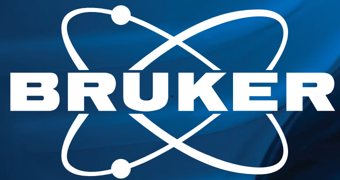


SPECTROSCOPIC REFLECTOMETRY

FilmTek 2000M TSV

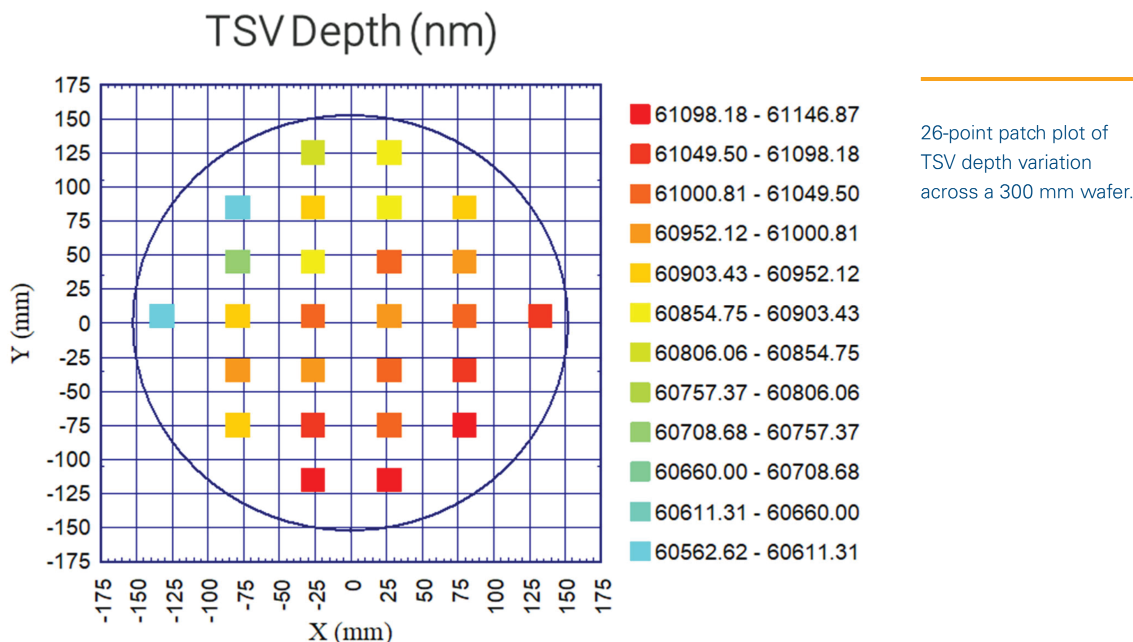
Non-Destructive TSV, CD, TTV, and Film Thickness Measurements Providing Real-Time Process Monitoring

2000M TSV Small-Spot Collimated-Beam Technology

FilmTek™ 2000M TSV is a fully automated non-destructive metrology tool that utilizes highly collimated light at normal incidence to measure film thickness, CD, total thickness variation (TTV), high-aspect ratio trenches, and through-silicon via (TSV) applications in both front-end and advanced packaging development. With its versatility and wide application coverage in a single platform, 2000M TSV is a valuable tool for high-volume semiconductor manufacturing, MEMS foundries, R&D, and shared common development facilities.

FilmTek 2000M TSV delivers:

- A wide range of thickness measurements from 5 nm to 350 µm, even on rough metal substrates, due to patented signal collection and post-processing.
- Nanometer resolution with a high-resolution detector/spectrometer, capable of resolving extreme high-frequency oscillations from thick films.
- Small spot size down to 2x1 µm allowing for measurements of high aspect ratio (HAR) vias or films in tight places.

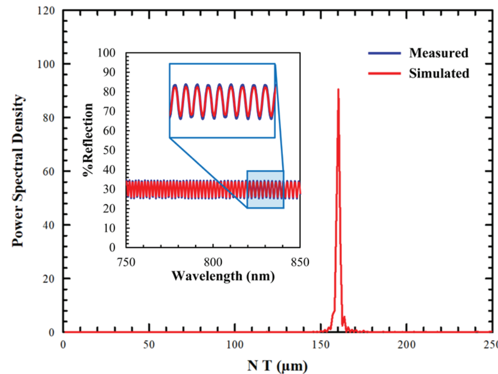


26-point patch plot of TSV depth variation across a 300 mm wafer.

Delivering Application Flexibility

Film Thickness Measurements Using a Patented Optical Design for Collimated Light

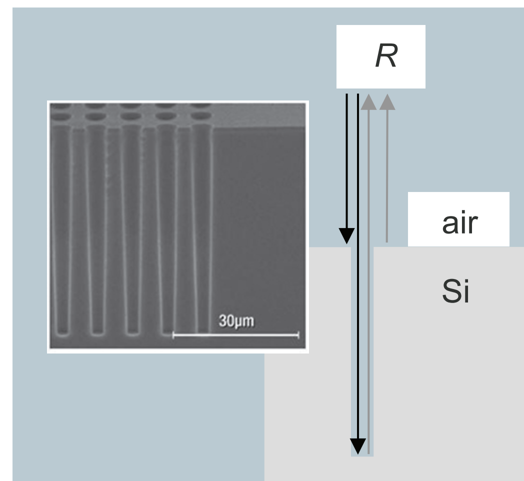
Typical reflectometry methods utilize a highly focused beam of light to achieve a small measurement spot size. A focused beam combined with high numerical aperture will collect a wide range of reflected angles, which results in destructive interference and incoherent reflectance for thick film applications. FilmTek 2000M TSV utilizes a patented optical design to generate a collimated beam with small spot size, allowing for coherent measurements of both thin and thick films. With a collimated beam and small spot size, it is possible to maintain coherent reflectance for very thick films, allowing for accurate thickness measurements from 5 nm up to 350 µm with 2000M TSV. Combined with a high-resolution spectrometer, 2000M TSV can fit and model the high-frequency oscillations common in the reflectance data of thick films.



