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Improving the Spatial Resolution of EBSD

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The spatial resolution of the point-to-point electron backscatter diffraction measurement is a function of backscattering coefficient and electron probe diameter and energy. Venables and Harland (1) estimated a limiting resolution of 10 nm for the technique, which was later first demonstrated by Troost (2). An orientation image showing the grain boundary structure of a Pt film having an average grain diameter of about 70 nm is shown in Fig. 3 along with the corresponding grain size histogram. Grains as small as 20 nm in diameter are reliably indexed without resorting to heroic efforts involving elaborate techniques. This resolution is routinely achievable using modern field emission SEMs with a Schottkey electron source. The high probe current and small diameter electron beam allow for this level of spatial resolution. In many materials (of lower *Z* than Pt), or when using a different electron source, the achievable resolution is not as high. Many theoretical studies have been performed that predict the resolution of EBSD based on beam energy, probe diameter, and incident angle of the beam to the specimen surface (cf. 3).

Beyond obtaining a more coherent and intense electron beam, there are a limited number of techniques available to the researcher to improve spatial resolution. An improved EBSD image detection system could offer significant advantages. The EBSD patterns are created only from high energy electrons that have been elastically scattered in the first few nanometers below the specimen surface. However, about 95 percent of the electrons incident on the phosphor screen have been inelastically scattered and contribute only to the noise in the image. By absorbing or repelling these low energy electrons, the contrast in the image may be significantly enhanced. The incorporation of an energy filter that increases the signal to noise ratio has been attempted by various researchers with limited success to this point (4). Additionally, working at lower accelerating potentials thereby decreasing the amount of beam spreading below the specimen surface could improve spatial resolution. To accomplish this may require replacing the phosphor screens currently in use with electron detectors that can better detect the lower energy electrons. Such detectors, if adequate speed and resolution were obtained could revolutionize the EBSD process.

Another approach to improve the spatial resolution of the EBSD technique involves simply thinning the specimen so that many of the electrons are transmitted through the specimen. The thin specimen will not allow for significant beam spreading since the specimen-beam interaction volume will be limited by the height of the specimen. Recently employed techniques that convert a standard SEM into a STEM type instrument (using a thinned specimen) reveal the success of using SEMs in this manner. Figure 2 contains one of our scanning-transmission images from Al 7050 obtained in a field emission SEM. The specimen holder is easily modified to allow simultaneous EBSD measurements. This requires allowing backscattered electrons to leave the specimen surface towards the phosphor screen, but must limit them so they cannot escape into the specimen chamber where they would interfere with imaging. EBSD resolution is slightly improved in Al using these thinned specimens.

A practical solution to the problem of improving spatial resolution is to improve indexing algorithms to more accurately deconvolute EBSD images simultaneously obtained from two or more crystallites. Fig. 3 shows EBSD images from two individual crystallites (right and left side images) and an image where the two patterns are obtained simultaneously (center image). Identification of the individual Kikuchi band positions is more challenging for such patterns, and the determination of the orientation from the convoluted information is increasingly difficult. To overcome these problems, the algorithms are modified to interrogate a supposed solution by searching for Kikuchi bands at the positions consistent with each solution. This slows down the indexing procedure considerably, but offers a more reliable method to obtain the solution for which the diffraction pattern is the strongest.

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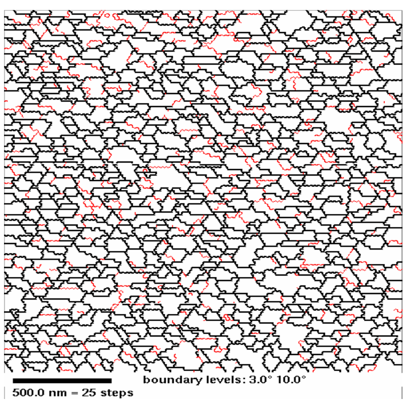


Fig. 1 – Grain boundary image of Pt film.

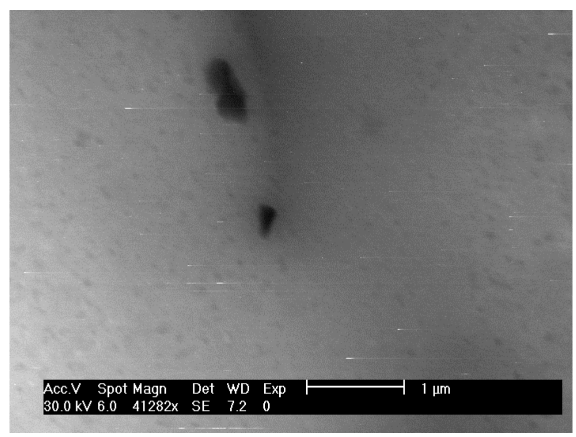
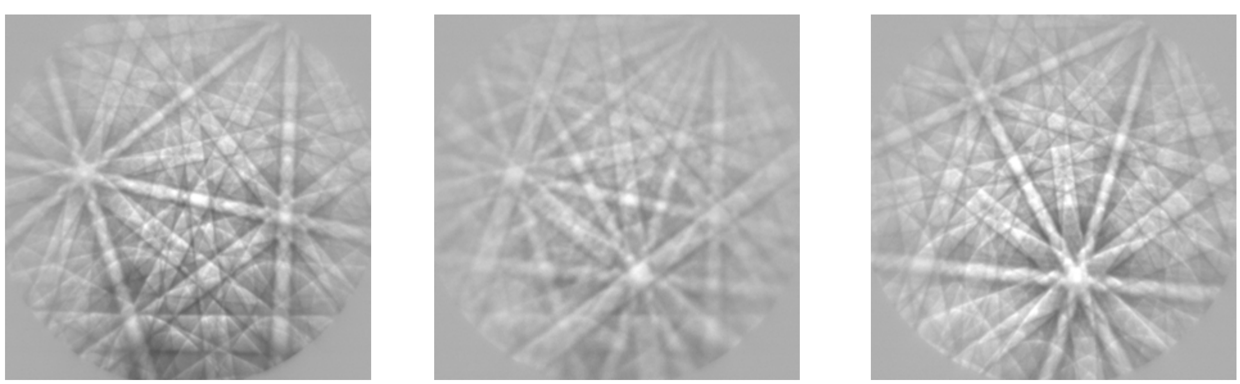


Fig. 2 – STEM image of AA 7050 from FE-SEM.



(a) (b) (c)

Fig. 3 – EBSD images obtained from two neighboring grains in a Ni-based alloy (images at the far left and right) and the center image from the grain boundary containing the overlapping patterns.

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