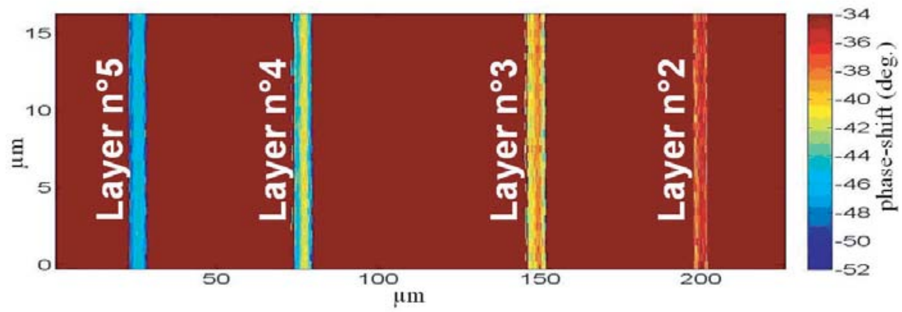


Figure 2: Phase-shift signature of 1100nm width copper lines located on different metal layers. Modulation frequency: 15 kHz. The phase shift information is giving direct access to the localization of the metal lines in Z (clear discrimination in the phase shift response between 2 consecutive metal layers, at different depth).

While the classical lock-in technique produces a two dimensional mapping of the chip, the phase-shift imaging allows us to extract z-information on the analyzed structure. This provides, in effect, a 3-dimensional defect localization technique.
Figure 2 shows an example of a phase-shift signature on 1100nm wide copper lines located on four different layers. Phase-shift analysis also demonstrates a capability to provide dimensional information such as copper line width. The phase-shift signature may be used to improve indirectly the defect localization accuracy by cross-referencing it with the CAD layout.

For more information on phase-shift signatures, see A. Reverdy et al. "Fast and Rigorous Use of Thermal Time Constant to Characterize Back End of the Line Test Structure in Advanced Technology", ESREF 2008.

A Success Story

DCG's OptiFIB-IV support team always welcomes a challenge, and a customer "special acceptance" provides no end to excitement. With the goal of achieving system sign-off, all eyes were focused over the shoulders of a new OptiFIB-IV customer as he drilled away at a node deep in the interface stack, awaiting the end-point indication that would signal the end of a long and complex acceptance test. Just one final edit to go...but what an edit it was! Our customers expect to push the system in order to test its limits, and this edit was living up to the challenge!

Four members of the DCG support team watched and waited as the customer patiently drilled away using Aperture 1… a mere 500 femto amps of beam current, as the FIB image danced with processed "snow." Drilling ever so deeply through layer after layer of dielectric, looking for a glimpse of secondary electron signal that made its way back out… looking for a blip on end-point plot that suggests, "Is that it?"… milling continues deep into an abyss.

Then, suddenly, but just as expected, the video image, once a sea of dancing noise, begins to lighten. The dark room begins to illuminate, as the deep node begins to be revealed. The end-point plot, once a flat line of no signal, suddenly takes an abrupt upward run, indicating we have milled through the remaining dielectric, and the conductor lies revealed. An intense luminosity reflects off the faces of all, plastered close to the 30 inch monitors…although it is late in the evening, the lab takes on a glow of daytime, as the exposed metal line glows an intense white, generating electrons a plenty. This is the glow of success!

The customer hits the stop button. The gases from the mill operation re-stage, an image is grabbed by the OptiFIB-IV FUSION software, and the CAD overlay refreshes, where an intense bright dot demarcates an exact registration over the required node. The customer's response: "Awesome!"

For the months of effort contributed by the Manufacturing team, the Engineering team, the Applications team, all working together in order to get the tool to a state of readiness to be accepted and shipped, the end result is well worth it: A satisfied customer!

