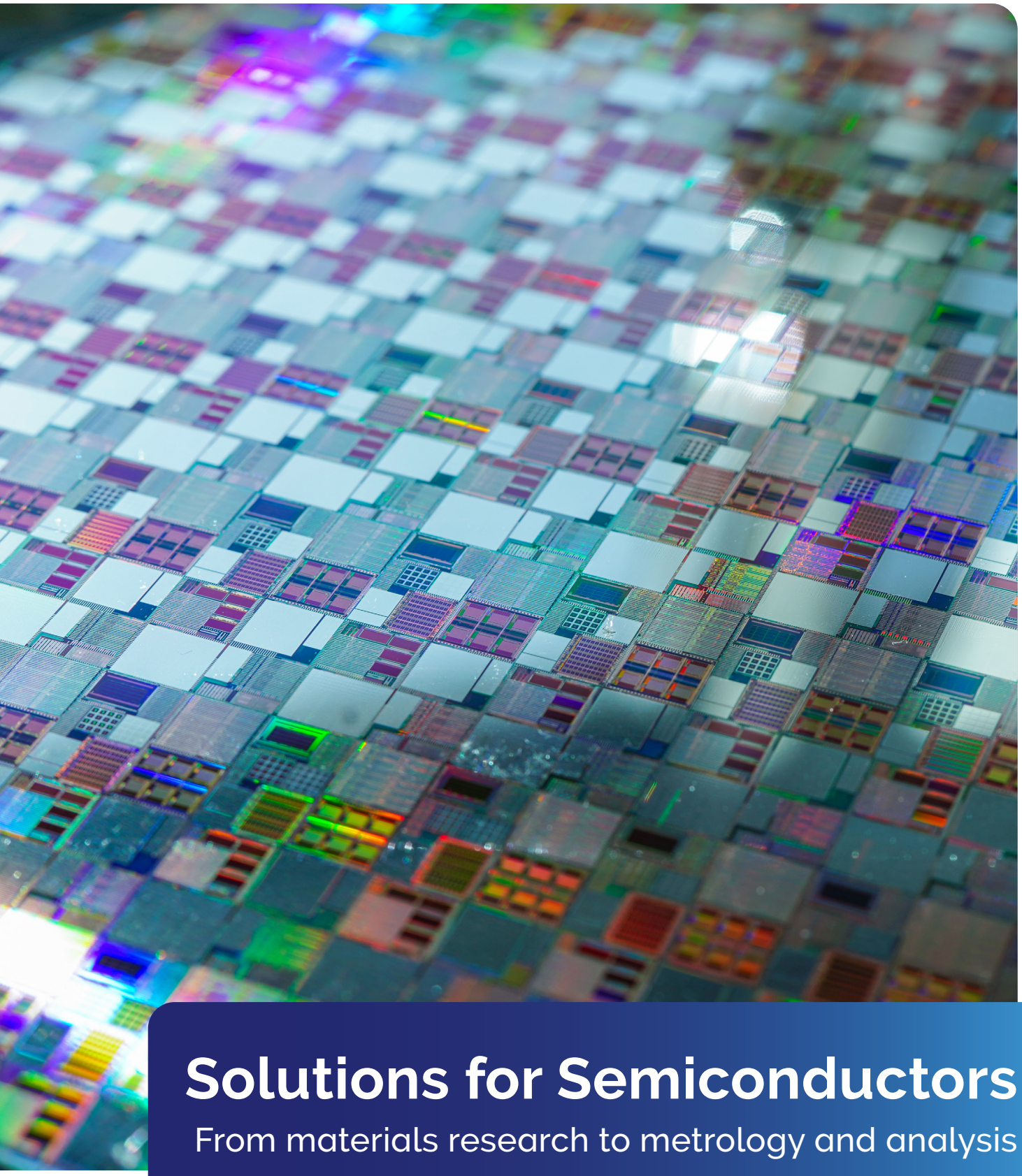
OXFORD INSTRUMENTS



Solutions for Semiconductors

From materials research to metrology and analysis

www.oxinst.com

Driving semiconductor innovation

Through advanced material development & quality control

ANALYSIS & CHARACTERISATION TECHNOLOGIES

AFM · Nanoindentation · EBSD · EDS · Scientific cameras · Spectroscopy · Raman

ADVANCED DEPOSITION & ETCH SOLUTIONS

High-performance, reliable and flexible systems across several etching & deposition technologies. Systems range from single load-lock R&D systems to full clusterable production systems for high volume manufacturing.
See more at plasma.oxinst.com

Etch · Deposition · Interface · Slanted etch · Smoothing

WAFER FABRICATION

CHIP DESIGN | FRONT-END-OF-LINE (FEOL) | BACK-END-OF-LINE (BEOL) | PACKAGING & ASSEMBLY | DISTRIBUTION & INTEGRATION

RESEARCH & ARCHITECTURE → MASK DESIGN & INSPECTION → WAFER PROBE & TESTING → FINAL TESTING & QUALIFICATION → END USE PRODUCTS

NEW MATERIAL DEVELOPMENT

Next-generation materials such as GaN, SiC, InP and GaAs, 2D materials (graphene, MoS_2), advanced memory materials, quantum materials, and novel transistor structures.

