C-V/I-V TESTING BECOMES FASTER, SIMPLER, AND MORE ECONOMICAL

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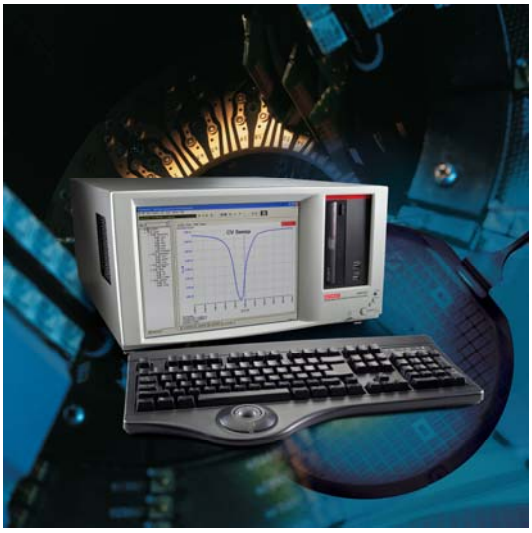
In the semiconductor industry, the need for increased test efficiency and productivity has never been greater. Rapidly changing technology is creating the need for more complex and faster testing to increase product reliability and get products to market more quickly. Keithley is filling this need with its new C-V test system, the first of its kind to enable tightly integrated C-V/I-V/pulse testing in a compact, benchtop design that enables users of all experience levels to make expert measurements. At the same time, its price and capabilities are lowering ownership costs for the semiconductor fabs and labs that use this equipment.



Keithley's new Model 4200-CVU is a C-V measurement instrument for its powerful Model 4200-SCS Semiconductor Characterization System. It is a module that plugs into any available instrument slot of the Model 4200-SCS, allowing fast and easy capacitance measurements from femtoFarads (fF) to nanoFarads (nF) at frequencies from 10kHz to 10MHz. Developed with the most modern and high performance circuitry available, the Model 4200-CVU has eight patents pending on its innovative design. This design provides

intuitive point-and-click setup, simple cabling, and built-in element models that eliminate the guesswork in obtaining valid C-V measurements.

The Model 4200-CVU comes with the most extensive set of test libraries available. Even more capabilities are available with Keithley's Model 4200-LS-LC-12, a special switch matrix and card with cables and adapters that enable tightly integrated C-V/I-V testing with a single prober touchdown. The optional Model 4200-PROBER-KIT allows easy connection of the Model 4200-SCS to the most widely used probers. The net result is comprehensive C-V testing that is as easy to set up and run as I-V tests.

With these new products, the 4200-SCS product line offers:

- Expanded parameter analyzer capability that seamlessly integrates I-V, C-V, and pulsed measurements within one compact chassis
- A multiuse instrument with a small form factor and single learning curve
- New and necessary test/measurement resources for today's and tomorrow's technologies
- Ease-of-use created from years of customer interaction and feedback
- Most powerful and flexible C-V software ever developed
- Ongoing investment protection through continuous upgrades and backward compatibility with existing Model 4200-SCS instruments

Broad Application Support

Keithley has taken the lead in C-V instrumentation and now satisfies the widest range of applications served by a single semiconductor test instrument, covering a broad array of probers, device types, process technologies, and measurement methodologies – including pulse I-V. The Model 4200-CVU and optional modules solve the problems of other characterization systems that either do not provide integrated C-V/I-V/pulse, or have limited support in their user interfaces and software libraries. Moreover, the system's flexible, powerful test execution engine makes it simple to combine I-V, C-V, and pulsed tests into the same test sequence, so the Model 4200-SCS can replace a variety of electrical test tools with a single, tightly integrated characterization solution. Nonetheless, Keithley's Model 4200-SCS will continue to support C-

V/I-V/pulse and other test methodologies utilizing a variety of third party instruments. These characteristics make the 4200-SCS/CVU solution the ideal choice for:

- Semiconductor technology development/process development/reliability labs
- Materials and device research labs and consortia
- Any lab needing a benchtop DC or pulse instrument
- Most semi labs and users needing multi-use/multi-instruments in a small form factor

Powerful Software. One key to easy test setup and analysis lies in the software's Graphical User Interface (GUI). Developed from many years of customer interaction and feedback, the ease of use continues with the new Model 4200-CVU hardware and software modules, which are a natural extension of the 4200's interactive test environment and execution engine. Keithley supports the Model 4200-CVU hardware with an extensive set of sample programs, test libraries, and built-in parameter extraction examples ready to run right out of the box. The eight software libraries provide the broadest range of C-V test and analysis available. They cover all the standard applications, including C-V, C-t, and C-f measurement and analysis, including junction, pin-to-pin, and interconnect capacitances. These tests include various linear and custom C-V sweeps, including full arbitrary DC waveform generation with up to 4096 data points.

