

High-performance digitizers in semiconductor manufacturing applications



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PC-based high-speed, high-resolution digitizers perform critical data acquisition functions during semiconductor fabrication, die packaging, and final chip testing

Data acquisition is a critical element of quality control and compliance testing during three stages of semiconductor manufacture. The first stage is fabrication, in which single-crystal semiconductor wafers are subject to various operations that leave them imprinted with micro-circuitry patterns. During the second stage, the wafers are diced up into individual silicon “die” that are packaged into final chips. The third stage involves functional testing of the final chips to confirm their operational compliance.

Today’s most advanced PC-based digitizers can perform the high-speed data gathering needed to implement critical analysis of various sorts during the semiconductor manufacturing process. Digitizers can accept electrical

waveforms from a wide variety of high-speed probes. The digitizer and its data can be easily integrated into a user’s customized semiconductor measurement system.

This article will introduce six applications where the performance of high-speed 16-bit digitizers is used to aid in the manufacturing process.

Real-time process control

This first application example shows how a high-performance digitizer was utilized to control a manufacturing process within a semiconductor fabrication facility in real-time. The digitizer continuously streamed waveform data to a host PC where complex digital signal processing (DSP) was performed. Although the digitizer was fully capable of maintaining the data stream, the CPU analysis could only process about 10% of the data, which was unacceptable. To solve this problem, our firmware engineers were able to transfer a large portion of the customer’s DSP algorithm into the digitizer’s on-board field programmable gate array (FPGA).

The resulting custom firmware afforded a 150X data reduction factor, while at the same time offloading most of the processing task from the CPU to the FPGA. The customer performed final floating-point operations on the CPU and was able to keep up with 100% of the data flow, as required for effective control loop operation. Data latency was also an important consideration to maintain a fast control loop response and was kept below five milliseconds. Sampling was performed at 500MS/s on eight digitizer channels. A key feature is the digitizer’s ability to stream 100% of the data and the capability to employ customized data reduction firmware.

Ultrasonic inspection

This second application regards the ultrasonic inspection of semiconductor chips immediately after packaging. Ideally, a semiconductor die is well bonded to its package so that it can dump its heat and avoid overheating. A poor bond presents an interface that reflects ultrasound. Consequently, a strong

reflected ultrasonic echo is a direct indication of poor bonding. Ultrasonic transducers are scanned in a 2D pattern parallel to the chip face so that the integrity of the entire die-package bond can be evaluated for rapid acceptance or rejection of chips under test. In this example, a two-channel, data streaming 2GS/s digitizer was used to realize the fastest possible 2D scanning rate.

Curve tracer measurement

In this application, development engineers needed a means to characterize unpackaged experimental dice during the semiconductor development process. Curve tracers are ubiquitous instruments used to characterize transistors. They apply DC voltages and currents to finished chips and measure resultant voltages and currents to characterize the device. An unpackaged die cannot accept the DC voltages from a curve tracer since the die cannot dump its heat fast enough and so will overheat. In this application, a curve tracer that uses short

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pulses that are only active for about a thousandth of the time is utilized, thereby reducing the heat load by a factor of a thousand. This AC curve tracer thus allows characterization of unpackaged dice, which reduces development time. A four-channel, 200MS/s digitizer with high, 16-bit resolution handles the high dynamic range signals measured by the curve tracer.

MOSFET characterization

Characterization of semiconductor chips after packaging may require expensive techniques like ultrasonic or x-ray inspection. In this application, the customer uses inexpensively measured noise spectra to characterize packaged MOSFET transistors. Various DC excitations are applied to the MOSFET under test. A four-channel, 16-bit, 200MS/s digitizer that simultaneously acquires multiple noise signals monitors MOSFET output noise at various test points. The frequency content of the measured noise spectra indicates MOSFET health or key failures. The system's ability to discriminate between different failure modes relies upon the high flatness of the digitizer's frequency response up to high frequencies.

DC power chip QA testing

This fifth application involves a company that manufactures DC power conversion chips. While most of their quality assurance tests use DC voltages, one high-speed AC test measures the trip point of an AC circuit as it is subjected to a ramping voltage signal. At the trip point, this signal is switched away from downstream circuitry to protect it from damage. This signal is monitored by a four-channel digitizer, whose 16-bit resolution allows high-fidelity acquisition of the signal. Its high DC accuracy allows for extremely accurate measurement of the signal amplitude at the trip point. In this application, multiple digitizers are used to enable simultaneous testing of several chips at once.

