Advanced Microscopy Services

Advanced microscopy techniques such as SEM (Scanning Electron Microscopy) (https://www.eag.com/scanning-electron-microscopy-sem/), TEM (Transmission Electron Microscopy) (https://www.eag.com/tem-stem/) and Dual Beam SEM (https://www.eag.com/techniques/imaging/dual-beam-fib/) are essential techniques to investigate sample microstructure, morphology, particle size, particle coatings and defects. These techniques often employ elemental mapping capabilities such as EELS (Electron Energy Loss Spectroscopy) (https://www.eag.com/electron-energy-loss-spectroscopy-eels/) and EDS (Energy Dispersive X-Ray Spectroscopy) (https://www.eag.com/energy-dispersive-x-ray-spectroscopy-eds/)which provide valuable information about elemental composition and location/distribution.

EAG offers a broad range and large installed base of different microscopy (https://en.wikipedia.org/wiki/Microscopy) tools and services to match your application, ranging from process development to failure analysis. In addition to providing high resolution imaging, our analytical capability makes us a unique partner that can help you during research, development, and analysis of failures.

Microscopy techniques can be used to characterize many types of defects. These include:

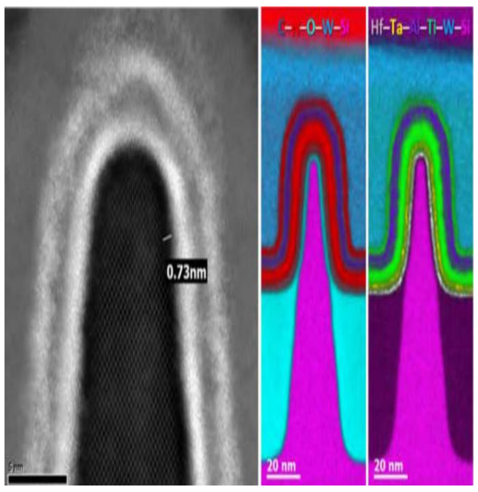
- Metal migration: FIB cross-section and investigation by STEM/EDS
- Voids: FIB cross-section and investigation by SEM
- Particles: Surface imaging or FIB cross-section to investigate size, chemistry and position in the layer stack
- Cracks and Delaminations: Small area FIB cross-sections or large area argon ion milled cross sections determine the location and of the delaminated interface. If needed, the interface chemistry can then be determined by TEM micro-analysis.
- Thickness and Uniformity: FIB cross-section and investigation by SEM

The types of materials tested using advanced microscopy techniques:

- Nanoparticles
- Alloys and metals
- Thin films
- Coatings on glass, silicon or carbon-based substrates
- Ceramics
- Composite materials
- IC devices
- Aluminum anodization

Industrial Applications of Microscopy

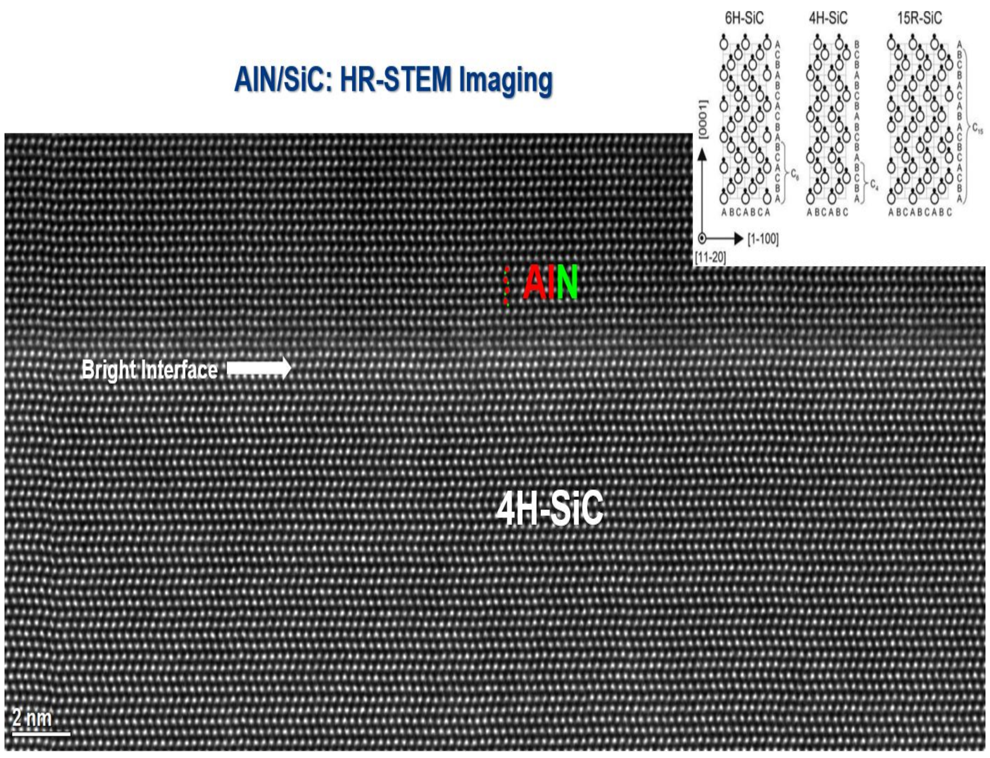
There has been a rapid emergence of new technologies which has enabled new industries such as facial recognition, autonomous driving, virtual reality, and 5G communication. These growth areas typically include FinFET, VCSEL, and III/V compound semiconductors. For our Advanced Microscopy team the materials indicate hetero-epitaxy, cubic and hexagonal lattices, where failures in devices often have complicated 3D structures.