NEW MATERIAL CHARACTERISATION

- Visualise nanoscale topography, electrical and mechanical properties with **AFM**.
- Accelerate new material discovery with our mechanical microscopy solutions.
- Structural, elemental and crystallographic analysis with **EDS** and **EBSD** detectors.
- Understand optical properties with our **spectroscopy** solutions including photoluminescence.
- Gain insight into chemical composition, stress, doping and crystallinity with our **Raman** solutions.

MASK DESIGN & INSPECTION

Our solutions address mask fabrication and quality assurance from material analysis to final inspection.

- **Optical spectroscopy** tools are used for mask inspection.
- **SEM/EDS** mapping qualifies cleanliness and defect-free surfaces, while advanced AZtec software speeds up feature classification.
- **AFM** to assess mask defects, photoresist properties, and line edge roughness.
- **Raman** for particle and contamination identification.

FAILURE ANALYSIS, CHARACTERISATION & SEMICONDUCTOR METROLOGY

- **EDS/EBSD:** Correlate composition, crystallography, and microstructure for comprehensive materials characterisation.
- **EDS:** Investigate elemental distribution, interfaces, phases, contamination and compositional uniformity.
- **EBSD:** Analyse crystal orientation, grain structure, defects, dislocations, and strain.
- **AFM:** Measure roughness, topography, and electrical properties for process development and failure analysis.
- **Raman/Photoluminescence/Spectroscopy:** Wafer-level quality control: localise, identify defects, impurities and stress.
- **Nanoindentation:** measure modulus, hardness and critical loads for interfacial failure.

PACKAGING & ASSEMBLY

- **EDS:** Characterise solder joints, bond wires, interconnects and packaging materials, and identify contamination.
- **EBSD:** Characterise grain structure, crystal orientation and strain in solder joints, interconnects and bond wires to investigate reliability and failure.
- **Nanoindentation:** Mechanical microscopy on solder alloys and copper interconnects, quantify evolution of local mechanical properties with temperature.

Our solutions: at a glance

Plasma Etching

- **Inductively Coupled Plasma (ICP)** etching delivers a powerful combination of performance, precision, and process flexibility for advanced semiconductor manufacturing.
- **Deep Reactive Ion Etching (DRIE)** enables the fabrication of deep, high aspect-ratio structures with excellent anisotropy, making it a critical technology for MEMS, advanced packaging and nanotechnology devices.
- **Reactive Ion Etching (RIE)** delivers both isotropic and anisotropic dry etching capabilities, enabling users to select the optimal balance of etch rate, directionality, and process control.
- **The Atomic Layer Etching (ALE)** process is controlled by the self-limiting removal of material one atomic layer at a time, to deliver atomic-scale precision for next-generation semiconductor devices.
- **Ion Beam Etching (IBE)** an ideal solution for demanding applications, with capabilities to etch virtually any material, support angled profile generation, and incorporate reactive gases to enhance etch rates.

Plasma Deposition

- **Inductively Coupled Plasma Chemical Vapour Deposition (ICPCVD)** delivers a wide range of dielectric films at low deposition temperatures with minimal substrate damage and excellent uniformity.
- **Plasma Enhanced Chemical Vapour Deposition (PECVD)** optimise device performance and process repeatability.
- **NanoCVD** supports the deposition of films with thicknesses down to a single atomic layer, promoting the growth of advanced nanostructured materials and high-quality thin films, enabling innovation in next-gen semiconductor and nanotechnology applications.
- **Ion Beam Deposition (IBD)** is a versatile thin-film deposition technology that delivers reliable, high-performance coatings with exceptional uniformity, repeatability, and control, advancing semiconductor technologies where film quality directly impacts device performance.

Plasma Enhanced Atomic Layer Deposition

Plasma-Enhanced Atomic Layer Deposition (PEALD) achieves ultimate thickness control, depositing one atomic layer at a time. Our PlasmaPro ASP offers flexible ALD processing and an accelerated route from development to pilot production, while our Atomfab™ system delivers the fastest remote plasma production ALD capability on the market.



Atomic Force Microscopy

AFM enables engineers and researchers to visualise surface morphology, roughness, defects, electrical and mechanical properties of wafers, thin films, and devices with nanometre-scale precision.

- **Cypher / Vero Series**: Exceptional resolution and versatility for characterisation of next-generation materials including ferroelectrics and 2D materials
- **Jupiter Discovery**: Large-sample AFM for R&D and process development on wafers and substrates up to 300 mm

Raman & Photoluminescence Microscopy

Advanced confocal Raman and photoluminescence microscopy for materials characterisation, bandgap analysis, stress mapping, and defect detection. These complementary techniques enable the non-destructive investigation of semiconductor materials and devices, providing chemical, structural, crystallographic, and optoelectronic information.

- **witec360:** Versatile and correlative research tool
- **witec360 Semiconductor Edition:** focus on automated workflows, industry and inspection of full wafers
- **RISE:** Integrated Raman-SEM solution for combined elemental, molecular and structural imaging

Electron Microscopy

Our solutions enable comprehensive structural, compositional, and crystallographic analysis across SEM, TEM, and FIB workflows. Combining leading analytical hardware with intelligent software, our portfolio delivers the insights needed for process development, failure analysis, yield improvement, and advanced device characterisation.

