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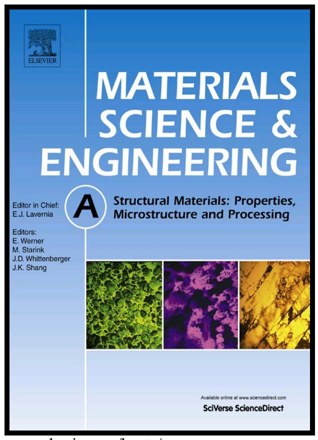

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On the Suitability of Peak Profile Analysis Models for Estimating Dislocation Density

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Abstract
Work-hardening in crystalline materials, i.e., increase in their flow stresses during plastic deformation, follow a square root dependence on the density of dislocations present. Dislocation density, defined as the length of dislocations present per unit volume (m/m^3), is thus an important parameter for simulating flow properties of a material. A number of techniques based on line profile analysis of x-ray peaks have evolved over the years for estimating dislocation density in addition to direct measurements on the basis of transmission electron microscopy. However, all these techniques suffer from certain limitations and the effectiveness of a specific technique is difficult to establish as different researchers used them to estimate dislocation density on individual samples. In the present work suitability of x-ray profile analysis techniques, based on moment analysis of tail portions of individual diffraction peaks (termed as the variance methods), for estimating dislocation densities has been verified on the basis of their estimation in commercially pure aluminium as well as pure copper samples deformed for varying degrees of deformation. The accuracy of estimated values of dislocation density has been confirmed by comparing them with those estimated by transmission electron microscopy analysis as well as on the basis of variations in their values that followed the observed work hardening behaviour. This study has also established that line profile analysis of x-ray diffraction peaks obtained using a laboratory x-ray diffractometer can make a good estimate of dislocation densities in metallic samples provided they contained a significant amount of deformation.

Keywords: X-ray diffraction; Transmission electron microscopy; Dislocation density; Peak profile analysis; Variance methods.

1. Introduction

Dislocations play a significant role in strengthening of crystalline materials. During plastic deformation, dislocations spawn from existing dislocations, grain boundaries and surfaces resulting in significant increase in their density and interactions among themselves in a complex manner. Work-hardening (i.e., increase in the flow stress) of a material during plastic deformation is therefore a direct consequence of the increase in the dislocation