Dislocation mechanics in KTaO3: room-temperature plastic deformation across the length scales

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Abstract

Oxides are normally believed to be brittle at room temperature due to the lack of dislocation (line defects in crystalline solids) activities. However, following the observations of dislocation-mediated bulk plastic deformation of SrTiO3 in 2001 (1) and KNbO3 in 2016 (2), there has been an ongoing quest on discovering more ductile perovskite oxides. In this work, we present our discovery of KTaO3 being the 3rd perovskite oxide to exhibit such behavior (3). This has been achieved by understanding the dislocation-based competition between plasticity and cracking. The mechanical response was investigated using bulk uniaxial compression, cyclic Brinell indentation and scratching at mesoscale, as well as the nanoindentation tests at micro-/nanoscale , revealing the material's plastic deformation behavior across multiple length scales. TEM (transmission electron microscopy) characterization reveals the activated slip systems and the tunability of dislocation densities, providing insights into the underlying plasticity mechanisms. These findings underscore the potential of mechanics-based engineering of dislocations in KTaO3, which is an emerging electronic oxide for versatile functional and mechanical properties.
Keywords: dislocations; KTaO3; plasticity; bulk deformation; cyclic deformation

References:

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