- **EDS detectors:** High-speed elemental mapping and quantitative compositional analysis for materials, interfaces, contamination studies, and process control.
- **EBSD detectors:** Rapid crystal orientation, phase, and grain structure analysis for defect investigations, strain studies, and advanced materials development.
- **BEX detector:** Live elemental imaging with exceptional sensitivity and speed, enabling rapid analysis of semiconductor devices, complex topographies, and charging materials.
- **Omni-Probe**: Precision in situ sample handling, lamella lift-out, and nanoscale testing for advanced FIB-SEM workflows.
- **AZtec Software**: Integrated analytics with automated particle and phase analysis, workflow and reporting automation.

Optical Spectroscopy and Imaging

High-performance scientific cameras, spectroscopy systems, and optical imaging platforms that enable researchers in academia and industry to study and tailor electronics, structural and optical properties of semiconductors using analytical modalities including photoluminescence, Raman, transient absorption, EUV/X-ray imaging, or integrate into industrial diagnostics for wafer QC and photolithography mask inspection.

- **Scientific cameras** (sCMOS, EMCCD, CCD, SWIR, iCCDs): ultra-sensitive detection
- **Kymera optical spectrographs**: modular, high-throughput optical spectroscopy

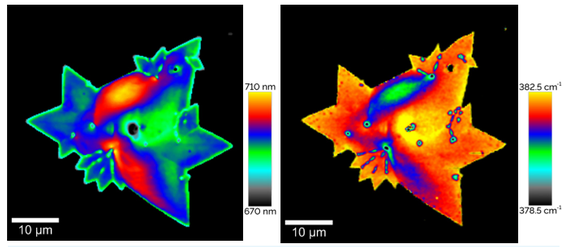
Nanoindentation

Our MEMS-based nanoindenter solutions offer site-specific mechanical metrology delivering high measurement precision and traceability required at all steps of device development and manufacturing. Characterise multi-material systems: from hard oxides and nitrides, through ductile metal alloys, to polymers and soft organic layers.

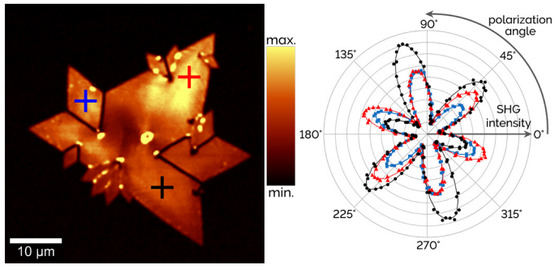
- **Standalone nanoindenters i04 and iX05** for mechanical microscopy, nanoindentation and nanoscratch testing.
- **In-situ nanoindenter NMT04** for microscale fracture or fatigue testing with simultaneous SEM imaging of crack propagation.

Novel materials research, development & characterisation

AFM Nanoindentation EBSD EDS Scientific cameras Spectroscopy Raman

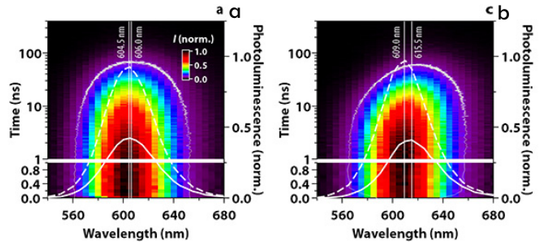


Correlative imaging of MoS_2. Shifts of the photoluminescence wavelength (left) and the Raman E_{2g} mode reveal areas of doping and strain as well as edge effects.



Correlative imaging of MoS_2. The second harmonic generation (SHG) image (left) shows grain boundaries (low intensity). Polarisation-dependent SHG intensity measurements (right) reveal different strain levels for the three indicated measurement positions.





Understanding energy transfer in quantum dots (QDs). Transient photoluminescence of InP/ZnSe/ZnS QDs in dispersion and resins. (a) Wavelength-time map of the photoluminescence of InP/ZnSe/ZnS QDs dispersed in toluene after photo-excitation with 400 nm light. The dashed and full white lines represent the emission spectrum after 1 and 20 ns, respectively, while the grey line is the emission intensity contour at I = 0.1. (b) The same for InP/ZnSe/ZnS QDs dispersed at high loading in the thiol-ene resin used for this work. Read more in our application note. Karadza, B., et al. (2023). Nano Letters, 23(12), 5490-5496

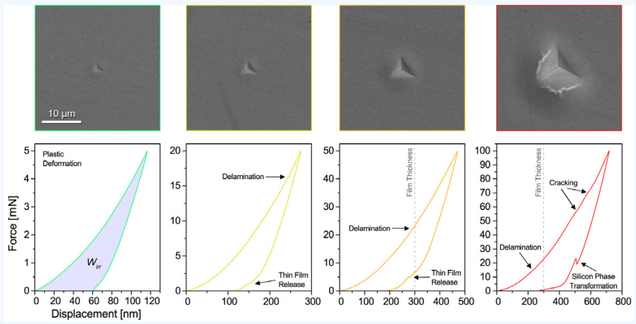


Failure analysis, characterisation & **semiconductor** metrology

Nanoindentation

Revealing interface reliability in semiconductor thin-film stacks
As semiconductor devices incorporate increasingly complex thin-film architectures, interfacial adhesion has become a critical determinant of reliability. Delamination can occur during wafer processing, packaging, thermal cycling, or field operation, leading to electrical failure and reduced device lifetime. Accurate characterisation of interface integrity is therefore essential during process development and failure analysis.

