Pushing the SEM to its limits while exploring new fields of applications of the high-angular resolution technique

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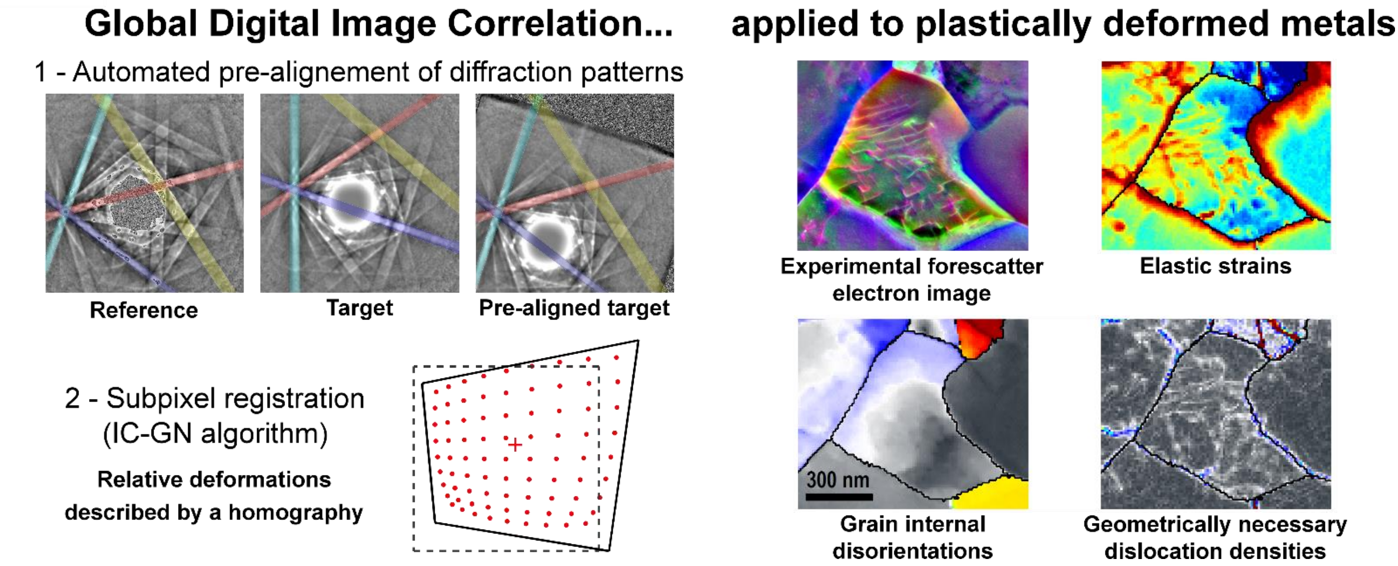
High-angular resolution (~0.01°) on lattice rotations and grain internal disorientations can be achieved in the SEM by registering high-resolution (1000x1000 pixels) electron diffraction patterns (EDP) with respect to a reference one using DIC algorithms. Developed under the impetus of Wilkinson et al. [1] in the 2000s, the HR-EBSD technique can also measure elastic strains with a resolution of 1.10^{-4} in ideal conditions. To this purpose, typically 20-200 small regions of interest (ROI) are considered within the two EDP to register.

In this work, a global DIC approach based on a single and large ROI is proposed. It borrows state-of-the-art algorithms from the field of computer vision. Implemented into the ATEX-Software developed at LEM3 [2], the method is applied to markedly plastically deformed metals in order to finely characterize the grain internal disorientations and the dislocation structures in terms of geometrically necessary dislocations (GND) densities and elastic strains.

The chosen materials are representative of engineering cases which are underexplored by the HR-EBSD community. Moreover, the technique is also transferred to the newly developed "on-axis" Transmission Kikuchi Diffraction (TKD) technique [3], which offers a lateral spatial resolution of few nanometres in the SEM by observing a thin foil in transmission. Using this technique, both the SEM and the DIC are pushed to their limits when characterising a nanostructured pure aluminium obtained by severe plastic deformation (SPD) at magnification of x500k.



[1] A.J. Wilkinson, G. Meaden, D.J. Dingley, High-resolution elastic strain measurement from electron backscatter diffraction patterns: New levels of sensitivity, Ultramicroscopy. 106 (2006) 307–313.

[2] B. Beausir, J.-J. Fundenberger, Analysis Tools for Electron and X-ray diffraction, ATEX - software, www.atex-software.eu, Université de Lorraine - Metz, 2017

[3] J.-J. Fundenberger et al., Orientation mapping by transmission-SEM with an on-axis detector, Ultramicroscopy (2016) 161, 17– 22