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Strategic Fabrication Demands Strategic Testing

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As the demand for low power mobile devices continues to drive down device voltages, it's become increasingly difficult to produce devices that operate in a stable manner within narrower performance margins, even when they're produced with well-understood processes and materials like Si/SiO_2/polysilicon/Al. Helping fabs address this challenge demands that test vendors deliver new, more sensitive electrical test methodologies – everything from algorithms to test equipment to extracting productive information from new types of data. Just as important, both fabs and test vendors alike need to understand the concept of strategic test, and how it can help fabs make more cost-effective choices about their test equipment investments.

The growing use of new materials further compounds the need for new test methodologies. Device and materials physicists understand it's impossible to keep achieving dramatic device performance gains simply through device scaling. In fact, performance gains attributable to the use of new materials were equal to those attributable to device scaling for the first time at the 90nm node. As 45nm processes inch their way toward production, IC makers continue to push devices based on their new materials into production at mind-numbing rates. Unlike traditional Si/SiO_2/polysilicon/Al materials systems, these new processes often include less electrically stable materials, like sSOI/high κ/metal/Cu/low κ. This reduction in electrical stability is forcing fabs to characterize their materials and devices at many more points in the materials characterization, device development, and process integration cycles, and far earlier than in the past.

Unfortunately, this urgent need for more intensive electrical characterization comes at a time when some fabs may be unprepared to provide it. There's an odd downside of two decades of working almost exclusively with extremely stable Si/SiO_2/polysilicon/Al materials—fabs may not have enough people with the skills needed to develop new electrical test methodologies for new materials and translate the volumes of data these tests will produce into usable process knowledge. While this level of expertise is often available in the lab environment, it's often difficult to transfer that knowledge to the production setting. In order to remain competitive, test suppliers and fabs will need to form even deeper partnerships and cooperative development initiatives in order to create new test methodologies to ramp up new processes based on new materials.

One of the first steps test vendors must take in helping the industry adjust to the new materials and new test methodologies is working with fabs to better distinguish between *commodity* testing and *value-added* or *strategic* testing. The perception within the IC industry is that the cost of test per device is staying steady or increasing while the cost of processing per device is dropping. While this may, in fact, be true for functional testers, which typically have proprietary designs and aren't repurposable for new devices, it's far from true for parametric test and device characterization/parametric analysis solutions. Today, the most far-sighted parametric test vendors understand that their customers are increasingly unwilling or unable to afford to replace their testers after several technology nodes. Instead, they offer test platforms that separate the repurposable "commodity" portions of the system (system controller, power supplies, basic DC instrumentation, prober, test head, etc.) from the "strategic" portion (modular instrumentation and fixtures designed to handle functions like AC impedance, RF, pulse, and reliability testing). Separating the commodity portion of the system from the strategic portion allows fabs to span multiple technology nodes cost-effectively by simply adding new modules as needed to the existing test configuration.

For example, wafer level RF measurements are acutely needed to develop and produce advanced ICs. Accurate s-parameter extraction has become essential for high frequency circuit modeling at 1–40GHz and for RF compact model verification. But, too often, IC makers assume RF testing is too time-consuming and expensive to perform in the fab, so they haven't pursued developing this capability. However, highly modular

tester designs make it possible to incorporate RF testing capabilities into an existing DC tester, without incurring the cost or floor space requirements of a separate tester and prober.

The strategic testing approach can be equally valid when applied to the reliability lab, where the gate dielectric behavior of new high κ materials is typically not well understood. Many existing stress-switch-measure systems simply aren't fast enough to test the Negative Bias Temperature Instability (NBTI) and Time Dependent Dielectric Breakdown (TDDB) of multiple devices. However, with the strategic addition of modular I-V source-and-measure channels, these systems can be adapted to provide the measurement speed needed to eliminate device relaxation problems and produce the vast quantities of data required for lifetime prediction and modeling.

The semiconductor industry faces some major challenges in preparing for the 45nm technology node. We must start thinking about testing in a new way—not as mere commodity testers with prices that must be driven down to satisfy the bottom line, but as a strategic testers that we must use intelligently to speed our progress toward 45nm processes and beyond. KEITHLEY

About the Author

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