Quality Test Systems for High-Power Semiconductors

With more than 30 years of experience, ABB designs and manufactures CE compliant customized test systems, covering the entire range of high-power semiconductor testing capabilities. Presently, over 70 test systems are in operation for routine and reliability measurement of power semiconductors, some of them have been in operation for more than 15 years. Thanks to close proximity to semiconductor development, application and production, we are in an ideal position to provide measurement systems to meet customers' needs. Automation, safety, operator friendly handling and easy to maintain are among the designed-in features. **R. Leutwyler, S. Gekenidis, ABB Switzerland Ltd, Semiconductors, Lenzburg, Switzerland**

Customers expect high-power semiconductors to be extremely reliable and without any failures while still being inexpensive. Continuous product quality improvement and production efficiency enhancement are therefore among the main focus areas of high-power

ABOVE Figure 1: Static and dynamic test system for thyristors and diodes

semiconductor manufacturers. Taking advantage of customized and highly automated test systems is one answer to this challenge.

Electrical test system

There is a broad variety of high-power semiconductor devices like diodes, phase control thyristors (PCTs), bi-directionally controlled thyristors (BCTs), fast switching and reverse conducting thyristors, gate turn-off thyristors (GTOs), integrated gate-commutated thyristors (IGCTs) or insulated gate bipolar transistors (IGBTs) available on the market. Their current and voltage ratings range from several hundred to about 5,000 A and from slightly above thousand to more than 8,000 V. These devices must be tested and characterized, however, at currents and voltages of up to 10 kA and 14 kV, respectively. Prior to shipment high-power semiconductors are tested statically and dynamically, at hot and cold temperatures and also undergo single-pulse and multi-pulse tests.

While production test systems are optimized for high throughput and the measurement of a fixed set of parameters of finished devices, test systems used in R&Dor in failure analysis labs must assure a high degree of flexibility to easily adapt to different voltage and current ranges, electrical configurations and mechanical footprints of subsystems, subassemblies or even wafers or chips.

It goes without saying that state-of-the art high-power semiconductor test systems must assure accurate, repeatable, reliable and save measurements and comply with internationals standards.

An example of a static and dynamic PCT and diode production test system is shown in Figure 1. This test system features an electrical breaker to protect the test system