Power spectral density (PSD) plot that enables fitting to yield improved thickness accuracy and repeatability. Inset: Measured and simulated reflectance spectra of ~100 µm photoresist on silicon, showing high-frequency oscillations.

High Aspect Ratio TSV Characterization Using Non-Destructive Reflectance Measurements

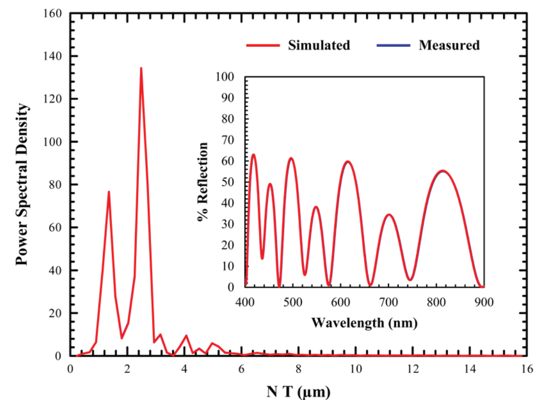
Filmtek 2000M TSV uses a patented optical design and processing technique to characterize HAR TSV structures via fast and non-destructive reflectance measurements. While typical reflectometry systems cannot reliably measure TSV depth due to incoherence, the optical design of 2000M TSV avoids this problem by using a collimated beam and adjustable spot size to provide consistent coherent reflectance data from HAR TSV structures. The high-resolution spectrometer is adapted to determine depths of TSV structures based on light reflected from the top and bottom of the TSV, while the CCD camera can be used to measure top CD of the TSV and for other imaging purposes. TSV diameters as small as 2 µm with aspect ratios of 40:1 can be accurately measured. Patented TSV data processes allow for a simple reflectance measurement to give detailed real-time results for TSV depth and CD analysis.



Schematic and scanning electron microscope image (inset) of HAR TSV structures.

Small-Spot Measurements for Next-Gen Semiconductor Applications

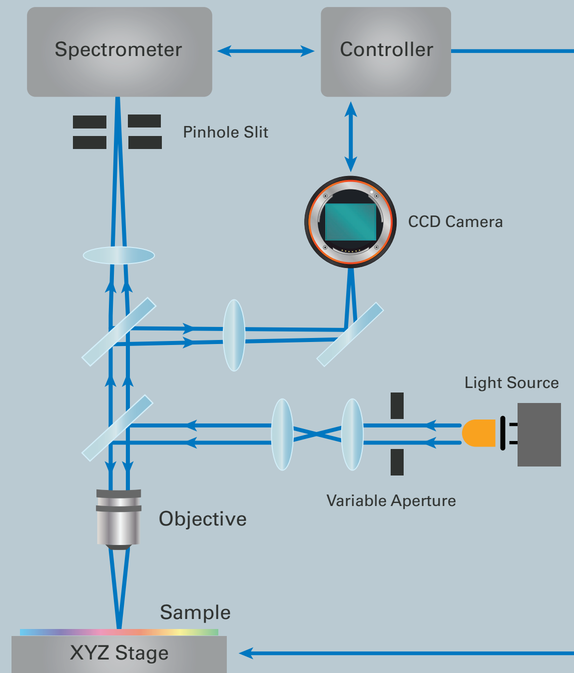
While the world of semiconductors continues to find creative ways to produce smaller devices, 2000M TSV's patented optical design allows manufacturers to stay a step ahead with a variable spot size that can go as small as 2x1 µm, capable of measuring the smallest test pads and in extremely tight spaces. From front-end manufacturing to advanced packaging and hard drive applications, 2000M TSV can measure thin and thick layers on top of and around devices to provide process control and reduce scrap.



PSD plot of 500 nm Si_3N_4 on 950 nm SiO_2 on an Si substrate, showing a distinct peak from each layer. Inset: measured and simulated spectra the SiN/SiO_2 stack, measured with a 2 µm spot size.

How Small-Spot Collimated-Beam Technology Works

A beam of white light is collimated by a variable aperture and directed through a microscope via beam splitters. Various low and high objective lenses are utilized to achieve various spot sizes, ranging down to 2x1 μm. The collimated beam exits the objective normal to the sample on the XYZ stage. The beam reflects off the sample back into the lens and then through a second beam splitter. Part of the beam travels through a pinhole slit and into a high-resolution spectrometer, while the second part goes to a CCD camera for a live view of the measurement location.



FilmTek 2000M TSV Specifications

Measurement function	TSV etch depth, bump height, critical dimension, and film thickness
Wafer handling	Brooks or Bruker's internal handling solutions
Substrate size	200 or 300 mm
Pattern recognition	Cognex
CD precision (1σ)	<30 nm
Etch depth precision (1σ)	<10 nm
Film thickness range	5 nm–350 μm (5 nm–150 μm is standard)
Film thickness precision (1σ)	<1 nm
Spot size	10x: 5x10 μm²; 20x: 2.5x5 μm²; 50x: 1x2 μm²
Light source	Halogen lamp
Detector type	2048 pixel linear CCD array
Wafer throughput	>40 WPH; 17-point map

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