Room-temperature cyclic loading on ceramic oxides: dislocation density tuning, crack initiation & propagation

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Due to the well-known brittleness of most ceramic materials, the studies of dislocations in such materials are rarely attracting attention, except at elevated temperatures. In recent years, dislocation-tuned functional properties such as electrical conductivity, thermal conductivity, and ferroelectric properties [1] in ceramic oxides are attracting serious research interest. A prerequisite for harvesting the dislocation-based functional properties in oxides requires successful introduction of dislocations with high density without forming cracks, which is a great challenge due to the brittle nature of ceramics. Here, we report a simple method to mechanically tailor the dislocation density in single-crystal perovskites $SrTiO_3$ and $KNbO_3$ at room temperature [2]. By using an indentation method with millimeter-sized Brinell (spherical) indenters, dislocation densities from 10^{10} m^{-2} to 10^{13} m^{-2} are achieved by increasing the number of indenting cycles. Depending on tip radius and indenting load, large plastic zones over hundreds of micrometers are created without forming cracks. By further increasing the load or number of cycles, crack initiation is observed. On the other hand, the engineered dislocations show great potential in suppressing crack propagation, hence increasing the fracture toughness. This simple approach opens many new opportunities in the area of dislocation-based functional and mechanical studies.

Keywords*: cyclic loading; dislocation engineering; ceramic oxide; crack initiation; fracture toughness*

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