Crystalline orientation maps obtained from channeling contrast: focus on acquisition and image treatments

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The Kikuchi diffraction is not the only way to obtain orientation maps on a polycrystalline bulk sample in a scanning microscope. The channeling contrast visible on images acquired with an ion beam or an electron beam also contains crystallographic information that can be used to map the orientations without using an extra detector or a dedicated camera. The proof-of-concept of this new method called CHORD for Channeling Orientation Determination was established recently in our group in two articles describing the *modus operandi* and presenting orientation maps on representative examples [1-2]. In few words, the CHORD approach consists in obtaining an image series of a region of interest (ROI) by rotating a pre-inclined polycrystalline sample with respect to the beam. Ion-induced secondary electron and back scattered electron signals are used for iCHORD and eCHORD respectively. Along with such image series, each (X,Y) pixel of the ROI undergoes an intensity variation that is plotted as a function of the rotation angle and used to recover the crystallographic orientation.

Initially developed using a standard scanning microscope goniometer with manually controlled rotation and drift correction, the CHORD acquisition part is now fully automated. Particularly, the use of a substage consisting in a X-Y-R translation and rotation stage mounted on top of the standard goniometer dramatically improve the acquisition efficiency. Using the X-Y translation, the ROI is first positioned on top of the rotation axis of the microscope goniometer. It allows keeping the ROI in the field of view during the rotation. The piezo-rotation stage is optionally placed below the X-Y translation in order to improve the precision of the rotation steps (see Figure 1). The present study aims at exposing the benefits obtained using such a substage in terms of acquisition speed, irradiation dose, contamination, and the possibility to easily map large sample area.

Once the image series is obtained, several image post-treatments are applied: noise reduction, contrast enhancement and particularly image alignment in order to have, for a given sample position, the same (X,Y) coordinates in all the images. These steps are critical as they have a strong influence on the angular and spatial resolutions of the final orientation maps. The respective roles of all the post-treatments are finally discussed.

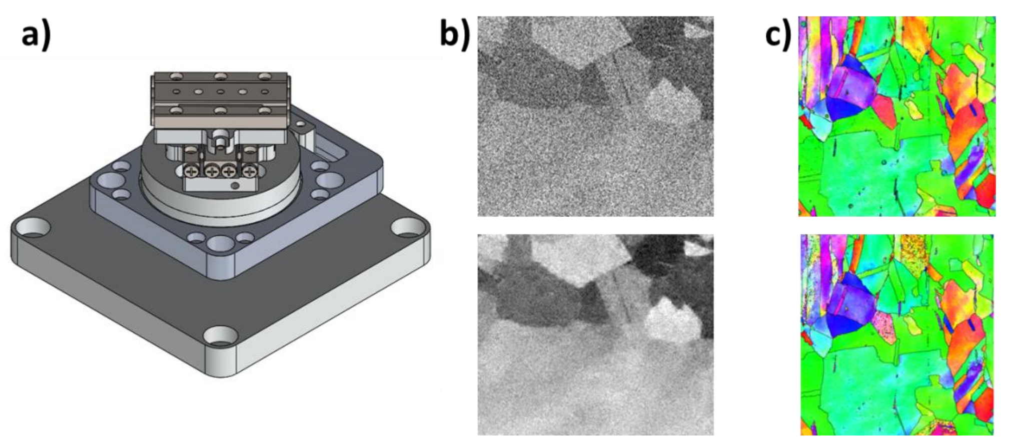

Figure 1: a) Drawing of the X-Y-R substage used in the present work, b) example of a denoising operation on raw BSE image, c) comparison between iCHORD orientation map (top) and EBSD map (bottom).

[1] Langlois C., Douillard T., Yuan H., Blanchard N. P., Descamps-Mandine A., Van de Moortèle, B. & Epicier T. (2015). Crystal orientation mapping via ion channeling: An alternative to EBSD. *Ultramicroscopy*, *157*, 65-72.

[2] Lafond C., Douillard T., Cazottes S., Steyer P. and Langlois C. (2018) Electron CHanneling ORientation Determination (eCHORD): An original approach to crystalline orientation mapping. *Ultramicroscopy*, 186, 146-149.