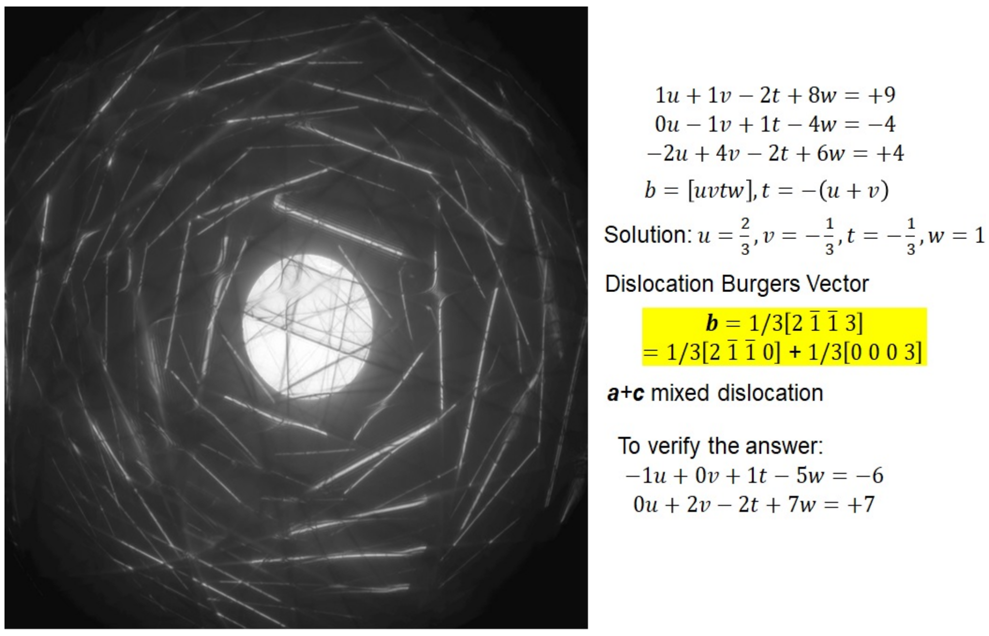
Recent development of FIB technology enables high-precision TEM sample preparation of 3D logic and memory devices. This example shows a HAADF image of a gate cut from a 22nm generation 3D FinFET device with L_{Gate}~30nm as seen in a recent paper by EAG Laboratories Advanced Microscopy team that was presented at Microscopy and Microanalysis 25 (S2): 690-691 (2019) (https://www.cambridge.org/core/journals/microscopy-and-microanalysis/article/industrial-applications-of-electron-microscopy-a-shared-laboratory-perspective/B0FC0E2BCDC49A3ABF2601B66D96309D) “Industrial Applications of Electron Microscopy: A Shared Laboratory Perspective”

Link to Paper (https://www.cambridge.org/core/services/aop-cambridge-core/content/view/B0FC0E2BCDC49A3ABF2601B66D96309D/S1431927619004185a.pdf/industrial_applications_of_electron_microscopy_a_s

Another interesting example is the picture below that shows a Aluminum Nitride/Silicon Carbide interface observed using HR-STEM imaging.



In the example below, we observe GaN Dislocation Typing: Burgers Vector Analysis with Large-Angle Convergent-Beam Electron Diffraction (LACBED)



$$1u + 1v - 2t + 8w = +9$$
$$0u - 1v + 1t - 4w = -4$$
$$-2u + 4v - 2t + 6w = +4$$
$$b = [uvtw], t = -(u + v)$$

Solution: $u = \frac{2}{3}, v = -\frac{1}{3}, t = -\frac{1}{3}, w = 1$

Dislocation Burgers Vector

$$\boldsymbol{b} = 1/3[2\,\bar{1}\,\bar{1}\,3]$$
$$= 1/3[2\,\bar{1}\,\bar{1}\,0] + 1/3[0\,0\,0\,3]$$

a+c mixed dislocation

To verify the answer:

$$-1u + 0v + 1t - 5w = -6$$
$$0u + 2v - 2t + 7w = +7$$

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