Small-scale plasticity of oxide ceramics: impacts of orientations and grain boundaries

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In engineering applications, ceramics with ionic and/or covalent crystals exhibit excellent robustness to environments including temperatures, pressures, chemicals, and radiations. However, the brittle nature typically with stochastic fractures at low temperatures, approximately <1000°C, have been the thick barrier against many potential applications of ceramics. The brittleness is mostly attributed to the limited plasticity, which is associated with poor mobility of lattice defects such as dislocations and interfaces. Therefore, defect engineering is of importance to enhance the plasticity and finally to overcome the brittleness, but conventionally with limited methodology to evaluate plastic behaviors of ceramics below their ductile-to-brittle transition temperatures. In recent years, researchers have been attracted to micromechanical testing extended from nanoindentation technologies, where macroscopically brittle ceramics exhibit considerable plasticity even at room temperature [1]. Our group has also characterized small-scale plasticity of oxide ceramics such as Y_2O_3-stabilized ZrO_2, Al_2O_3, and $SrTiO_3$ to evaluate the impacts of orientations and grain boundaries on their strength and ductility through nanoindentation [2,3] and micropillar compression [4]. In these works, plastic behaviors of oxide ceramics exhibited strong anisotropy due to dislocation activities, whereas grain boundaries insignificantly affected the local hardness as compared with metallic materials. This seminar would discuss their physical mechanisms based on the metallurgical frameworks.

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