DISLOCATION-BASED COMPETITION OF PLASTICITY AND CRACKING IN OXIDES: UNDERSTANDING AND APPLICATION

Xufei Fang, Technical University of Darmstadt, Germany
fang@ceramics.tu-darmstadt.de
Hanna Bishara, James Best, Gerhard Dehm, Max-Planck-Institut für Eisenforschung, Germany
Kuan Ding, Till Frömling, Karsten Durst, Technical University of Darmstadt, Germany

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Dislocations in ceramic oxides are drawing increasing attention thanks to their promising properties, such as dislocation-tuned electrical conductivity, thermal conductivity, and electro-mechanical properties. However, due to the brittleness of most oxides at room temperature, it remains a great challenge to engineer dislocations without forming cracks, which is a prerequisite for harnessing the functionalities. From the aspect of mechanical deformation, nano-/micromechanical testing has been found to be a feasible approach to achieve this goal. Here, we demonstrate dislocations can be effectively introduced into various ceramic oxides ($SrTiO_3$, $BaTiO_3$, TiO_2, and Al_2O_3) at room temperature by using nanoindentation pop-in stop tests [1]. Interestingly, we find a size-dependent competition between purely dislocation-dominated plastic deformation under a critical tip radius and a concurrent appearance of cracks and dislocations when the tip radius is larger than a certain value. We further extend the deformation scale up to millimeter regime and identify a reversal of the above size-dependent competition. We will address the underlying mechanisms by examining the dislocation nucleation, multiplication, and motion individually to shed new light on the dislocation mechanics in oxides at room temperature. Last but not least, the dislocation-tuned electrical [2] and thermal conductivity will be briefly showcased using our developed methods for dislocation introduction.

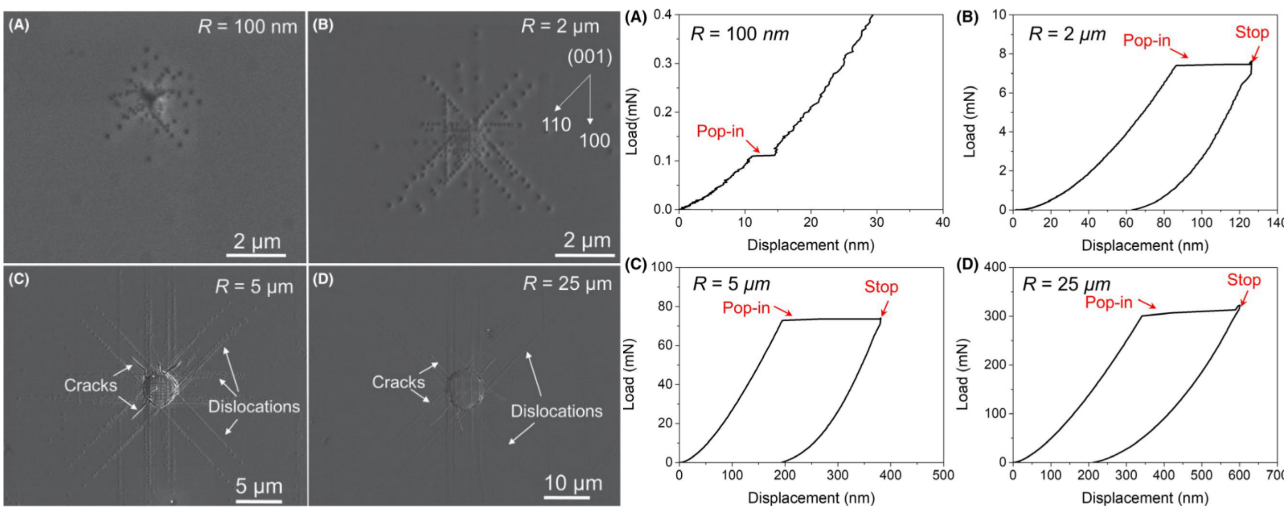

Figure 1 (Left) SEM images featuring the size-dependent competition for pure dislocations activation (A, B) and concurrent appearance of dislocations and cracks (C, D) in single-crystal $SrTiO_3$; (Right) representative pop-in stop tests corresponding to the SEM results in the left figure (note: no pop-in stop in A).

References:

[1] X. Fang, H. Bishara, K. Ding, H. Tsybenko, L. Porz, M. Höfling, E. Bruder, Y. Li, G. Dehm, K. Durst, Nanoindentation pop-in in oxides at room temperature: dislocation activation or crack formation?, *Journal of the American Ceramic Society* 104 (2021) 4728-4741.
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