Automatic Dislocation Imaging in Scanning Electron Microscopy

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Up to date, the most suitable characterization technique for dislocation imaging is the Transmission Electron Microscope (TEM). It is however very local and requires a tedious sample preparation that can, in some cases, affect the observed dislocation structure. Electron Channeling Contrast Imaging (ECCI) (Zaefferer 2014) (DeGraef 2012), also proved its efficiency for defects characterization on bulk samples, using the channeling contrast of electrons. This method is nowadays widely used as the sample preparation is simplified as compared to TEM. However, in both cases, (*i.e.* TEM and ECCI), defects are visible only when the matrix is in Two Beam orientation. Therefore, TEM and/or ECCI observations are time-consuming and, most of the times limited to a very low number of grains, as observation in a given grain require a specific sample orientation. The representativeness of such measurements is then questionable. It is indeed well known that the deformation is orientation dependent, and a minimum number of grains with different orientation must be characterized to estimate the lowest and largest dislocation density for a given deformation state.

A new method is developed for the characterization of dislocations in a large number of grains at the same time and without any consideration of grains orientations prior to the observations. In the last few years, MATEIS microscopy researchers (Langlois 2015, Lafond 2018) have developed the CHanneling ORientation Determination (CHORD) technique which utilizes a set of ECCI images to map automatically the crystallographic orientation of grains in a polycrystal (without the use of EBSD detector). To achieve this orientation mapping, the sample is tilted 10° with respect to the electron beam and 360° rotated, so that an image is recorded for every rotation degree (360 images). After alignment of the series of images, an intensity profile as a function of the rotation angle is obtained at each pixel of the area of interest. This intensity profile is a signature of the orientation of the grain. As it can also be calculated from theoretical Electron Channeling Pattern (ECP), a comparison of theoretical and experimental profiles is performed and the orientation of each pixel is deduced. Still under current development, the implementation of this method is simple and the whole approach is efficient and fast. In addition with the grain orientation, dislocations are also visible for some particular rotation angle. From the rotational series, a quantitative determination of the defects density and nature *e.g.* direction, Burgers vector, in all grains of the area of interest is possible. As an example, Figure 1 presents two images extracted from a 360° rotational series of an austeno-ferritic duplex steel. As it can be seen, without any specific orientation of the sample, dislocations as well as stacking faults appear in different grains.

This methodology can be applied to any crystalline material containing defects, and allows in a reduced acquisition time (less than 30 minutes for one data stack) to collect information about dislocation in different grains.

[Lafond 2018]C. Lafond, et al, Ultramic., 2018
[Langlois 2015]C. Langlois, et al Ultramicroscopy 2015

*[Zaefferer 2014]S. Zaefferer, N. Elhami.. Acta Materialia **75**, 20 - 50, Elsevier BV, 2014.*

*[DeGraef 2012]M. De Graef.. Microscopy and Microanalysis **18**, 682 - 683 2012.*

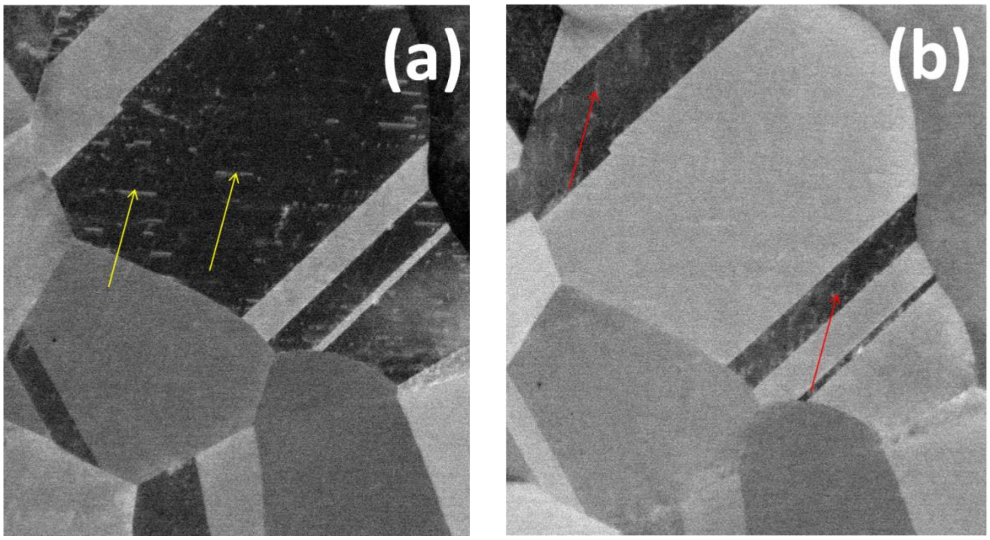

Figure 1: Images extracted from a rotational series, where the dislocations (red arrow) and stacking faults (yellow arrow) can be seen in several grains for particular orientations.