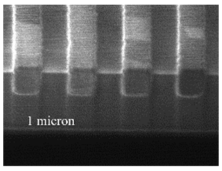
Bruker pioneers nanoscale property mapping of subsurface and buried layers of materials and devices via scanning probe microscopy

Free pilot analysis access – limited time offer

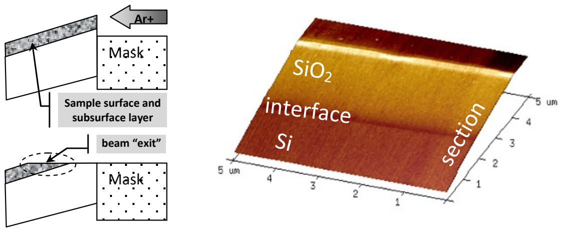
Bruker Ltd & LMA, Ltd with Lancaster University

MULTILAYER and heterogeneous three-dimensional (3D) structure of advanced materials and devices is a vital feature of modern semiconductor processors, memory chips, optoelectronic lasers, LEDs, optical sensors, energy saving glass coatings, rechargeable batteries, functional coatings and composite materials – naming just a few.

IMAGING and probing of the nanoscale subsurface 3D structure and interfaces is crucial for both the development of novel materials and devices, and production quality control. The conventional approach for cross-sectioning using focused ion beam (FIB) followed by electron microscopy (EM) typically allows to study narrow (up to few tens of um wide) sections, with sample surfaces often modified by the energetic Ga ions masking intrinsic properties of the material or device.



BRUKER NANO SURFACES together with Lancaster University based LMA, Ltd, pilot innovative Ar-ions Beam Exit Cross-section Polishing (BEXP™) producing near-atomically flat oblique sections of near and sub-surface layers of up to 0.5 mm wide. The unique approach based on pioneering US and EU patents, allows direct study of these cross-sections via scanning probe microscopy (SPM), providing ultra-high resolution maps of morphology, mechanical, thermal, and electronic properties of internal structure of material/device across depths from a few nanometres immediately below the surface down to 50 um deep.



BEXP™ - Beam Exit Cross-Sectional Polishing (left) produces **SPM-compatible** near-atomically-flat section of sample subsurface layers. These, analysed in Bruker material-sensitive SPM modes, offer nanoscale resolution maps of elastic and viscoelastic properties, conductivity, electrochemical activity, and morphology of hidden nano-structures. (Sample- thermal SiO_2 on Si). US/EU patents- **US 9082587, EP 2537017 B1**.

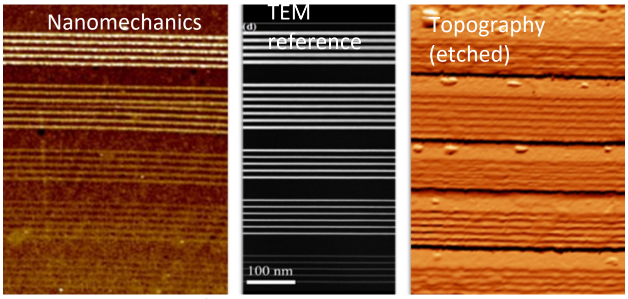
THE BEXP-SPM has already been successfully used for subsurface and 3D mapping of

- Optoelectronic MBE and CVD grown structures and devices (Si/Ge and III-V);
- Phase change materials and devices;
- Vertical cavity surface emitting lasers (VCSELs);
- Two-dimensional (van der Waals) materials including transition metal dichalcogenides;
- Thermal interface materials;
- Semiconductor process materials;
- Hard and soft composite coatings, and multilayer engineered glazing;
- Magnetic data storage;
- Solar cells.

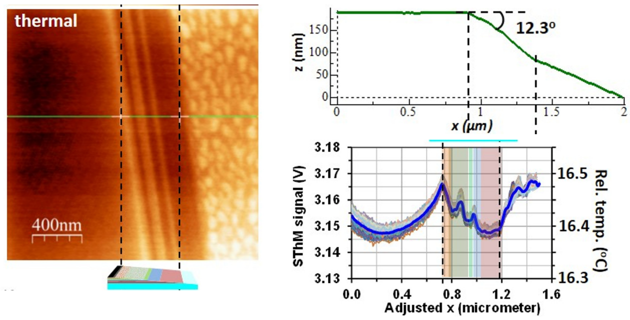
TO REVEAL following properties of buried layers, interfaces and 3D nanostructures

- Morphology and layer and structure dimensions;
- Material composition, stoichiometry and material quality;
- Nanoscale mechanical properties;
- Nanoscale electrical transport;
- Nanoscale thermal conductivity.