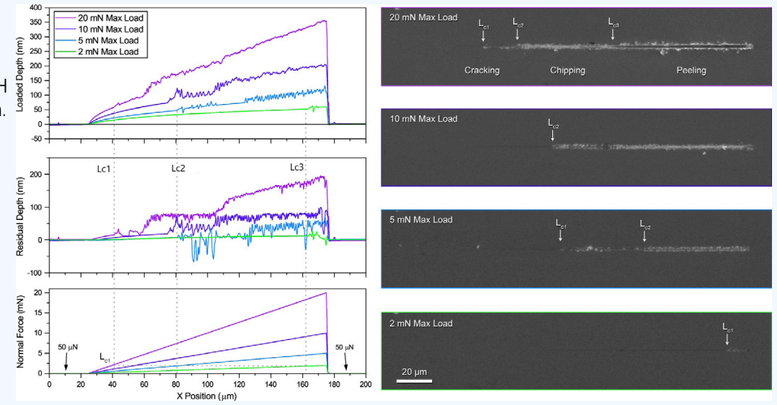
Nanoindentation provides a highly localised method for probing thin-film adhesion. By introducing controlled stresses beneath the indenter, the technique can trigger interfacial failure at weak interfaces while simultaneously recording force-displacement data. This enables direct correlation between mechanical response and the onset of damage.



Detecting delamination in metallic layers
Interfacial cracking and delamination produce characteristic signatures in nanoindentation curves. Sudden changes in the loading response, hardness, or stiffness can indicate the initiation of subsurface damage. In the example shown left, a sputtered WTi thin film with a thickness of 300 nm is indented to progressively increasing loads. This allows to follow the onset and progression of failure via irreversible energy dissipation: from predominantly plastic deformation at low forces to blister formation followed by cracking and film fragmentation at higher indentation loads.

Force-displacement curves and corresponding secondary electron (SE) micrographs of progressively deeper indentations into WTi thin film on Silicon. Irreversibly dissipated energy, W_{irr}, is shaded in the first curve

Verifying adhesion strength in ultrathin dielectric layers
SiOCH (silicon oxycarbide) films are hybrid organic/ inorganic materials deposited using methods like plasma-enhanced chemical vapor deposition (PECVD). While promising as low-k dielectric, their porous nature can result in poor mechanical performance, limiting the integrity of interconnect architectures. The figure (right) shows results from nanoscratch testing on a low-k dielectric SiOCH thin film with a thickness of 60 nm. As the scratch force increases, measured depth response during loading and after load removal (residual depth) indicate elastic deformation followed by progressively more severe damage events: first cracking within the film, then chipping (film detaches in small flakes) and finally peeling (the indenter tip penetrates below the film and removes it via shear). Each event is characterised by the critical load L_c, a standard metric of film performance, defined in analogy to scratch testing at larger scales.

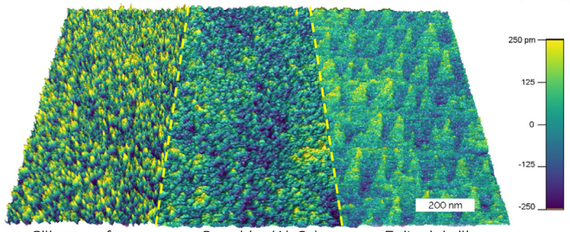


Scratch forces and depths vs. position during 2, 5, 10 & 20 mN progressive scratches of 60 nm SiOCH film on silicon with accompanying electron micrographs of the residual scratches.

In summary, the combination of nanoindentation and nanoscratch testing delivers a comprehensive toolkit for pinpointing the phenomena driving mechanical failure in semiconductor thin films. Together, these techniques help R&D teams identify interfaces susceptible to mechanical failure and increase the reliability of thin-film stacks.

Failure analysis, characterisation & **semiconductor** metrology

AFM



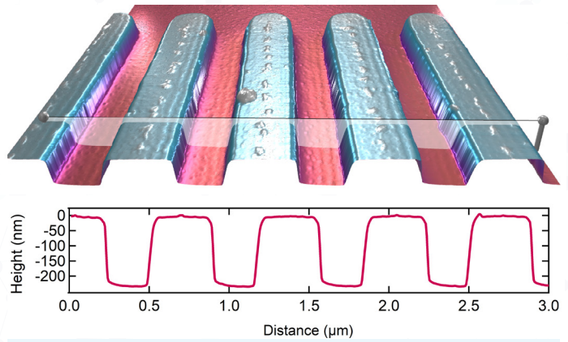
Silicon wafer
S_a: 121 pm (1.21 Å)

Sapphire (Al_2O_3)
S_a: 85.6 pm (0.85 Å)