Figure 2: Baseplate flatness test system

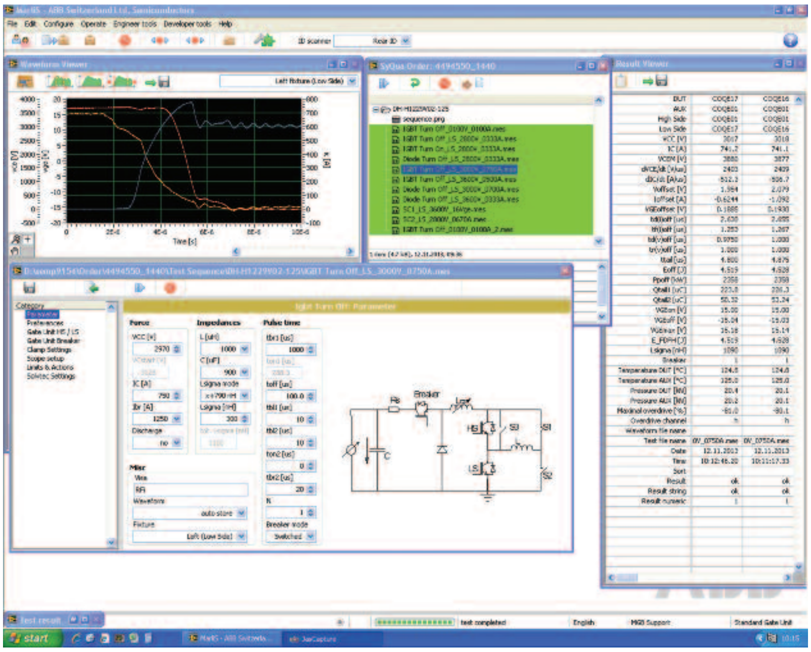


Figure 3: **Typical main user interfaces**

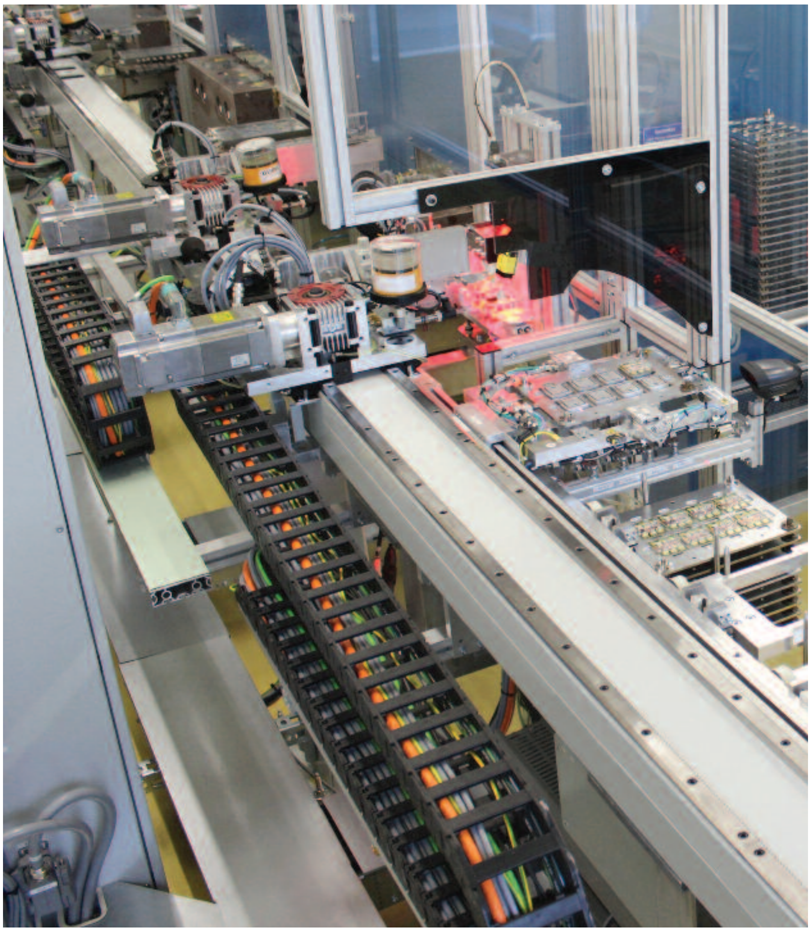


Figure 4: **Substrate handling and conveyer for testing with 25°C static, 125°C dynamic and 125°C static**

by limiting the current at device failure programmable test circuits to configure eg the stray inductance (down to 60 nH) in order to measure devices of different voltage classes; a programmable gate unit to cover a wide range of triggering capabilities; easily interchangeable barcode traceable snubber modules and the mechanical adaption of test fixtures within less than a minute to measure different device footprints; clamping devices of up to 240 mm in diameter with a clamping force of up to 240 kN; heating up to a precise temperature of the uniform clamped device of up to 200°C (production test systems) and a cooling down to a precise temperature of -40°C in an environmental chamber (engineering test systems).

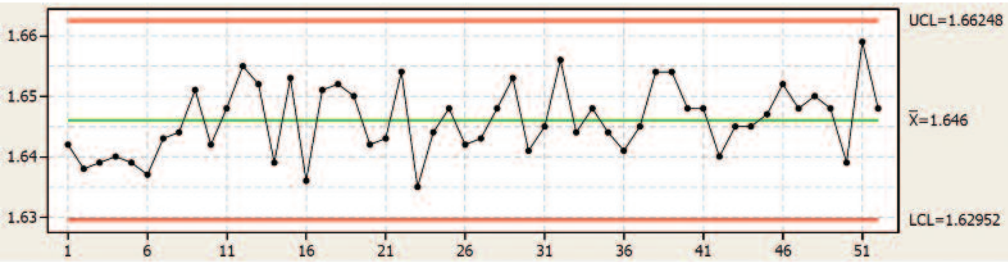
Mechanical test system

In order to ensure outstanding reliability and failure-less operation of high-power semiconductors, not only electrical parameters but also mechanical specifications must be carefully monitored and controlled. One example is the baseplate flatness of IGBT modules. A test system as shown in Figure 2 enables the accurate, fast and reliable flatness measurement at predefined points of baseplates as incoming material or at finished products. The tests are performed at baseplates of up to 140 mm x 190 mm under nominal mounting conditions with an accuracy of better than 1 µm.

Visualization and automation

The control and visualization software together with a user friendly interface are crucial to both allowing for flexibility, enabling automation and offering easy programming. Setup verifications, test sequences, actions after measurement failures, setting of control limits, definition of sample plans and the programming of a configurable gate unit, signal generators and other peripheries are all to be programmed and visualized with the software. An example of a typical main user interface is shown in Figure 3. The test system and its software preferably also allow for direct or remote operation and must offer the capability of easy switching from the operator mode into the engineering or service mode.

To enhance production efficiency and improve quality the system shall take advantage of built-in barcode readers to control and verify the main test system configuration (eg snubber module fixture, active clamp module, etc) and read the measured device's part number, serial number, etc. It also shall interface with a manufacturing execution system (MES) to automatically download production orders with the corresponding test sequences as



RIGHT Figure 5: Example of a SPC control chart

well as with a quality management system to upload the measured data for statistical process control (SPC, Figure 5). Automation and quality are both further improved by minimizing human interaction through integration of a sequence of different testers with conveyor belts as shown in Figure 4.

Quality

High quality products can only be delivered when tested with high quality testers. The careful and regular calibration of the test system is a prerequisite. A test system calibration includes the calibration of all electrical, mechanical, thermal and optical sensors. It also includes the verification of the clamping force of the press system, the pressure homogeneity, the mechanical centering, the alignment of the adapters, the temperatures, the voltage (AC/DC) and the current probes. Such a test system calibration is preferably done in collaboration with an independent national institute like the Swiss Federal Institute of Metrology. Repeatability and reproducibility of tests is ensured by frequent gage R&R control measurements (Figure 6).

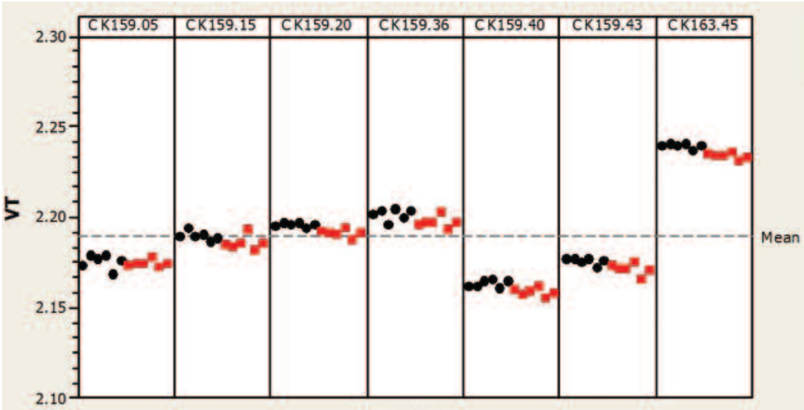


Figure 6: Example gage R&R for an on-state measurement on two static test systems