An Overview of TIVA and OBIRCH

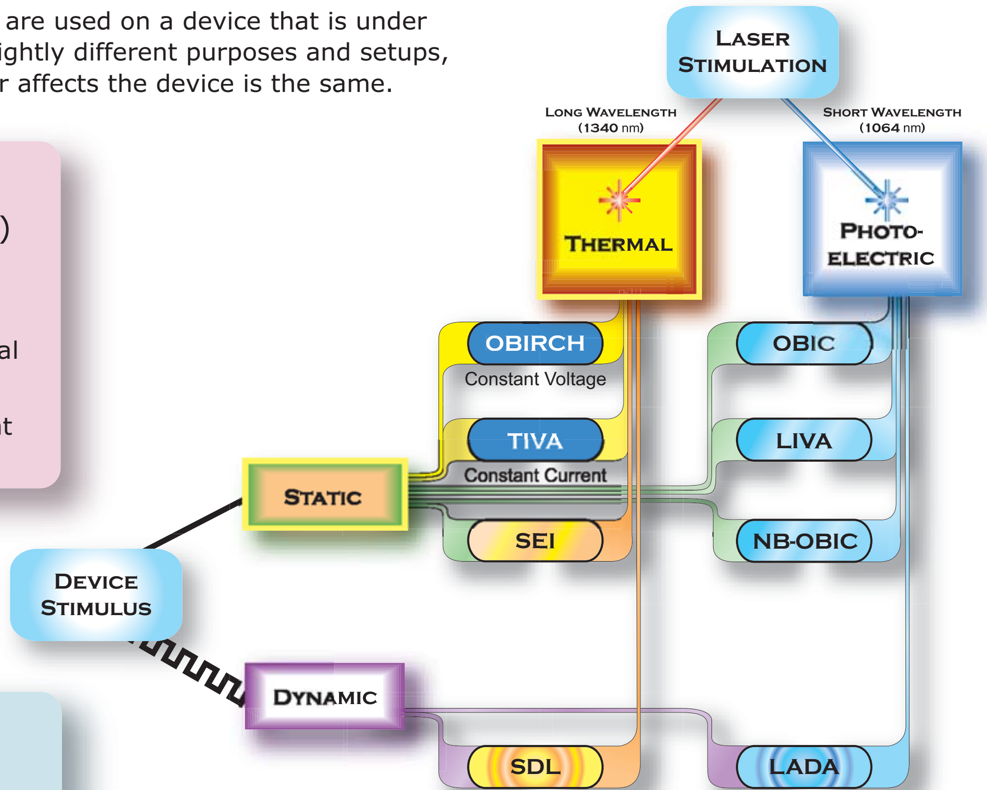
Both of these thermal techniques are used on a device that is under static bias. Although they have slightly different purposes and setups, the mechanism by which the laser affects the device is the same.

Thermally Induced Voltage Alteration (TIVA)

Locate: electrical shorts.

Laser effect: induces local thermal gradients

Device bias: constant current



Optical Beam Induced Resistance Change (OBIRCH)

Used to: locate voids and other defects. It is useful for characterizing electromigration effects on metal conductors.

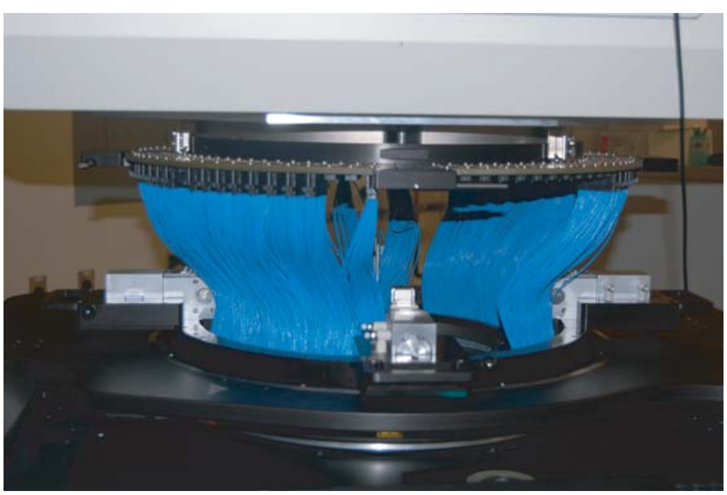
Laser effect: locally heats a defective area on a metal line passing a current

Device bias: constant voltage

How it works

Both techniques rely upon a long wavelength (typically 1340 nm) laser beam to induce a thermal change in the device in order to modify its operating characteristics. When the laser strikes an area containing a defect such as a short circuit or metal void, local heating causes the resistance of the defective area to change. This results in a fluctuation in overall power consumption of the device, which can be correlated with the point in time at which it occurred. Since the position of the laser at the time of the induced power fluctuation is known, the X-Y coordinates corresponding to these resistance changes are plotted onto an image of the device, thus mapping the locations of the defects.