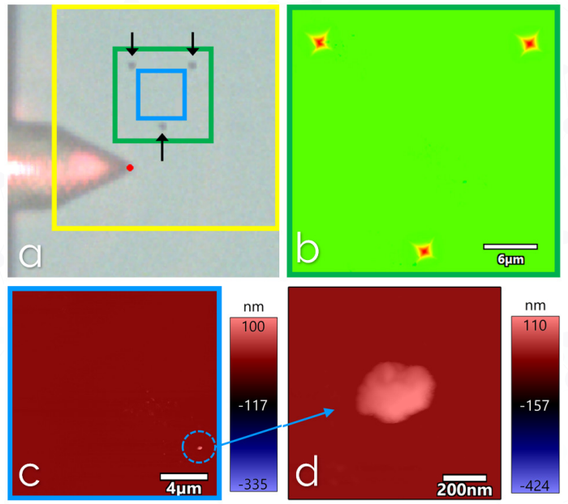
Epitaxial silicon
S_a: 66.2 pm (0.66 Å)

Sub-Å roughness measurements. Today, many semiconductor substrates, thin films, and processed surfaces exhibit roughness below 1 Å, a scale that requires AFM noise performance low enough to distinguish meaningful process differences from measurement artifacts. AFM images show a comparison of surface roughness of silicon (S_a=1.21 Å), sapphire (S_a=0.85 Å), and epitaxial silicon (S_a=0.66 Å).

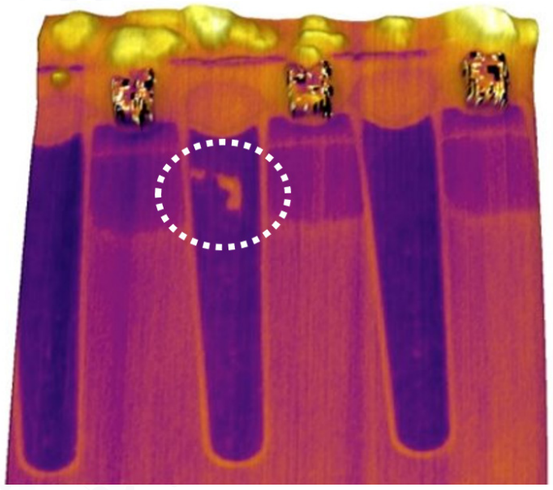
Automated inspection of epitaxial silicon wafer roughness. Non-uniform grain size is often observed in epitaxial silicon layers, especially near the wafer edge where greater variations in process conditions may occur. As shown in the diagram, a series of locations on a 150 mm (6-in) wafer were pre-defined in software and used in an automated routine to acquire topography images. a) Image acquired 200 µm from the wafer edge with S_a=0.785 Å. b) Image at 1.6 mm from the edge with S_a=0.833 Å. c) Image acquired 62.4 mm from the edge (12.8 mm from the centre) with S_a=0.902 Å.



Critical dimensions. AFM provides true 3D metrology thanks to fully calibrated measurements in X, Y and Z. There is little to no sample preparation, and there is no need for sample cross sectioning or coating. Here, a waveguide was imaged showing 230 nm depth and 280 nm width.



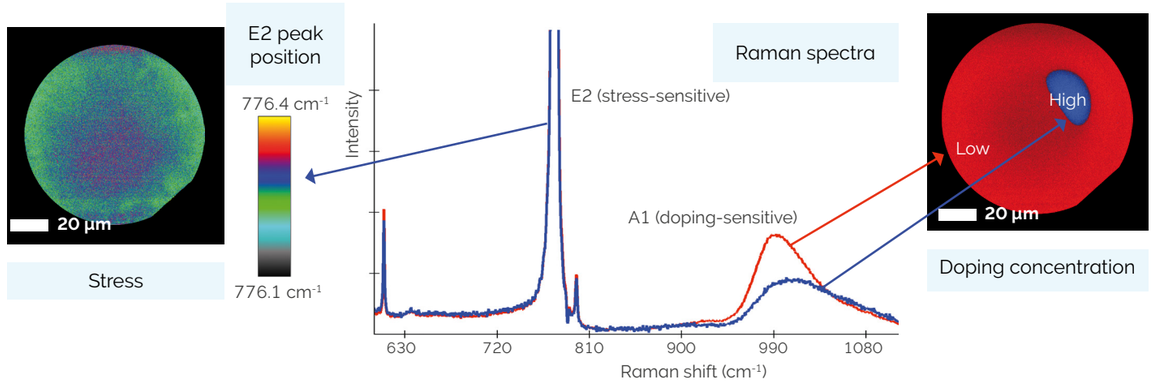
Defect review. AFM can distinguish between a particle and pit or another surface irregularity. a) optical view of the sample showing indents (arrows), the AFM tip (red dot), and the outlines of the different scan areas for reference: 20 µm (blue), 30 µm (green), 100 µm (yellow). b) AFM image showing the 3 indents visible in optical image. c) AFM image of the area where the contamination was detected. d) zoom in into the contamination area showing a particle of ~250 nm in diameter.



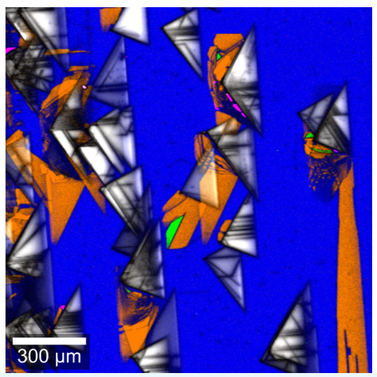
Failure analysis. In addition to topography, AFM can measure other signals such as electrical or mechanical response. Here, AFM capacitance data is overlaid on AFM topography image of an insulated-gate bipolar transistor device, uncovering a defect.

