DOI: 10.1017/S143192760550415X
Microsc Microanal 11(Suppl 2), 2005

Energy-dependence of an EBSD Pattern

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Electron backscatter diffraction (EBSD) is an analytical technique of the SEM capable of rapid crystallographic measurements including grain boundary mapping, texture analysis, and phase identification [1]. EBSD patterns form when backscattered electrons, emanating from a highly tilted specimen, are diffracted and illuminate a phosphor screen. These diffracting electrons have different energies, and those that have an energy close to that of the incident beam are thought to be the major contributors to the diffraction pattern. To explore the concept we have utilized an energy filter developed by STAIB instruments [2-3]. In this device, a lens system is used to retard and collimate the electrons, which are then filtered through an energy grid with a resolution of ~10 eV. The cutoff, the energy below which electrons will be turned away by the grid, is variable from 0 to 20 keV

Figures 1 and 2 show EBSD patterns of Si, obtained with an accelerating voltage of 20 keV, for cutoff values of 0 keV (not filtered) and 18 keV. Comparing the two figures, it is clear that by eliminating electrons with energies below 18 keV the contrast of the Kikuchi bands significantly increases. This was expected, as the low energy electrons are thought to contribute to the diffuse background of the pattern. Interestingly, though, the intensity of the pattern has shifted towards the lower half, whereas the unfiltered pattern, figure 1, has roughly uniform intensity throughout.

To understand this phenomenon, we used a modified Monte Carlo model [4] to simulate the diffuse background of the EBSD patterns. Figures 3 and 4 are the simulated backgrounds for the experimental conditions of figures 1 and 2, respectively. The axes are tangents of angles from the physical pattern center axis, and the circle in each figure indicates the size and position of the experimental screen. The simulations confirm that electrons above 18 keV contribute mainly to the lower half of the pattern. Physically, the reason for this is that electrons with higher energies will scatter in a more forward direction than their lower energy counterparts; hence, the signal maximum of the higher energy electrons will exist at a lower position on the screen.

Finally, to identify the contribution of electrons of different energy, EBSD patterns were taken with cutoff values of 14.5, 15, 18, and 18.5 keV. From these, figures 5 and 6 were constructed, representing contributions of electrons in the range of 14-14.5 keV and 18-18.5 keV, respectively. This was accomplished by simple subtraction after matching the image sizes. Note that the outer rings of these images are due to a lens aberration, which can be ignored toward the image centers. While the 14-14.5 keV electrons are roughly evenly distributed, the 18-18.5 keV electrons are lower in the pattern. This demonstrates the energy-dependence of EBSD patterns [5].

References

[1] A.J. Schwartz et al., *Electron Backscatter Diffraction in Materials Science*, Plenum Press, New York, 2000.
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[3] T.K. Hooghan, P. Staib, and A. Eades, *Micros. Microanal.* 10 (suppl. 2) (2004) 938.
[4] D.C. Joy, *Monte Carlo Modeling for Electron Microscopy and Microanalysis*, Oxford University Press, New York, 1995.
[5] Support from DOE, under grant DE-FG02-00ER45819, is gratefully acknowledged.

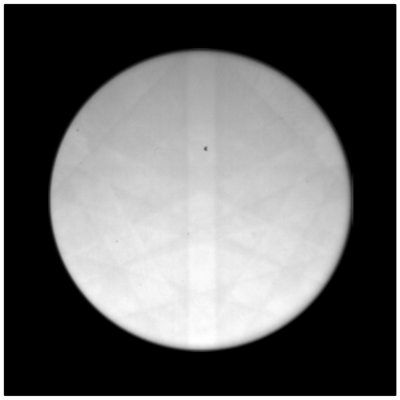

FIG. 1. Unfiltered Si EBSD pattern: cutoff = 0 keV

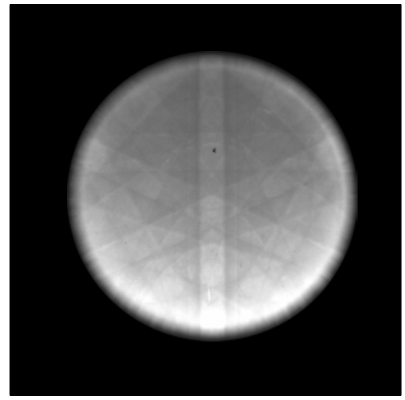

FIG. 2. Filtered Si EBSD pattern: cutoff = 18 keV

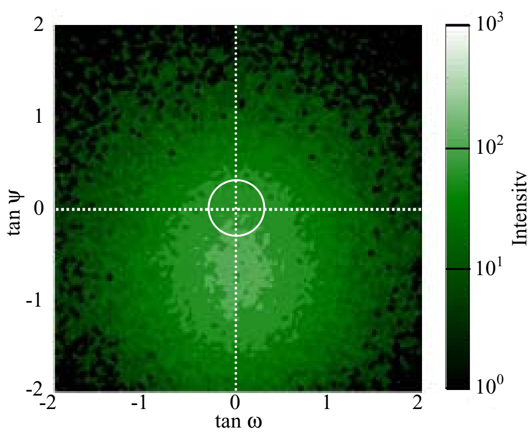

FIG. 3. Simulated Si EBSD background: cutoff = 0 keV

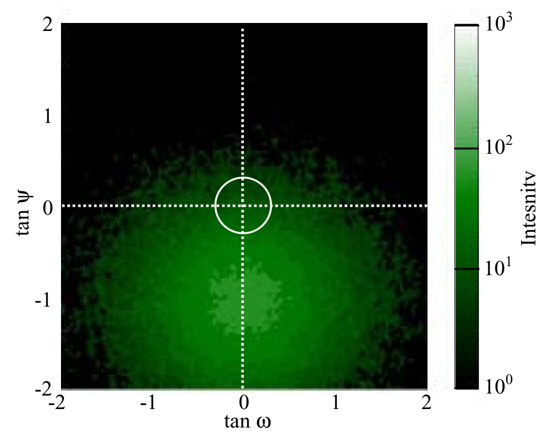

FIG. 4. Simulated Si EBSD background: cutoff = 18 keV

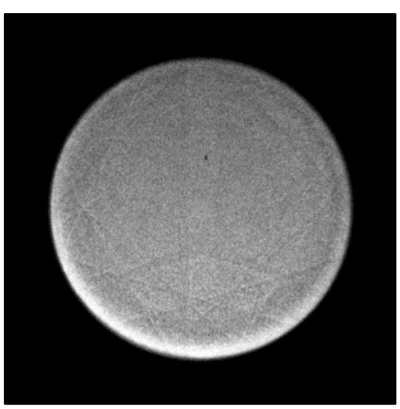

FIG. 5. Contribution of 14-14.5 keV electrons

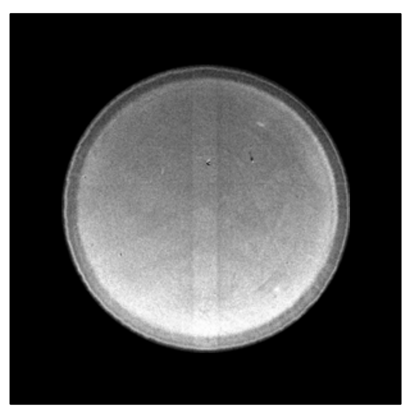

FIG. 6. Contribution of 18-18.5 keV electrons

https://doi.org/10.1017/S143192760550415X Published online by Cambridge University Press