New *Meridian WaferScan* Advantest T2000 Interface



The *Advantest T2000* docked to the *Meridian WaferScan*

The new *Meridian WaferScan* Advantest T2000 high-speed interface has been tested successfully. This interface provides vertical, theta and tilt adjustment. Full vertical motion of approximately 3 inches. Push-button connection to both the WaferScan and the tester makes installation easy.

The first unit has been shipped to an offshore foundry for low yield investigations.

Customer Support Engineer Spotlight

DCG Systems is rich in industry knowledge and experience, and one need look no further than Customer Support (Field Service) for a good example. Jerry Barone's career in the semiconductor industry began in November of 1983, after receiving a Bachelor's Degree (EET) from DeVry Institute of Technology. Jerry was hired by Fairchild Camera and Instrument as a Systems Test Engineer, and worked on the Sentry 20 and 21 testers, among others. Owned by Schlumberger Limited since 1979, Fairchild's Test Division would eventually become Schlumberger ATE. In 1988, Jerry transitioned to Field Service in Colorado, with Unisys being his primary customer.

As memory and analog tester activity began to drop off, a revolutionary new system was introduced by Sentry Schlumberger: The IDS 5000 Electron-beam Prober. Always up to a new challenge, Jerry would become proficient on Sentry's revolutionary new technology, and would go on to support the IDS 3000 and IDS 10000 series of E-beam systems. When Schlumberger introduced the IDS Probe Point eXtension (P2X), a focused ion-beam system integrated into an IDS 5000 chassis, Jerry took the opportunity to learn yet another exciting new technology.

As we fast forward through the 90's up to the present, we see Jerry being widely recognized as one of the top FIB Customer Support engineers in the world, with over a quarter-century of experience! His principle customer in Colorado today is LSI, where Jerry installed the very first OptiFIB shipped to the field. He has traveled to Canada, Europe, and Asia for installations and maintenance support, and occasionally travels to the factory in California to learn the latest advances in technology, as well as to provide training to other Customer Support personnel.

On the personal side of things… Jerry and his wife Nancy have two daughters, Tabitha – age 13, and Nickola – age 12. He loves the outdoors, including fishing, hiking, and riding ATVs and snowmobiles. Whenever he gets the chance, he escapes the city life and heads to his mountain cabin. He has also been a student of Kempo Karate for four years, attaining the highest level of Brown Belt. In June of this year, he will test for Student Black Belt.

From Fairchild/Schlumberger, to NPTest Probe Systems, Credence DCG, and now DCG Systems, Jerry's path has been lined with challenges and rewards; customer support involves walking a tightrope between technical obstacles on one side, and customer confidence and satisfaction on the other. He's managed to keep his balance all these years. On a recent trip to Taiwan, Jerry celebrated his 25th anniversary with DCG Systems President and CEO Israel Niv, along with a handful of other co-workers.

Those few people from the "old guard" who still remain with our company today have produced a legacy of hard work and service. With the continued dedication of people like Jerry, that legacy will be a lasting one.

Jerry Barone celebrates his 25th company anniversary in Taiwan

From left to right:

Front Row: Steve Lin (VP, Spirox), Jerry Barone, Israel Niv (CEO, DCG), James Wu (General Manager, Spirox) Back row: CJ Hsieh, (VP, Spirox), Joffe Huang (Sales Manager, Spirox), Colin Bolger (Technical Marketing and overseas Sales Director, Spirox), Cliff So (Dir. Sales/Business Development-Asia, DCG)

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