Orientation Imaging Microscopy Using ESEM
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We have used an Environmental Scanning Electron Microscope equipped with the
Orientation Imaging Microscopy attachment to obtain single orientation measurement in
conducting (metals) and non-conducting materials. Electron Backscattered Pattern (EBSP)
technique has been shown to be an effective tool for measuring lattice orientation of bulk
polycrystalline materials in an SEM. Automation of this technique through Orientation
Imaging Microscopy (OIM) has opened a new realm of materials characterization which
was previously available only through Transmission Electron Microscope (TEM) of thin
foil specimens. Grain orientation and grain-to-grain misorientation are among a number
of parameters which are crucial in studying the mechanisms of deformation in advanced
materials. Such measurements have been successfully obtained for conducting specimens
and under high vacuum conditions. The combination of ESEM and OIM provides the
capability for measuring grain orientations in non-conducting crystalline materials with
grain sizes of 1 micron or larger by eliminating the need for a conductive coating.

Our microcharacterization studies have initially focused on metals, specifically
superplastic aluminum (Al-8090). TEM analysis of grain structure and subgrain formation
could only provide information for individual grains or at best small regions of the
microstructure, hence it does not provide a global picture. On the other hand, the data
obtained by OIM technique and the regeneration of the microstructure based on different
criteria to define grain boundaries by misorientation angle can provide a better
understanding of superplasticity. Figures 1 and 2 show OIM images of a 25% biaxially
defomed Al-8090 specimen (early stage of superplastic forming). To form these images,
EBSPs were collected at points 1 micron apart (a six sided hexagon is used to represent
each data collection point). Grain boundaries (sub-grain boundaries) are identified using
different line widths for different small (1-3°, 3-7° in Figures 1a,b) and large (10° and
above in Figure 2a) misorientation angles. The first micrographs in Figure 1 shows the
presence of equiaxed structures. However, if the classical definition of 10° is chosen to
represent the cut-off for large angle boundaries, a new microstructure is obtained which is
shown in Figure 2a. The corresponding pole figure is shown in Figure 2b. Detailed
texture studies clearly identified the presence of a recrystallization texture at the early stage
and texture randomization at the later stages of deformation.

This study has recently been extended to investigate the effects of increased chamber
pressure and the possibilities for using OIM to analyze non-conducting (semi-conducting)
materials (ceramics and crystalline polymers). This technique shows promising results in
metals under low vacuum conditions. The patterns showed very little increase in diffusivity
under low water vapor pressure (less than 1 torr). EBSPs have been obtained from
Bi,Sr,CuO, and efforts are currently underway to obtain OIM images.

References:
Figure 1- Misorientation boundary micrographs. Black lines depict boundaries with misorientations a- greater than 3° greater than 7°.

Figure 2- (a) 10° Misorientation boundary micrographs. (b) Pole figure representation of the previous figures. Different regions are represented by poles of the same color.