EFFECT OF PRE-EXISTING DISLOCATIONS ON THE STRENGTH OF GOLD AT VERY SMALL SCALES

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This work aims at understanding the effect of pre-existing dislocations on the strength of gold at very small scales. Previous studies have investigated this topic by correlating values of site-specific strength with average values of pre-strain or dislocation density of the parent bulk material. However, the mechanical response at the nano-scale is rather governed by the local microstructure of the small volumes being tested, which might not be representative of the average microstructure of the bulk material. Therefore, we propose a new method to correlate site-specific strength, as characterized by the hardness at the elastic-to-plastic transition, with the respective values of local deformation states, characterized non-destructively prior to nanoindentation using a new EBSD strain parameter derived from uncorrelated misorientation angle distributions. The analysis is performed on polycrystalline gold samples submitted to different degrees of bulk pre-straining. Consistent with other works, our results show that pre-existing dislocations decrease the strength of gold at the nano-scale; the Taylor relation is shown not to hold in this regime. We discuss this in view of a model proposed by Johnson and Ashby to predict the strength of a metal as a function of dislocation density, and a similar one applied to nanoindentation by Lilleodden and Nix. In addition, a conceptual model similar to that of Hall-Petch is used to analyze the results in the context of size effects in the strength of metals at small scales.