Failure analysis, characterisation & **semiconductor** metrology

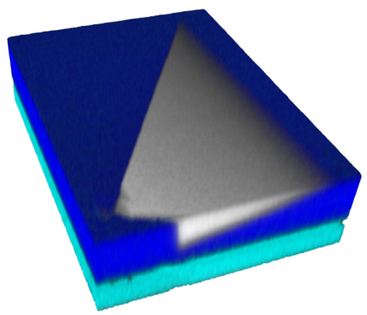
Raman



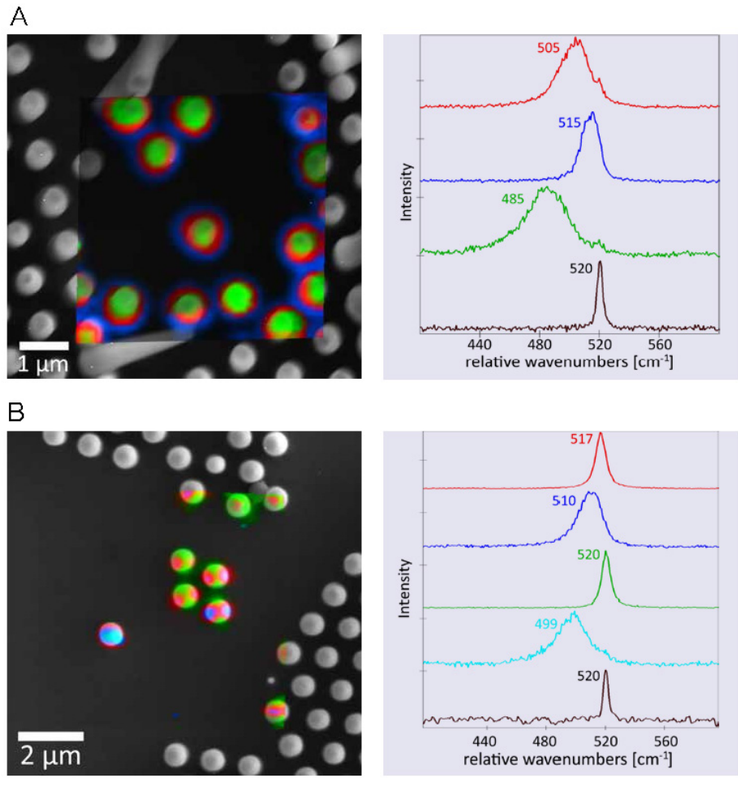
Full-area wafer inspection. Large-area Raman images of a 150 mm SiC wafer revealed variations of stress and doping. Left image: Colour-coded position of the stress-sensitive $E_{2(high)}$ peak, showing stress-induced shifts. Right image: Crystal facet region with a different doping concentration (blue) compared to the bulk area (red). Read more in our application note: Correlative Raman Imaging of Compound Semiconductors.



PL mapping of SiC polytypes and stacking faults. Photoluminescence image of defects with different bandgap properties in a 4H-SiC wafer, showing spectral characteristics of 4H-SiC (blue), 4H-SiC with stacking faults (orange, green) and 3C-SiC (grey).



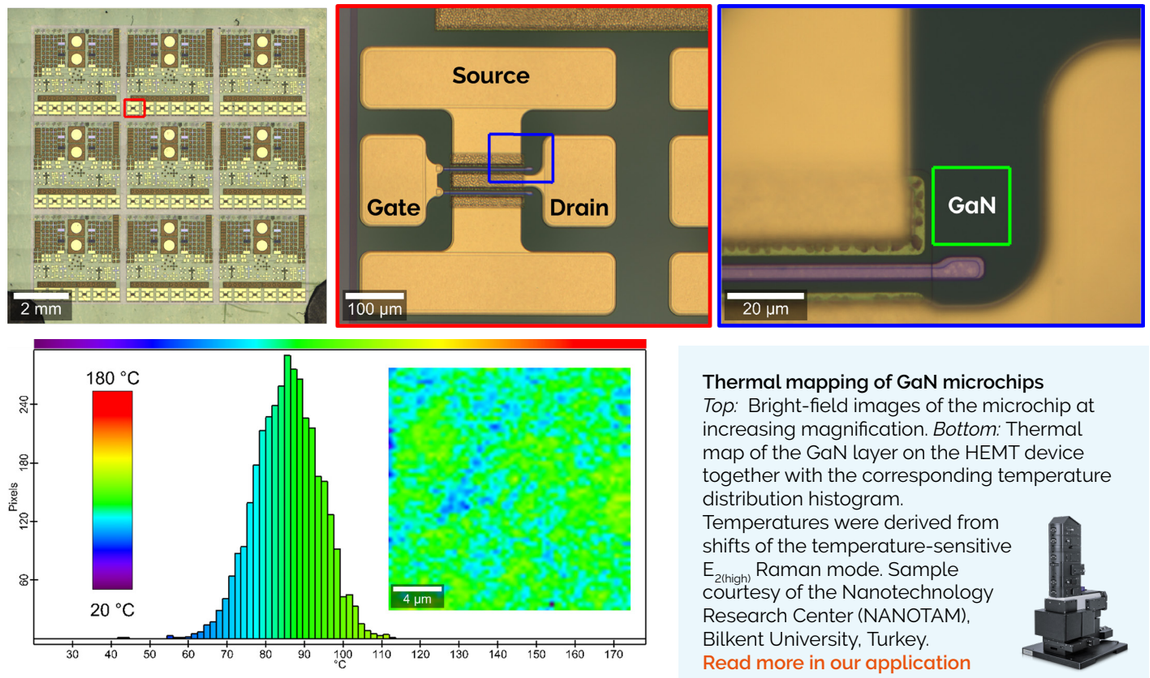
3D defect analysis. 3D Raman representation of a defect (grey) in an epitaxially overgrown (blue) SiC wafer (cyan). Dimensions: 180 x 245 x 7 µm³.



