
Donor doping affects dislocation plasticity across the length scale in SrTiO₃

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Abstract

Donor doping is widely utilized to tune the physical properties of functional oxides, but its influence on mechanical behavior, particularly dislocation plasticity and fracture, remains largely unexplored. This study investigates dislocation mechanics and fracture of Nb-doped single-crystal SrTiO₃ across the length scale, using bulk uniaxial compression (macroscale), Brinell cyclic indentation (mesoscale), and nanoindentation (nano-/microscale). We find that 0.5 wt.% Nb-doped samples exhibit significantly higher yield stress (~ 50%) and reduced fracture strain at bulk scale, compared to the reference sample. Brinell indentation test (2.5 mm indenter diameter) reveals a discrete density of slip traces (evidence of dislocation activity) on 0.5 wt.% Nb-doped samples indicating a hindered dislocation mobility and multiplication analogous to macroscale deformation. In addition, 0.5 wt.% Nb-doped sample exhibits higher nanoindentation pop-in load and lower indentation creep rates than the reference sample, suggesting less favored dislocation nucleation and mobility. This combinatorial approach consistently shows suppressed dislocation-based plasticity while promoting cracking across the length scale in 0.5 wt.% Nb-doped samples. These findings provide new insight into the impact of defect chemistry on the mechanical plasticity and cracking of doped SrTiO₃, with the potential to be extended to other oxides. Keywords: Dislocations; oxides; plasticity; fracture; chemical doping

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