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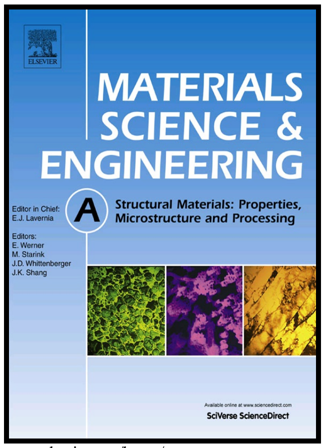

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The influence of the indentation size in relation to the size of the microstructure of three polycrystalline materials indented with a Berkovich indenter

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Abstract

Three different polycrystalline materials, a fine-grained martensitic steel (CrMoV), a coarse-grained high-purity copper (C110), and a two-phase microstructure titanium alloy (Ti-6Al-4V), have been selected to investigate the heterogeneity of deformation following indentation using a depth-sensing indentation instrument fitted with a Berkovich indenter. The geometry of the pile-up profiles, measured with an atomic force microscope, were observed to be very sensitive to the indentation size with respect to the size of the microstructure and the material properties and crystallographic plane of the indented grain. In contrast, neither the recovery of the area of indentation nor the degree of piling-up were affected by the presence of indentation size effects (ISE). Furthermore, based on the results of a full-3D finite element simulation, it was concluded that the misalignment of the indenter alone does not explain the significantly asymmetric piling-up in highly anisotropic materials, e.g. C110 copper, but that this is due to the crystallographic orientation of the single grain tested. In addition, the experimental results revealed that, although a thicker mechanically hardened layer formed during polishing is more prone to recovery during unloading, leading to a smaller residual indented area, the degree of piling-up is unaffected provided that the ratio of maximum depth (h_{max}) to the thickness of the strain-hardened layer is above unity. Moreover, on the same premise, the surface roughness and the thickness of the strain-hardened layer can be discarded as length parameters affecting hardness measurements.

Keywords: Depth-sensing indentation, pile-up, indentation size effect, atomic force microscopy