Discover Insights inside Advanced Semiconductor Packages

ZEISS Crossbeam laser FIB-SEM

ZEISS Crossbeam laser FIB-SEM is a site-specific cross-section solution enabling faster package failure analysis (FA) and process development.

ZEISS Crossbeam laser combines powerful imaging and analytical performance of an FE-SEM with the high-throughput and high-quality sample preparation capability of a femtosecond (fs) laser and FIB to enable the fastest FA workflows. The isolated laser chamber prevents contamination of electron column and detectors, with optional automated sample transfer between the SEM and laser chamber under vacuum. The unique Crossjet feature keeps the laser entrance window clean with gas purging, aiding continuous large-volume removal with long-time reliable milling.

Fastest access to buried structures

The fs-laser can remove one cubic millimeter of Si with high-quality finish and minimal artifacts in less than 30 minutes, compared to the days it would take with other commonly used approaches. Optimized laser processing ensures efficient removal of diverse materials in IC packages, including metal, silicon, thermal interface material (TIM), mold compound, etc. Integration of the laser and FIB into a single system and correlated workflows provide the fastest results and highest success rate with 2 µm of laser milling accuracy.

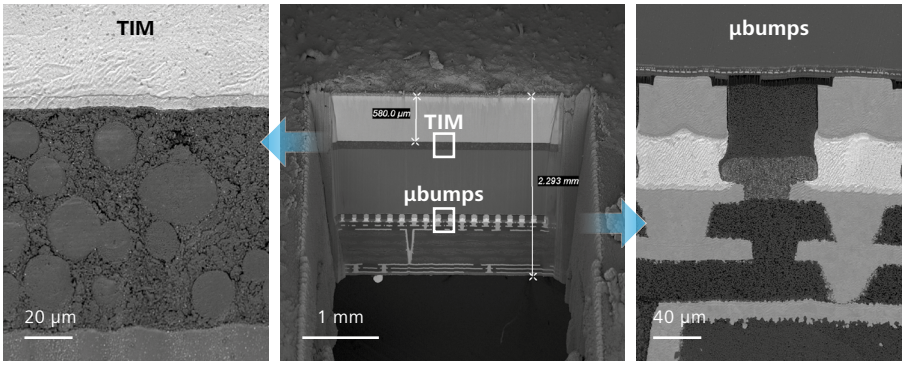
Best sample preparation quality with minimal artifacts

The Crossbeam laser workflow avoids mechanical polish artifacts such as delamination or cracks in fragile and stressed materials, while providing higher cross-section accuracy than mechanical cross sections. Fs-laser ablation is for the most part athermal so the laser affected zone (LAZ) is minimal, and it is often possible to image package interconnects immediately after laser ablation, without a need for FIB polish.

Highest imaging performance without ablation contaminants

The ZEISS Gemini I and II electron columns deliver well-known image quality with their in-column SE and energy-selective BSE (EsB) detectors for highest resolution and unique material contrast. The Crossbeam laser family has optional charge control solutions for high quality analysis of insulating and low-contrast materials.

Optimal use of these features to achieve highest imaging quality requires clean chamber conditions. These conditions are enabled by isolating the laser ablation in a segregated chamber. Samples can be easily shuttled back and forth under vacuum between the imaging and ablation chambers, ensuring a pristine system and sample condition throughout the entire preparation and analysis sequence.



Fast large-scale cross sections with fs-laser on a power electronics package with thermal interface material (TIM). More than 30 mm³ materials were removed within 1.7 hrs. The interface and interconnects are imaged directly after using the laser (without any ion polish).

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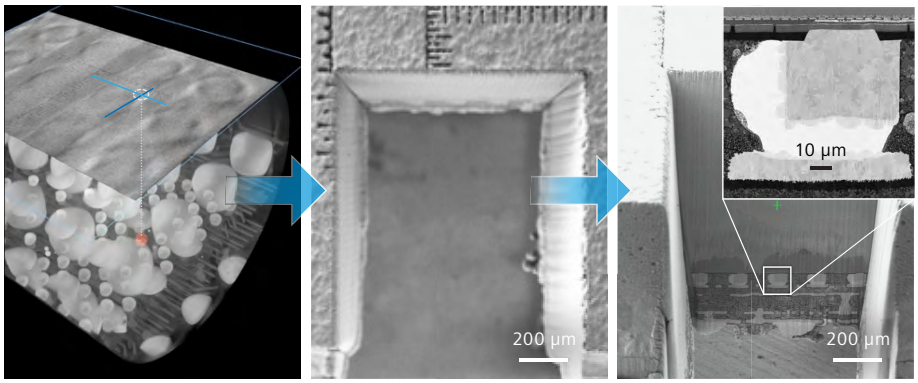
Seeing beyond