An extensive suite of C-V sample tests and parameter extraction formulas are bundled with the Model 4200-CVU to give users working in semiconductor technology development, process development, and reliability labs the tools they need to work more productively. Bundled sample tests include:

- Standard C-V sweeps for generic MOSFETs, diodes, and capacitors.
- MOScap: Measures C-V on a MOS capacitor. Extracted parameters include oxide capacitance, oxide thickness, doping density, depletion depth, Debye length, flatband capacitance, flatband voltage, bulk potential, threshold voltage, metal-semiconductor work function difference, and effective oxide charge.
- MOSFET: Makes a C-V sweep on a MOSFET device. Extracted/calculated parameters include oxide thickness, oxide capacitance, flatband capacitance, flatband voltage, threshold voltage, and doping concentration as a function of depletion depth.

- Lifetime: Determines generation velocity and lifetime testing (Zerbst plot) of MOS capacitors.
- Mobile Ion: Determines mobile charge using the bias-temperature stress method and extracts flatband voltage. Includes built-in control of a hot chuck to test sample at room temperature, then heated, then room temperature to determine flatband shift.
- Capacitor: Performs both a C-V sweep and a C-f sweep on a Metal-Insulator-Metal (MIM) capacitor and calculates standard deviation.
- PNjunction: Measures the capacitance of a p-n junction or Schottky diode as a function of the DC bias voltage across the device.
- Photo Voltaic cell: Measures forward and reverse biased DC characteristics of an illuminated solar cell and extracts parameters such as maximum power, max current, max voltage, short-circuit current, open-circuit voltage, and efficiency. Also performs characteristic C-V and C-f sweeps.
- BJT: Measures capacitance (at 0V bias) between terminals, including C_{be}, C_{bc}, and C_{ec}.
- I-V/C-V switch: Demonstrates using DC SMUs, CVU, and Keithley Models 707A/708A (switch matrix) in one project. Switches back and forth between DC and C-V tests and connections to the DUT.
- Interconnect Capacitance: Measures C-V of small interconnect capacitance on wafer.
- Nanowire: Makes C-V sweep on a two-terminal nanowire device.
- Flash: Performs C-V measurements on a typical floating gate Flash memory device.

Unlike other characterization systems, the Keithley C-V/I-V analysis and extraction programs operate in a well-documented open environment, allowing users to easily make modifications and customize their routines. Integrated sample projects, developed from standard textbook models and the deep applications knowledge of Keithley engineers, help to shorten program development time.

The well proven capabilities of the Model 4200-SCS provide the best user experience with the shortest learning curve. It solves the problems faced by semiconductor lab managers when

striving to increase productivity and efficiency in device characterization and modeling. For example, the training time is much shorter, particularly in a multi-user lab environment.

Designed for higher throughput

Much of the credit for the Model 4200-CVU's exceptional measurement accuracy, speed, and efficiency is due to the Model 4200-SCS's high speed digital measurement hardware and tight hardware and software integration, as well as Keithley's adherence to low-noise system design principles. This combination of strengths means the Model 4200-CVU can improve users' productivity significantly, whether the task is as simple as setting up a single measurement or running a preset test sequence with a single mouse-click, or as sophisticated as triggering and plotting multiple C-V sweeps. The system's high speed digital architecture means the Model 4200-CVU can run and plot C-V sweeps in real time faster than any competitive C-V meter.

Highly Versatile Test Environment

In addition to I-V, C-V, and pulse testing in one flexible, fully integrated test environment, Model 4200-SCS users have several other options. These include a choice of up to eight medium- or high-power DC source-measure units (SMUs), dual-channel pulse and waveform generators (up to eight channels maximum), and an integrated digital oscilloscope. Like the Model 4200-CVU, all of these instruments plug into the Model 4200-SCS instrument slots and are controlled by the powerful Keithley Test Environment Interactive (KTEI, version 7.0). This point-and-click interface streamlines test setup, test sequence control, and data analysis. KTEI can also control a variety of external instruments, including numerous probers, hot chucks, and test fixtures, as well as Keithley's high integrity switch matrices, which provide the widest connection flexibility available in the industry.

The Model 4200-CVU also comes with a variety of advanced diagnostic tools to help ensure the validity of C-V test results. Uncertain if a test result is accurate? Just click the on-screen "Confidence Check" button or use the real-time front panel to isolate portions of the test setup for validation.

Obsolescence Protection. Some instrument manufacturers produce a continuous stream of products that are not compatible with each other, and a new product often signals the end of a previous offering – leaving no investment protection. Keithley's policy of continual hardware and software upgrades to the Model 4200-SCS means that the Model 4200-CVU module, along with all associated software and optional hardware, can be retrofitted to any Model 4200-SCS ever built. This easy upgrade path eliminates the need to buy a new parametric analyzer every few years to keep pace with innovations in device or materials technology. Systems can be upgraded cost-effectively to keep up with the industry's evolving test needs, so capital investments in the Model 4200-SCS stretch much further than in competitive test solutions. Furthermore, external hardware and test program development is held to a minimum.

For additional information on this Keithley test solution, visit http://www.keithley.com/pr/078.

About the Author

Lee Stauffer is a Senior Marketer with Keithley Instruments in Cleveland, Ohio, USA, where he is responsible for developing and supporting products for the semiconductor manufacturing and research markets. His formal education in electrical engineering and semiconductor device physics is complemented by 17 years experience in semiconductor process and product engineering, device characterization, and instrumentation design. He can be reached at 440-248-0400, or by e-mail at lstauffer@keithley.com.

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