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Observations in 3D of Tensile Twinning and Slip in Zr

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ABSTRACT

Low symmetry crystals and polycrystals have anisotropic mechanical properties which, given better understanding of their deformation modes, could lead to development of next generation materials. Understanding how grains in a bulk polycrystal interact will guide and improve material modeling. Here, we show that tensile twins, in hexagonal close-packed metals, form where the macroscopic stress does not generate appropriate shear stress and vice versa. In other way, Schmid factors are not a reliable guide for predicting the onset of twinning. We use nondestructive near-field High Energy X-ray Diffraction Microscopy to map local crystal orientations in three dimensions over a series of tensile strain states in a zirconium polycrystal. Twins and intragranular orientation variations are observed and it is found that deformation induced rotations in neighbor grains are spatially correlated with many twins. We conclude that deformation twinning involves complex multigrain interactions. Comparisons are made with self-consistent and full-field polycrystal plasticity models.