Correlative analysis of nanostructures. RISE Microscopy measurement of strained silicon pillars etched out of differently-oriented Si substrates. A section of the respective SEM image is overlaid with the Raman image of this region. The Raman image is colour coded according to the spectra shown on the right. (A) Nanopillars etched out of a (111) silicon substrate. (B) Nanopillars etched out of a (100) silicon substrate. Sample courtesy of Prof. Alois Lugstein (Institute for Solid State Electronics, Vienna University of Technology, Vienna, Austria).

Read more on Correlative Raman Imaging of Semiconducting Materials



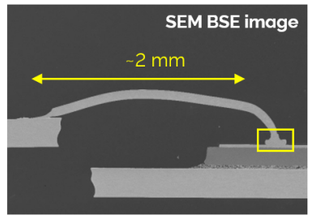


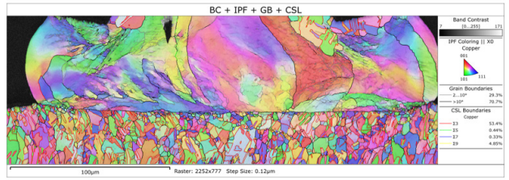
Thermal mapping of GaN microchips
Top: Bright-field images of the microchip at increasing magnification. *Bottom:* Thermal map of the GaN layer on the HEMT device together with the corresponding temperature distribution histogram.
Temperatures were derived from shifts of the temperature-sensitive $E_{2(high)}$ Raman mode. Sample courtesy of the Nanotechnology Research Center (NANOTAM), Bilkent University, Turkey.
Read more in our application note.

Failure analysis, characterisation & **semiconductor** metrology

EBSD EDS

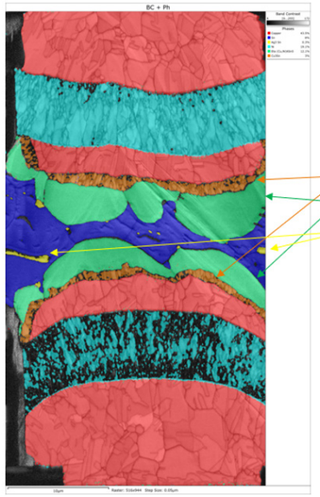
EBSD: Understand crystallographic structure, phases, grain boundaries and strain in semiconductor devices and packaging.





Wire bonding: High resolution analysis of texture, boundaries and strain at bonding interface.



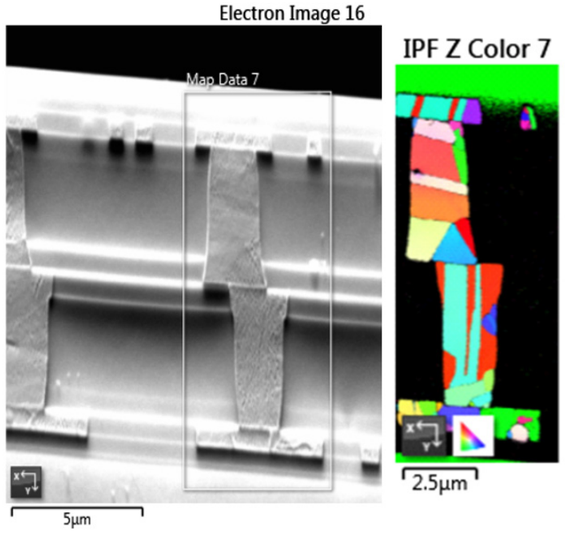


Note formation of IMCs:
Cu_3Sn
Eta $(Cu.Ni)_6Sn_5$
Ag_3Sn

Phases	
Copper	43.5%
Sn	8%
Ag3 Sn	0.3%
Ni	19.1%
Eta (Cu,Ni)6Sn5	12.1%
Cu3Sn	3%

Microbump: 12-minute scan revealed clear formation of multiple intermetallic compounds (IMCs) in SAC alloy system.

