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# Rectification of EBSD results from large scale maps

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Most polycrystalline solid materials develop a texture, which causes anisotropy of many material properties as much as 20-50% of the property value [1]. Therefore, the determination and interpretation of texture is of fundamental importance in materials technology and understanding texture evolution in the course of various processing steps helps to understand and control the underlying mechanisms. Texture has been studied since methods of X-ray diffraction (and later neutron diffraction) appeared. Besides these well-established so called *macrotexture* techniques, in the last decades we can take advantage of analytical devices embedded in transmission or scanning electron microscopes, which are able to study the so called *microtexture*, i.e. local orientation with the resolution given by the interaction volume of electron beam with material. The technique based on electron backscatter diffraction (EBSD) [1,2] is rapidly evolving and it has become a frequent option of analytical add-ons mainly in the field of scanning electron microscopy (SEM). Then we can study orientation of individual grains even in submicron range, quality of grain boundaries, point-to-point orientation correlations, distribution of phases etc. For obtaining unbiased and accurate results the geometry of EBSD signal collection has to be carefully calibrated. Sample position (most simply a 70° tilt towards the vertical recording screen), diffraction pattern centre and sample-to-screen distance are the most important parameters. Both the calibration procedure and the evaluation of Kikuchi patterns suppose that the backscatter electron signal originates at the electron image centre, i.e. at the sample intersection with optical axis. This causes no problem when collecting EBSD maps at high magnification. This work discusses the catches of collecting large maps in SEM at low magnification. In such case a departure from the image centre means a change of signal path geometry and hence a position-dependent error of orientation evaluation. EBSD data post-processing is proposed, which removes the bias caused by geometrical effects. Let us take a rather extreme example of measuring an EBSD map at magnification as low as about 50× (horizontal view field 2.5 mm) with sample inclined by 70° towards the screen and with sample-to-screen distance of 23 mm. In that case the point at the image edge 1.25 mm off the centre (Figure 1) produces a Kikuchi pattern shifted by 1.25 mm. If the software does not compensate for the shift and expects the signal coming from the centre, it falsely interprets the pattern shift as an additional rotation of the volume under beam by angle $\tau$. In our example $\tau$=3.1°. It means that the apparent angular difference in our example measured between two points and reported by the software reaches up to 6.2° along the central horizontal line and even 7.6° between opposite corners. These are values markedly exceeding the angular resolution, which is on the order of 0.5° for standard EBSD platforms [2]. Figure 2 shows the position-dependent magnitude of angular deviation from the central beam. The above mentioned geometrical effect is less important at higher magnifications and of course it can be completely avoided if we scan by the stage and thus keep the geometry of signal collection invariable (on the other hand scanning by stage is slower and the positioning is less accurate compared to beam scanning). When using standard beam scanning to collect orientation maps at lower magnification, we always have to bear in mind that the local orientation evaluated by the system depends on the position even in the case of perfect single crystal: e.g. angular deviation of two points increases with their distance. This artefact mixes with the true changes of crystal grains orientation. Did we detect a continuous rotation while scanning across a large packet of subgrains or lamellas? It can have physical meaning, but we should be careful and consider different explanation as well. We worked with an Oxford Instruments Analytical system INCA Crystal (The Microanalysis Suite - Issue 15) and recently also with the AZtecHKL system (version 2.0). Until the correction for beam position is eventually built in the software by developers (which seems to be quite straightforward and the most correct solution) we find it useful to post-process the data from large scale EBSD maps collected at low magnification. Euler angles and coordinates of all points in a map were exported to a worksheet and an additional rotation was applied depending on the magnification and point position. By this way we could improve the data quality and reach an uncompromised precision in microtexture analysis (see a demonstration in Figure 3) [3].

1. V. Randle and O. Engler, Introduction to Texture Analysis, Taylor & Francis, London, 2000.
2. A.J. Schwartz, M. Kumar,·B.L. Adams and D.P. Field (Eds.), Electron Backscatter Diffraction in Materials Science, Springer Science+Business Media, New York, 2009.
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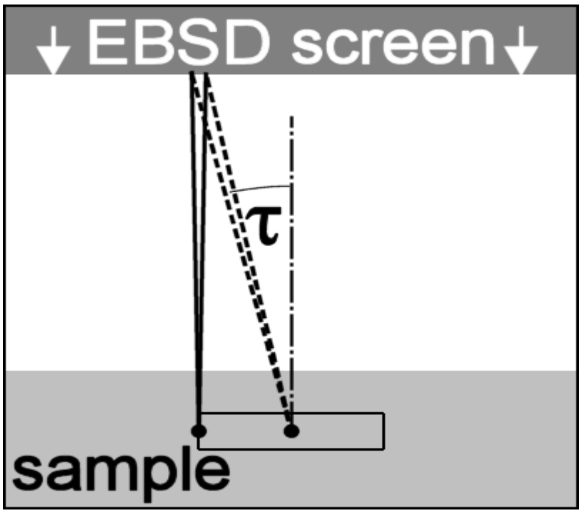

