eurofins

EAG Laboratories

Electron Backscatter Diffraction (EBSD) Services

Electron Backscatter Diffraction (EBSD) is a technique that is uniquely suited to characterize crystallographic properties of samples.

Electron backscatter diffraction (EBSD) is a SEM-based technique. As the electron beam raster across the polished sample surface, tilted at 70°, backscattered electrons channel out the surface and project onto a fluorescent screen to form a diffraction pattern. These diffraction patterns are captured by a CMOS-based camera and indexed at a maximum rate of 3k frames/second. Based on the interplanar angles between Kikuchi bands, diffracting planes are assigned, and the crystallographic orientation is then computed. Typically, the physical spatial resolution of the technique is between 20 -50 nm and the angular resolution is about 0.2°. Due to the uncertainty in the project geometry, the absolute orientation accuracy is between 1 – 2°.

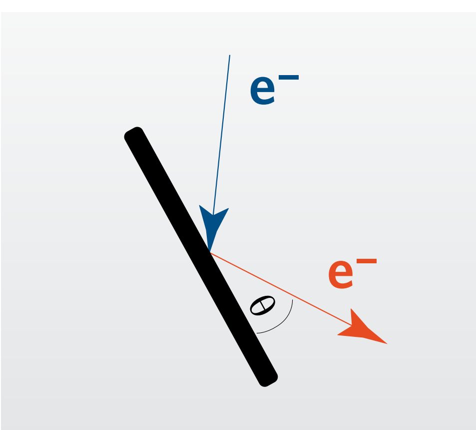

Figure 1: Schematic of how EBSD works in the SEM

Strengths

- Accurately provides spatially resolved grain size and phase information from several 10s of nm to several 10s of mm.
- Provides texture information from localized area.
- Provides grain boundary angle information.
- Can be used for failure analysis.

Limitations

- The phase information needs to be known a-priori.
- Cannot analyze amorphous materials.
- Cannot distinguish phases of similar crystal structures (need to use EDS-EBSD technique).
- High-quality polished surface is required.

Common Applications

Microstructure Characterization

- Grain size, grain shape, grain orientation
- Phase distribution
- Texture and texture component analysis

Material Properties

- Grain boundary properties e.g. CSL, LAGB, HAGB
- Schmid factor and slip system analysis
- Anisotropic properties e.g. Young’s modulus

Correlative Analysis

- Simultaneous EDS – EBSD
- Qualitative defect analysis
- Recrystallization fraction analysis
- Classification of martensite

Defect Imaging

- ECCI: surface threading dislocations, atomic steps

Industry Sectors and Technologies

- Advanced manufacturing
- Automotive and aerospace
- Energy generation and storage
- Consumer electronics and semiconductors

Case Study: Montage EBSD of Additively Manufactured Stainless Steel

Microstructure anisotropy in additively manufactured materials is one of the key factors to consider during manufacturing to ensure the quality of the printed components. Montage EBSD enables component-scale investigation of the grain size and orientation distribution. A grain area map can be used to show the uniformity of grain size and how grain size varies across the sample. In this case study, we find large columnar grains that cover the entire sample. In addition, smaller grains are found to enclose all the non-uniform columnar grains.

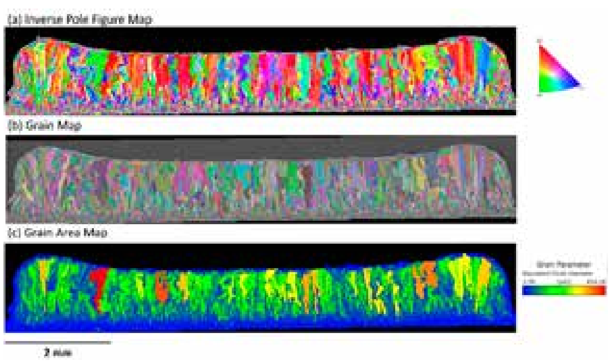

Figure 2: EBSD analysis on the cross-section of additively manufactured stainless steel: (a) inverse pole figure map-IPFX, (b) grain map randomly colored, (c) grain area map showing the equivalent circle diameter of grains.

Case Study: Non-destructive defect imaging on GaN

The presence of defects such as dislocation has a huge impact on the performance of devices. For example, surface threading dislocations in semi-conductors serve as non-radiative recombination sites for electron-hole pairs which reduce the efficiency of light emitting diodes (LEDs). The non-destructive defect imaging technique, such as electron channeling contrast imaging, enables defect imaging over a large area, providing enough statistics for quantitative analysis. In this example, threading dislocations were imaged over an area of 32µm by 22µm.

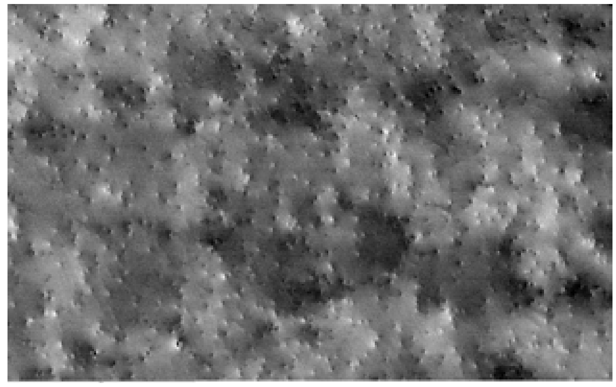

Figure 3: Electron channeling contrast imaging of surface threading dislocation on GaN (32 µm × 22 µm)

Complementary Techniques

Although XRD and EBSD are both diffraction-based techniques, they provide complementary information. While EBSD uses phase information to map grain orientation and boundaries, it cannot accurately identify unknown phases. XRD accurately determines the phase of the unknown materials, but it cannot provide any spatially resolved information such as grain boundary properties. In addition, EBSD is very similar to two other techniques called transmission Kikuchi diffraction (TKD) and precession electron diffraction (PED). Both TKD and PED have much better spatial resolution than EBSD.

	EBSD	XRD
Grain size	>100 nm	50- 200 nm (data convoluted with strain)
Texture Measurement	Pole figures and inverse pole figures determined from a selected area (>1 µm^2)	Pole figures are measured one at a time (minimum area -1 cm^2)
Determination of Deformation	Yes	Yes (data convoluted with grain size)
Phase ID	Limited ability of phase classification	Capable of high accuracy identification of unknown phases
Grain Boundaries Properties (CSLs, HAGB, LAGB)	Yes	No

EBSD at EAG

EAG has one of the fastest CMOS-based EBSD systems located within our network of labs. This allows us to provide texture and grain size analysis on ceramics, thin films, alloys, and semiconductors for an area of interest between hundreds of nanometers to a couple centimeters at the component scale. In addition, EBSD data can be post-processed to derive knowledge about the structure-processing relationship and conduct root case failure analysis. Coupled for forescatter diodes mounted on the EBSD detector, EBSD also enables correlative analysis of microstructure and surface topography.