The Determination of the Dislocation Structure in Copper Single Crystals from X-ray Diffraction Profiles

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A careful analysis of X-ray diffraction profiles obtained from copper single crystals with dislocation densities between $10^4$ and $2 \times 10^6$ dislocations per cm$^2$ has been performed. Lattice tilts and strains introduced by the as-grown dislocations have been deduced from double-crystal rocking curves recorded in a large range of Bragg angles, up to 89°. A new numerical deconvolution method [Mendes, M. & Delestre, C. Submitted to Acta Cryst.] has been applied successfully to unfold the broadened diffraction patterns. The dislocation density $Q$ has been determined by etch-pit counting and by the application of Wilkens' theory [Wilkens, M. (1970). Phys. stat. sol. (a) 2, 359-370] to the diffraction profiles. Very good agreement has been obtained between the methods. The samples were free from low-angle grain boundaries. However, as a function of $Q$ the lattice tilts increased much faster than the strains, thus revealing the non-statistical distribution of the dislocations. The results indicate an arrangement of the dislocations in walls or cells as proposed by Bassim, M. N. & Kuhlmann-Wilsdorf, D. [Cryst. Lattice Defects (1973). 4, 9-27]. The refined X-ray diffraction technique applied in this work has proved to be useful for obtaining information about the average arrangement of a great number of dislocations which is difficult to extract from topography or electron microscopy experiments. It can be used even for nearly perfect crystals.