Unlocking room-temperature superplasticity in ceramic oxide by dislocation engineering

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Dislocation-tuned functional properties such as electrical conductivity [1], thermal conductivity [2], and superconductivity [3] in ceramic oxides are attracting increasing research interest. A prerequisite for harvesting such functional properties requires successful introduction of dislocations without forming cracks in oxides, which is a great challenge due to their brittle nature. Here, we report a simple method to mechanically tailor the dislocation-mediated plasticity in single-crystal $SrTiO_3$ at microscale. By first introducing surface dislocations by grinding and polishing, pre-existing dislocations with a density up to $10^{15}/m^2$ in the skin region (~1 μm in depth) of the sample are created. These surface dislocations serve as sources to dramatically promote the dislocation multiplication later during the micro-pillar compression tests, leading to a plastic strain of ~30% without fracture. Post-mortem TEM characterization shows clearly the dislocation structures inside the deformed micro-pillars. The dislocation multiplication mechanisms are discussed based on molecular dynamics simulation. In contrast, the micro-pillars without surface dislocations exhibit brittle fracture immediately after the elastic limit. This simple approach of engineering pre-existing dislocations opens many new opportunities in the area of dislocation studies in oxides.

Keywords*: dislocation engineering; ceramic oxide; micro-pillar compression; dislocation multiplication*

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