Semiconductor head testing

Data stored on conventional rotating hard drive units are read by a magneto-resistive semiconductor head that glides over the disk surface maintaining a gap of a few nanometers. This application involves the production testing of such heads, where they are characterized by measuring their noise output as they are subjected to a magnetic field. Certain head

failures manifest as specific noise signatures, which are used to reject bad heads. The system in this application used an embedded four-channel, 16-bit digitizer sampling at 200MS/s to capture noise signals from each read head. In this application, multiple four-channel digitizers are used to simultaneously characterize multiple heads to maximize testing efficiency.

Getting results

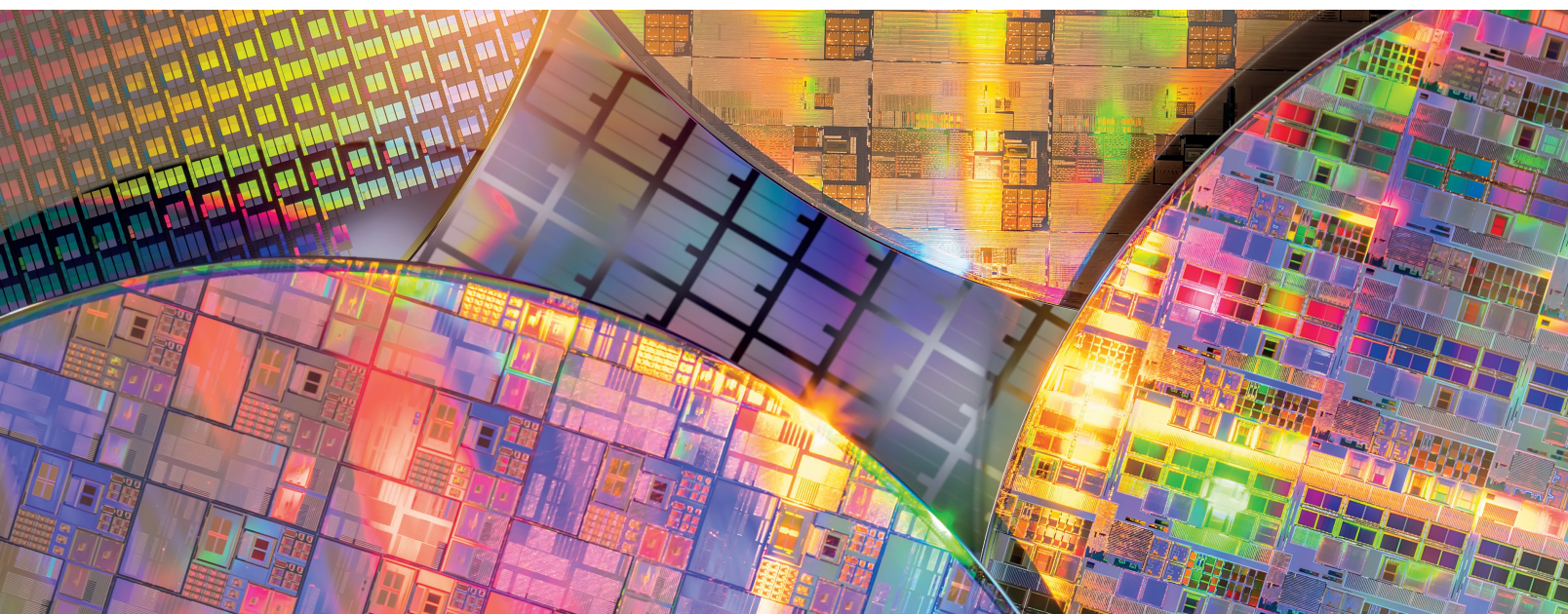
Semiconductor manufacturers need effective test and

measurement tools during the fabrication and packaging process. Digitizers, such as the one described in this article, provide high sampling speed, high vertical resolution, high absolute accuracy, high channel count, fast data transfer speed, and software and firmware customization that may be used to advantage in a wide variety of semiconductor test systems.

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The GaGe CompuScope four-channel, 200 MS/s digitizer with 16-bit resolution is an example of a high-performance, high-speed digitizer used for testing during semiconductor manufacture



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