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Development of Tools to Increase the Spatial Resolution of EBSD Maps

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The characterization of the distribution and micro-texture of submicron phases is of great importance for many modern applications. With submicron spatial resolution, EBSD is a viable technique to study fine microstructures.

The spatial resolution of EBSD is anisotropic due to the elliptical shape of the interaction volume at high tilt angle. The resolution typically reported is therefore the smallest one which is the one in the direction parallel to the tilt axis. The resolution is also influenced by many factors [1]. Some factors like the density and atomic number are specimen dependant. Some others are dependent on the experimental conditions and therefore not easy to change: accelerating voltage (limited by the camera sensitivity) and beam diameter of the SEM. Mechanical drift of the stage or electronic drift caused by charging and contamination are also decreasing the resolution. All these factors contribute to the apparent resolution of EBSD which is in the order of 200nm for a Cu_3Sn-Cu_6Sn_5 interface (Figure 1) [2]. This is the resolution conventionally measured using the 5-95% change between two conditions. However, at a boundary, the diffraction pattern observed is a linear combination of the diffraction patterns from the two adjacent phases or grains. Depending on the pattern quality and if there is a significant difference in intensity, indexing algorithms are able to identify the phase or grain with the highest intensity, thus improving the resolution. The result is an effective resolution which is usually of the order of 10-40nm [1, 3-4].

The indexing algorithm plays an important role in determining the resolution of an EBSD system. The ability of a system to identify the correct phase and orientation from overlapping information in a diffraction pattern is directly linked to the effective resolution of an EBSD mapping. The aim of this study is to compare algorithms currently available and to develop new tools to improve the spatial resolution.

Spatial resolution can be improved by skipping real-time indexing of the diffraction patterns. The acquisition step would only consist of recording and saving the diffraction patterns to disk. Doing computation intensive processes, such as the Hough transform along with phase and orientation identification, after the acquisition can decrease the acquisition time by 30% (calculated from HKL Channel 5's time per point), thus reducing the effects of drift. More importantly, it also allows more advanced (and thus slower) algorithms to make additional computations leading to better indexing of noisy patterns. Since patterns are completely independent from one another, parallelization of the indexing routine can be easily implemented.

To evaluate different band detection and indexing algorithms, a series of simulated patterns with known conditions (phase, orientation, detector distance, etc.) will be used. Scanning the indexing parameter space (number of bands and reflectors, pattern quality, sharpness of the bands, etc.) will outline the limits and accuracy of the algorithms. An example of a simulated pattern is shown in Figure 2.

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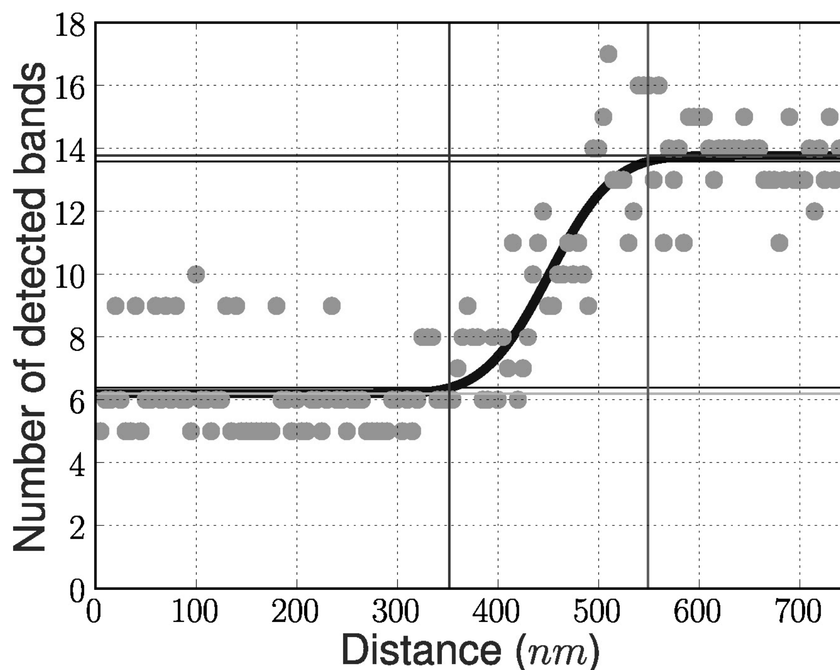

Fig. 1:Apparent resolution measurements across a Cu_3Sn-Cu_6Sn_5 interface using the number of bands. The interface was grown from a electro-deposited Sn coating on a Cu substrate. The line scan was performed at 15kV on a Hitachi S-4700 cold-field emitter with a step size of 5nm.

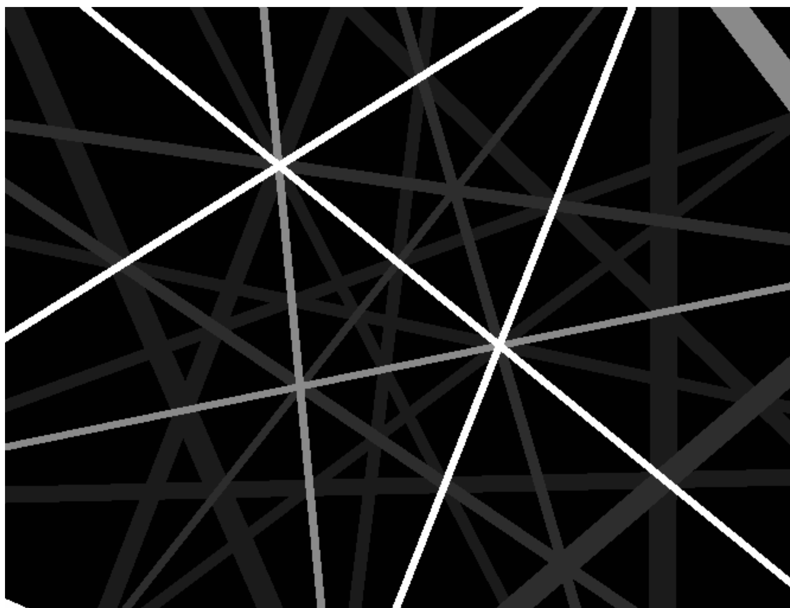

Fig. 2: Simulated patterns of a FCC crystal (a=0.543nm, 20kV, 70º tilt, 25 reflectors, Bunge Euler angles of 20 º, 35 º and 5 º). The intensity corresponds to the electron kinematic scattering factor from the International Tables for Crystallography [5]

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