Advanced characterization techniques for high-angular and high-spatial resolutions in the scanning electron microscope

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☒ Oral presentation ☐ Poster presentation

ABSTRACT

High-angular resolution electron diffraction-based techniques aim at measuring relative lattice rotations and elastic strains with an accuracy about 1.10^{-4} (<0.01°) in the scanning electron microscope (SEM). These metrics are essential for the fine characterization of deformation structures in terms of grain internal disorientations and geometrically necessary dislocation densities. To this purpose, relative deformations between electron diffraction patterns are retrieved with subpixel accuracy using digital image correlation (DIC) techniques. Here, a novel DIC approach is proposed. It relies on a linear homography [1], i.e., a geometric transformation often met in photogrammetry to model projections. The method is implemented in ATEX-software [2], developed at the University of Lorraine. Its performances are illustrated from both a semi-conductor and a metal. First, lattice rotation and elastic strain fields are investigated in the vicinity of a giant screw dislocation in GaN single crystal using the electron backscattered diffraction technique (Fig. 1). Second, the proposed method is coupled with the on-axis Transmission Kikuchi Diffraction (TKD) configuration to characterize a nanocrystalline aluminium obtained by severe plastic deformation. On-axis TKD consists in observing a thin foil in transmission in the SEM, using a scintillator is placed beneath the specimen, perpendicularly to the electron beam. Thanks to this coupling, high-spatial (3-6 nm) and high-angular (~0.01°) resolutions are simultaneously achieved in SEM. [3].

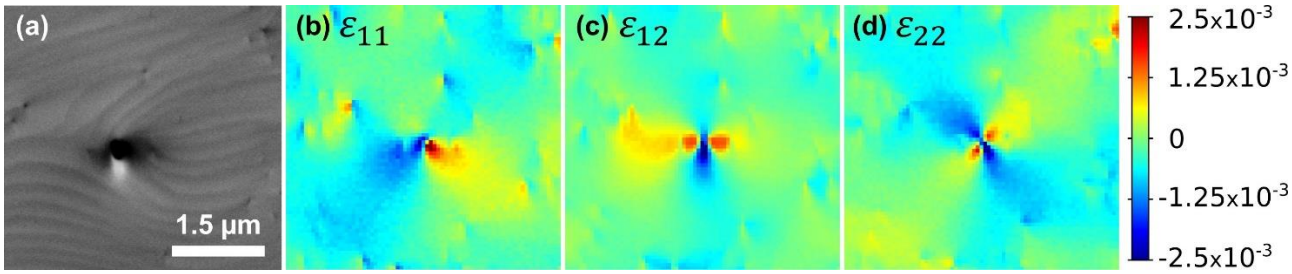

Figure 1. (a) Forward Scatter Detector (FSD) image of a giant screw dislocation in GaN and (b-d) elastic strain maps obtained using the proposed high-angular resolution technique.

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[2] B. Beausir, JJ. Fundengerger, Analysis Tools for Electron and X-Ray Diffraction, ATEX - Software, Université de Lorraine, Metz (2017)
[3] C. Ernould, B. Beausir, JJ. Fundenberger, V. Taupin, E. Bouzy, Scr. Mater. ,185 (2020) 30–35