**Figure 1.** EBSD pattern collection geometry (top view, drawing not to scale). A pair of Kikuchi lines is generated at the edge of the mapped region. This is falsely interpreted by the system as a pair generated at the centre with additional tilt τ.

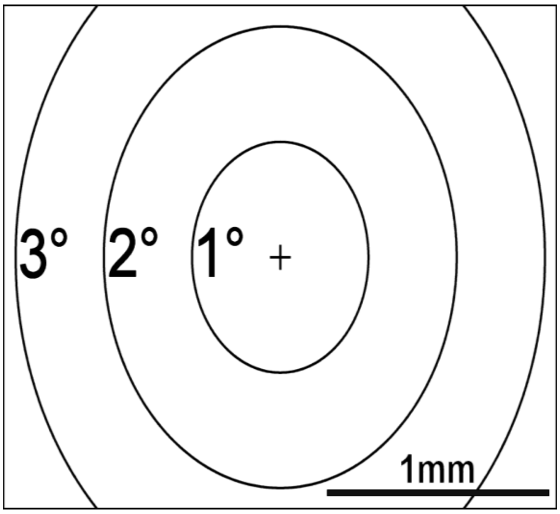

**Figure 2.** Magnitude of additional tilt due to signal collection geometry (plan view). Isolines are not circles due to sample surface tilt relative to EBSD screen. The values are calculated for sample tilt 70° and sample-to-screen distance 23 mm. With increasing magnification we are zooming in on the central part and the geometric effect becomes less important.

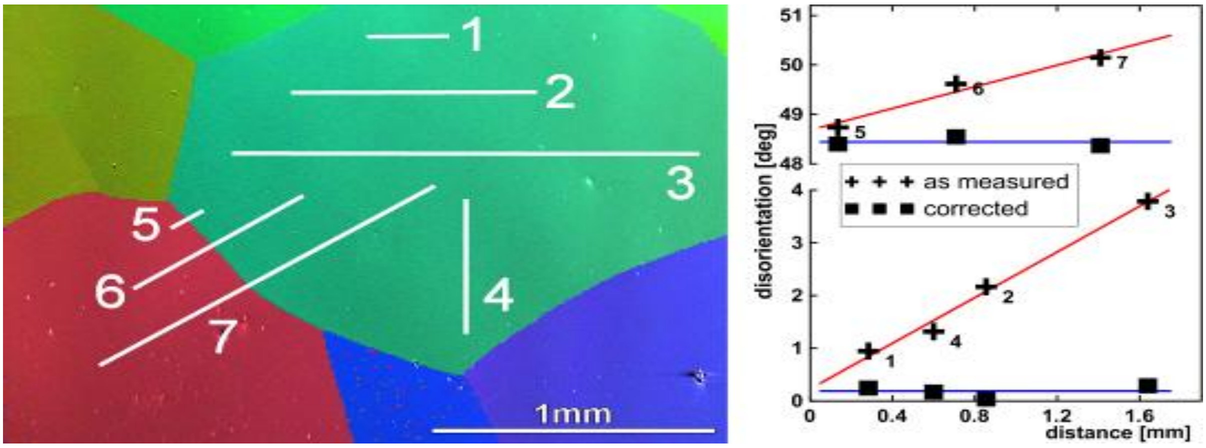

**Figure 3.** EBSD orientation map of a coarse grain annealed copper with several measurements of disorientation between line endpoints. Inside a single grain (measurements 1 to 4) the values reported by the analytical system increase nearly proportionally with the endpoints distance. This artefact is completely removed by our data post-processing (see the plot on the right). Similar situation occurs while measuring disorientations across a grain boundary (lines 5 to 7). After data post-processing we do not need to worry about the line length: all the measurements give almost the same result.