Stereological analysis of 2D EBSD data to assess the five-parameter grain boundary character distribution

N. Bozzolo[1*], *G. Rohrer*[2], *A.D. Rollett*[2]

[1] *MINES-ParisTech, CEMEF - Centre de Mise en Forme des Matériaux, CNRS UMR 7635, BP 207, F-06904 Sophia-Antipolis *nathalie.bozzolo@mines-paristech.fr*

[2] *Department of Materials Science and Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213-3890*

Grain boundaries and interphase boundaries are characterized by five macroscopic parameters describing i) the lattice misorientation between the neighbouring crystals and ii) the orientation of the interface plane. Only four out of those five parameters can directly be obtained from conventional 2D EBSD data. Providing that the EBSD mapping step size is small enough to achieve a suitable spatial resolution, grain boundaries can be detected based on a misorientation angle threshold. Classically, in the case of an equiaxed microstructure, the step size is chosen to be about one tens of the mean grain size, and any misorientation higher than 5° between neighbouring pixels can be associated to the presence of a grain boundary. Along each detected boundary, the misorientation between the pixels on both sides can be calculated, which leads to three parameters (e.g. Euler angles, or misorientation angle and axis). In addition, the orientation of the grain boundary trace in the analysed section provides one of the two plane orientation parameters. Determining the fifth parameter, which fixes the 3D plane orientation, from a single 2B EBSD map is not as straightforward, but can nevertheless be achieved by using the stereological approach that has been developed at Carnegie Mellon University. Each grain boundary segment is the zone axis of all possible grain boundary planes. Plotting the normals to those possible planes in the crystal reference frame, and accumulating that hypothetical information for a large number of segments allows for determining which crystallographic planes are the most probable. This procedure can be run for all grain boundaries to get the grain boundary plane distribution, or only for boundaries with a particular misorientation to assess a selected part of the five parameter grain boundary character distribution (GBCD). The method has been validated first using an artificial microstructure with a controlled GBCD [1] and then by comparison of the GBCD obtained by that stereological method with the one experimentally obtained by serial sectioning [2,3]. A number of ceramic and metallic polycrystalline materials have now been analysed [e.g. 4-7], and the outcome is that grain boundaries seem to preferentially lie in low free-surface energy crystallographic planes.

[1] D.M. Saylor, G.S. Rohrer "Determining crystal habits from observation of planar sections" Journal of the American Ceramic Society, 85:11 (2002) 2799-2804

[2] D.M. Saylor, B.S. El-Dasher, B.L. Adams, G.S. Rohrer "Measuring the five parameter grain boundary distribution from observations of planar sections" Metallurgical and Materials Transactions A, 35A (2004) 1981-1989

[3] D.M. Saylor, B. El Dasher, T. Sano, G.S. Rohrer "Distribution of grain boundaries in SrTiO3 as a function of five macroscopic parameters" Journal of the American Ceramic Society, 87 (2004) 670-676
[4] D.M. Saylor, B.S. El Dasher, Y. Pang, H.M. Miller, P. Wynblatt, A.D. Rollett, G.S. Rohrer "Habits of grains in dense polycrystalline solids" Journal of the American Ceramic Society, 87:4 (2004) 724-726
[5] C.S. Kim, Y. Hu, G.S. Rohrer, V. Randle "Five-parameter grain boundary distribution in grain boundary engineered brass" Scripta Materialia, 52 (2005) 633-637
[6] G.S. Rohrer, V. Randle, C.S. Kim, Y. Hu "Changes in the five-parameter grain boundary character distribution in alpha-brass brought by iterative thermomechanical processing" Acta
Materialia, 54 (2006) 4489-4502
[7] V. Randle, G.S. Rohrer, Y. Hu "Five-parameter grain boundary analysis of a titanium alloy before and after low-temperature annealing" Scripta Materialia, 58 (2008), 183-186