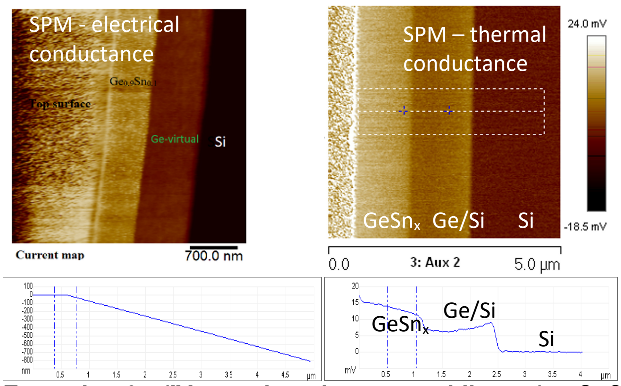
Selected examples from the BEXP^{TM}-SPM analysis



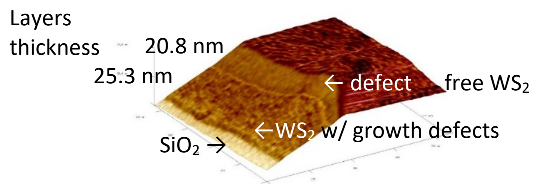
Example 1 (*III-V compound semiconductors superlattice*). Molecular Beam Epitaxy grown $Al_xGa_{1-x}As/GaAs$ superlattice. 3 nm layers with variable x (0.2−1) and variable GaAs spacing (8.5 to 1 nm). *Left* – SPM nanomechanical contrast, *centre* – reference cross-sectional TEM, *right* – SPM topography w/ etch. TEM/SPM thickness correlation is within 0.2nm.



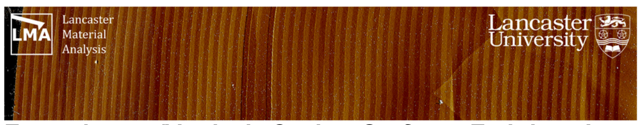
Example 5 (*Metallic nanolayers - heat assisted magnetic recording media*). Multilayer glass / adhesion layer / Fe / Ru /Ta / / CoCrPt- CoPtX structure is directly observed in nanothermal SThM image and profiles.
(Sample courtesy Kevin O'Grady, University of York, UK).



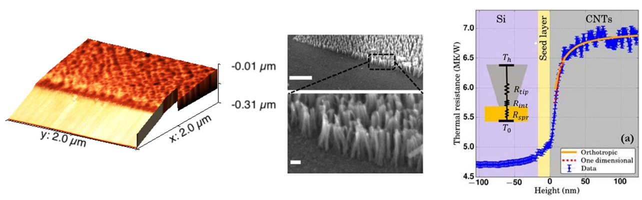
Example 2 (IV semiconductor multilayers). $GeSn_x$ epitaxial layer/ Si-Ge layer / Si bulk substrate. Local thermal conductance via Scanning Thermal Microscopy (SThM) reveals dislocations at the SiGe/Si interface & composition gradient in the $GeSn_x$ layer (sample courtesy J. Schulze, Institute Semiconductor Engineering, Stuttgart, Germany).



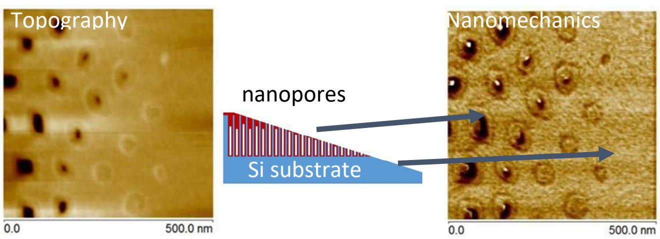
Example 6 (*2D van der Waals materials*). CVD grown transition metal dichalcogenide (TMD) WS_2 on Si substrate. SPM nanomechanical contrast, low defects top layer and the high defect density bottom layer clearly seen, with thickness measured with nm precision.
(Sample courtesy S. Jin group, University Wisconsin, USA).



Example 7 (*Vertical Cavity Surface Emitting Laser (VCSEL)*). Multilayer structure of distributed GaAs/AlGaAs Bragg reflectors, with GaSb Quantum Rings in active region. Total z-scale of structure is 13 um.
(Sample courtesy M. Hayne, Lancaster University, UK).



Example 3 (*Nanowires on a substrate - CNT based thermal interface materials (TIM)*). Carbon nanotube (CNT) layer of TIM is gradient "trimmed" via BEXP^{TM} producing increasing length brush to provide absolute measurements of intrinsic thermal conductance of the TIM (Sample courtesy O. Bezencenet, Thales, France).



Example 4 (*Nano-porous layers as supercapacitors*). The base and the stem of deep-etch vertical nanopores in the Si substrate as well as oxide pore clogging are clearly observed. (Sample courtesy M. Prunilla, VTT, Finland.).

THESE examples are just a subset of BEXP^{TM}-Bruker SPM capabilities that include QNM nanomechanical mapping, nanoindenting, nanoelectrical mapping via PeakForce-TUNA^{TM}, KPFM, sMIM^{TM} and photoconductive AFM.

BRUKER AND LMA Ltd in collaboration with Lancaster University currently offer **a limited-time free testing of this pioneering materials analysis toolbox for your samples.** We are happy to discuss your SPM setup to accommodate BEXP^{TM}-SPM at your site.

SEND/DISCUSS your samples analysis request:

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