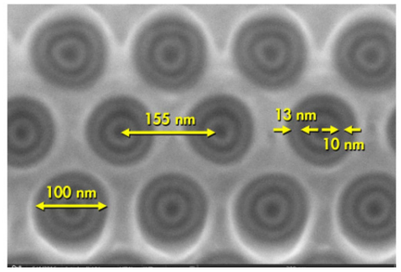




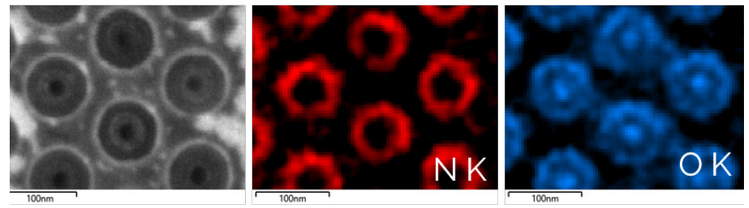
TSV boundaries and grains
3 mins at 1050 pps and 20 nm step size. High speed ideal for orientation and grain boundary analysis, with no drift.



EDS for semiconductor analysis: Characterise elemental composition and distribution across semiconductor devices, interfaces and packaging. Choose Ultim Max Infinity for high-performance EDS analysis, or Ultim Extreme when maximum light-element sensitivity and X-ray collection from nanoscale structures are required.

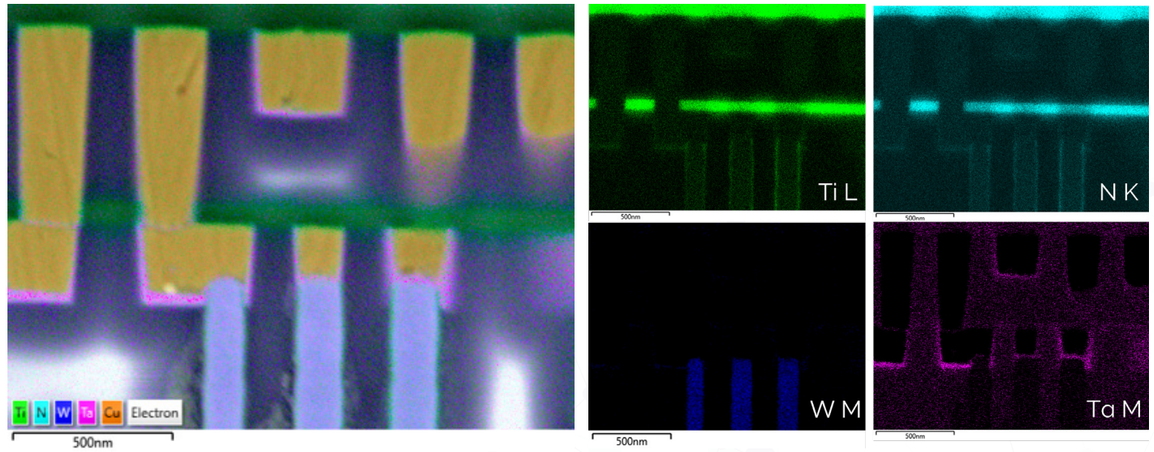


Ultim Extreme ∞ 1.3 kV



Advanced NAND characterisation with windowless EDS: The combination of low-kV analysis and windowless EDS improves sensitivity to low-energy X-rays from nitrogen and oxygen while minimising interaction volume. This enables clearer differentiation of SiN and SiO_2 layers within advanced NAND ONO stacks, supporting compositional characterisation at the nanoscale. Image description: Low-kV (1.3 kV) windowless EDS elemental maps of an advanced NAND structure, clearly resolving nitrogen and oxygen distributions within the ONO charge-trap stack.





Analyse bulk samples before committing to TEM
Ultim Extreme enables nanoscale EDS analysis directly on bulk semiconductor samples, helping you assess device layers before committing to TEM sample preparation and analysis. At 3 kV and 500 pA, Ultim Extreme mapped a 7–10 nm TiN/TaN layer in a bulk sample. Its high solid angle maintains strong X-ray signal giving flexibility to optimise imaging conditions while retaining signal for elemental mapping.



How we deliver **customer service excellence**

Our global footprint

We have a large network of strategically positioned regional service hubs, allowing us to deliver our best-in-class global customer support by leveraging local talent.

Our people

Our highly qualified, industry-leading, and accredited service engineers are here to provide the highest level of system expertise to give you the peace of mind you deserve.

Strategic service hubs

We place key parts at our regional service hubs and constantly monitor stock to ensure that parts are available, and we can respond quickly if a customer needs us.

Sustainability

We consistently develop our products and offer the latest processes and know-how to reduce the risk to the local and global environment.

Our commitment is clear: to **deliver innovative solutions** and **exceptional services**, that **help our customers stay ahead** in a fast-moving technology landscape.



With you every step of the way

Oxford Instruments brings together a broad range of technologies and expertise to help customers develop, manufacture and characterise advanced semiconductor materials and devices.

At Oxford Instruments, we go beyond delivering exceptional products. We provide a full suite of innovative services and support to ensure the optimal performance and longevity of your scientific systems.

Our expert Service Engineers work to maximise uptime, while our application and process specialists collaborate with you to fine-tune your workflows and guarantee consistent, high-quality outputs. We are here to ensure your current production runs seamlessly and reliably, while supporting the rapid development and successful launch of your future technologies.

We are dedicated to exceeding expectations, building lasting partnerships, and driving your continued success.

Enhanced functionality

Ongoing optimisation

Partnering for ambition development

Enabling a smooth start
Support to investment go live

Ensuring lifetime success
Maximising your investment

Advancing your capabilities
Enhancing your investment

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