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High-angular resolution in the scanning electron microscope: homography-based approach & application examples

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HR-EBSD/TKD *Geometrically Necessary Dislocations (GND)* *Elastic strain*

Abstract High-angular resolution techniques measure orientation gradients and relative elastic strains within a crystal with a typical accuracy of 10^{-4} (rad). They therefore reveal fine dislocation structures that are not detected by standard orientation mapping analyses and quantify them in terms of geometrically necessary dislocation densities (GND). To do so, they register electron diffraction patterns with respect to a reference one using digital image correlation techniques. The method developed transfers photogrammetry techniques to electron microscopy. A linear homography catches the effects of lattice rotations and elastic strains through a unique and large region of interest [1]. Such a global image registration is recommended for both accuracy and robustness against large internal grain disorientations. It employs Fourier-transform based cross-correlation techniques and an inverse-compositional Gauss-Newton (IC-GN) algorithm for pattern pre-alignment and subpixel registration, respectively. Its numerical efficiency is further improved by integrating the correction of optical distortions caused by the camera lenses into the IC-GN algorithm, thus avoiding a time-consuming pattern straightening step. Implemented in ATEX-software [2], developed at LEM3, the method is applied to a semi-conductor and a deformed metal. Elastic strain field in the vicinity of a screw dislocation is investigated in GaN single crystal using EBSD (Fig. 1) [3]. Nanocrystalline aluminum obtained by severe plastic deformation is characterized at both high-spatial (3-6 nm) and high-angular

resolutions in the scanning electron microscope (Fig.2) by coupling the method with on-axis Transmission Kikuchi Diffraction (TKD) [4].

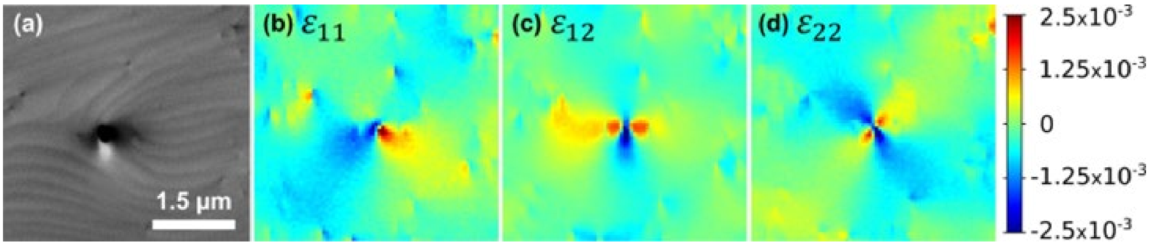

Figure 1 - *(a) Forward Scatter Detector (FSD) image of a screw dislocation in GaN and (b-d) elastic strain maps obtained by the HR-EBSD method.*

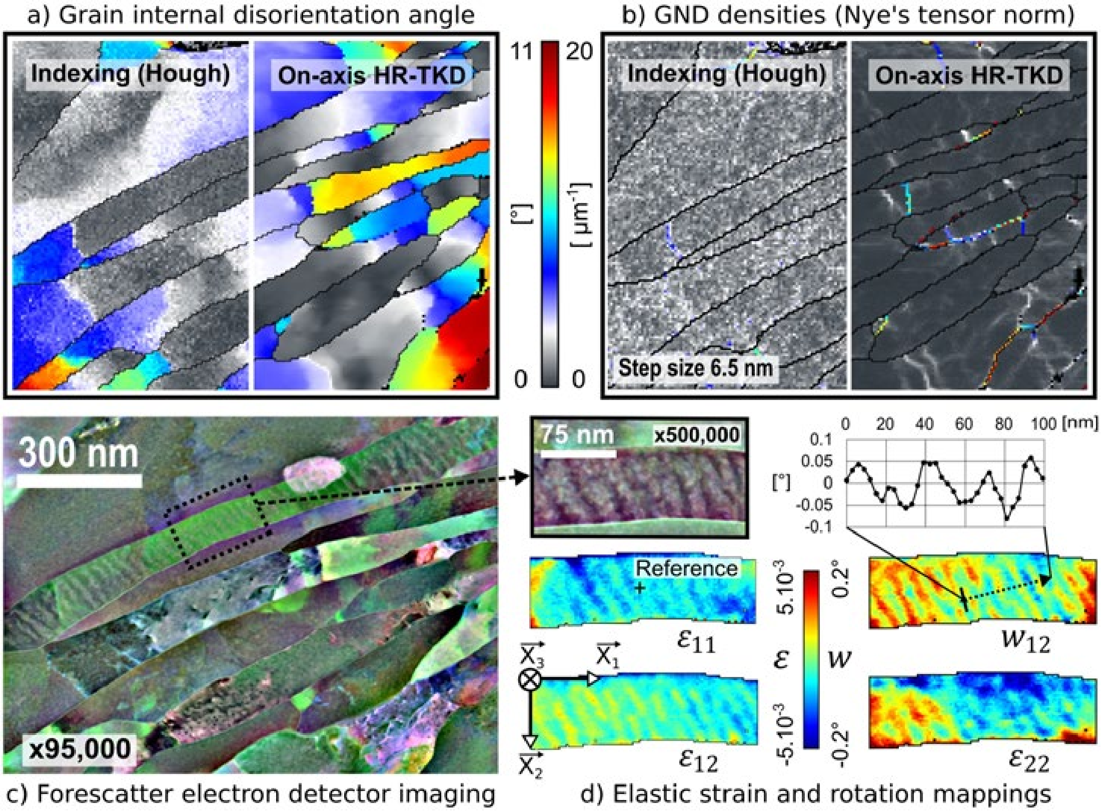

Figure 2 - *On-axis HR-TKD characterization of a nanocrystalline aluminum and comparison with a standard indexation-based analysis.*

References

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