Precisely identify, access, and analyze with XRM/LaserFIB correlated workflow

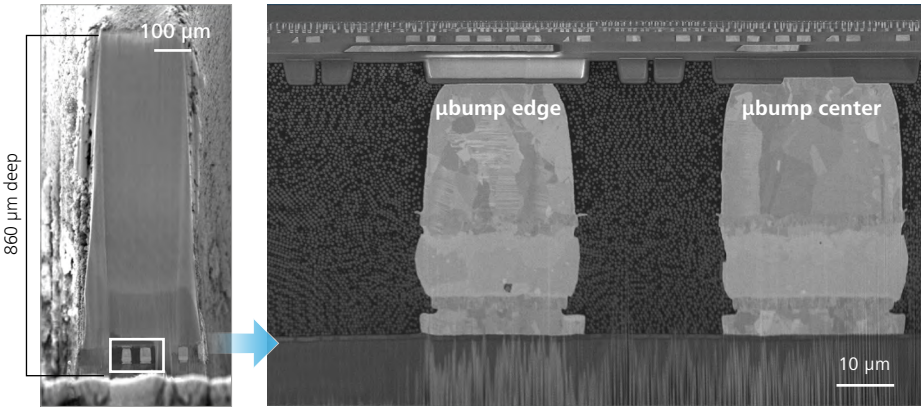
ZEISS 3D X-ray microscopy (XRM) has been the gold standard for non-destructive imaging of IC packages. With the assistance of 3D XRM dataset, analysts can virtually navigate through the entire package volume to identify the specific regions of the interest and failures. The subsequent laser milling and FIB polishing enable rapid access and preparation of site-specific cross sections with extremely high precision. True sample anomaly information is extracted from SEM images and material analysis data.



XRM/laserFIB workflow shows that a small Cu-pillar bump in a smartphone package-on-package (POP) is accurately targeted, cross sectioned and imaged with the aid of laser-made fiducials.

A new approach for better and faster cross sections

- Rapid site-specific sample preparation with or without the guidance of 3D XRM data
- Large-volume removal for millimeters cross sections
- Fast milling through packages and stacked dies for failure analysis on interconnects, TSVs, hybrid bonds, and BEOL structures
- Suitable for many materials including TIM, polymers, SiC, ceramics and glass
- Maximize FIB capacity with efficient large-volume processing



High quality imaging of microbumps and BEOL structures buried 860 µm deep in a 3D package; <1 hour total laser + FIB time.

Crossbeam fs-laser System Data

Ablation Rate	15 Mio. µm³/s (for Si)
Scan Speed	0.1–9000 mm/s
Scan Field Sizes	40 × 40 mm
Max Sample Sizes	For 8 mm sample height (mounted directly on laser holder): 30 × 30 mm squared / 75 × 20 mm rectangular / Ø 32 mm circular
	For 4.8 mm sample height (mounted on 3.2 mm high standard stub): 36 × 36 mm squared / 75 × 26 mm rectangular / Ø 39 mm circular
Laser Safety Class	1

Optics

Focal Length	f = 100 mm (telecentric)

Laser

Type	Diode pumped solid state laser, crystal fiber
Average Laser Power	10 W @ 1 MHz
Peak Power per Pulse	>29 MW (at nominal energy)
Max Pulse Energy	10 µJ @ 1 MHz
Pulse Duration	<350 fs (at nominal energy, sech2-fit)
Wavelength	515 nm (green)
Pulse Repetition Rate	0.1 kHz–1 MHz
Focus Diameter	<15 µm
Rayleigh Length	50 µm
Beam Quality	M^2 <1.2
Max Focal Point Adjustment	6 mm (±3 mm)

Laser Positioning on Sample

Calibration Process	Dedicated sample holder with high precision markers to define common coordinate system between SEM and laser ablation system. A semi-automatic registration process of marker positions ensures calibration between SEM and laser.
Accuracy	<15 µm in the centered scan field size of 25 × 25 mm and <2 µm on local area with additional offset correction

Standard Features

- Burst mode to improve milling speed and material-dependent effect on machining performance
- Laser recipe library
- Scripting of the LaserMill software to facilitate its operation
- Cross-jet to facilitate largest sample removal volumes, efficient parameter optimizations, and a clear optical path.

Optional Features

- Automatic sample transfer between laser chamber and main chamber
- External navigation camera for fast targeting on large samples when high accuracy is not needed or when samples are larger than recommended
- Metallographic sample holder to mount samples of up to 30 mm in diameter and 12 mm in height

microscopy@zeiss.com
www.zeiss.com/crossbeam