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Pulsers Answer Emerging Testing Challenges

Todd Stocker
Keithley Instruments, Inc.

ELECTRONIC equipment and device manufacturers face continued technical challenges. With the rapid advance of technology, new devices and materials are being introduced into new product designs. But with these new materials and devices come new challenges for characterization and testing.

In order to keep up with these changing technology trends, new testing techniques that address these emerging needs have become prevalent. Pulse testing is one example of a technique in which engineers are becoming more interested as a way to address the emerging testing challenges they face.

What is a Pulser?

Pulse testing involves outputting a voltage or current that changes from a low level to a high level at a specified transition rate. Pulses are most commonly used to test for a transient response of a device in order to determine its transfer function. This helps in characterizing a material's electrical behavior.

Pulse or pattern generators are used in both the lab and on the production line. Researchers often need to stimulate a device under test (DUT) with a pulse, series of pulses, or known data patterns at specified rates in order to characterize device performance. Pulse or pattern generators are often configured into test systems that also include source-measure units (SMUs), digital multimeters, voltmeters, switches, and oscilloscopes.

The increased need for pulse testing is due to many factors, one of which is the increased speed of electronic circuitry that highlights the limitations of DC testing of analog components. A reduction in the size of components is another factor, which leads to an increase in self-heating effects in these smaller, more sensitive devices.

Key applications for pulse testing include the growing world of nanotechnology research. Also, semiconductor test and characterization, memory device testing, clock simulation, the functional test of electronic components, and generating streams of digital data of both plain and coded patterns.

Applications

Pulse generators are used in a variety of diverse applications. One common use is in thermal analysis. Here, a pulse with known parameters is applied to a device intended to heat the material. As heat transfers through the device, another parameter, such as temperature or current, is measured. This is an important technique in areas of material research and development.

Additionally, pulse generators are used for device lifecycle or stress testing. This is typically done on memory devices such as Flash, DRAM, SRAM or new memory technologies. In the case of memory testing, a pulse generator outputs write/erase pulses to exercise a particular memory location a large number of times. The characteristics of the memory location are measured before and after the stress test to determine the amount of change to the memory cell as a result of the multiple write/erase cycles. This process allows users to analyze the reliability of the device, evaluate the manufacturing process, and verify the design of the particular material or component.

Pulse generators are also used as clock or data simulators. Clock and digital data simulation is used to determine how a device behaves if the clock or data signal is not ideal. Here the pulse stream can be controlled to give the precise shape to test the performance limits of a device.

Another common test is pulsed current-voltage testing, or pulsed I-V, which is used for device characterization. Much like traditional I-V testing, pulsed I-V is used to determine the device characteristics as current or voltage increases. Pulses minimize the effect of heat on the device and secure accurate measurement results, whereas a DC signal would generate too much heat or would be too slow to give good results.

Charge Pumping

One very common, if not specialized, use of pulse testing is in making charge pumping measurements in semiconductor applications. Charge-pumping is widely used to characterize interface state densities in MOSFET devices. Recently, with the development of high dielectric (high κ) gate materials, charge pumping has proven especially useful in characterizing charge trapping phenomena in high-κthin-gate films. In thin-gate films, leakage current is relatively high due to quantum mechanical tunneling of carriers through the gate. As a result, the traditional technique for extracting interface trap density—collecting simultaneous quasi-static and high frequency C-V measurement data and comparing the difference—can't be used, because quasistatic C-V is very hard to achieve at the leakage current level.

However, charge-pumping measurements can still be used to extract interface trap density, and the effect of gate leakage can be compensated for by measuring charge-pumping current at lower frequency and subtracting it from measurement results at higher frequencies.

The basic charge-pumping technique involves measuring the substrate current, while applying voltage pulses of fixed amplitude, rise time, fall time, and frequency to the gate of the transistor, with the source, drain, and body tied to ground. The pulse can be applied with a fixed amplitude, voltage base sweep or a fixed base, variable amplitude sweep.

In a voltage base sweep, the amplitude and period (width) of the pulse are fixed, while sweeping the pulse base voltage. At each base voltage, body current can be measured and plotted against base voltage.

A fixed base, variable amplitude sweep has a fixed base voltage and pulse frequency with step changes in voltage amplitude. The information obtained is similar to that extracted from a voltage base sweep. These measurements can also be performed at different frequencies to obtain a frequency response for the interface traps.

Conclusion

Pulse generators are becoming an important tool for designers working on the next generation of semiconductor and nanotechnology devices and high-speed components. Faced with intense budget and time-to-market constraints, they cannot compromise on measurement quality. Pulse generators enable high-quality testing and characterization of the latest semiconductor materials.

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KEITHLEY INSTRUMENTS, INC. ■ 28775 AURORA ROAD ■ CLEVELAND, OHIO 44139-1891 ■ 440-248-0400 ■ Fax: 440-248-6168 ■ 1-888-KEITHLEY ■ www.keithley.com

BELGIUM
Sint-Pieters-Leeuw
Ph: 02-363 00 40
Fax: 02-363 00 64
www.keithley.nl

CHINA
Beijing
Ph: 8610-82255010
Fax: 8610-82255018
www.keithley.com.cn

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Espoo
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Fax: 09-88171662
www.keithley.com

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TAIWAN
Hsinchu
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www.keithley.com.tw

UNITED KINGDOM
Theale
Ph: 0118-929 75 00
Fax: 0118-929 75 19
www.keithley.co.uk

 Printed in the U.S.A. No. 0000 0307