Achieving Room Temperature Plasticity in Brittle Ceramics Through High Temperature Preloading

High-temperature preloading introduces defects, enabling plasticity in normally brittle ceramics.

Ceramics are commonly utilized as structural materials due to their high mechanical strength, thermal stability, chemical stability, and electrically insulating properties. However, their inherent brittleness at low to room temperatures (RT) prevents their widespread application with the industry. The brittleness exhibited by ceramics is due to their inability to accommodate plasticity, attributed to high friction stress and obstacles in dislocation nucleation. There have been various methods to improve plasticity of ceramics, through the utilization of ceramic composites to using emerging techniques such as flash sintering. However, a challenge in the industry remains towards developing a more generalized and scalable approach for producing ceramics that have improved RT deformability.

Purdue Researchers have developed a method for enhancing room temperature plastic deformability of ceramics through a technique that preloads them at elevated temperatures to artificially introduce numerous defects. This approach was tested on single crystal (SC) TiO2 and Al2O3 model systems and showed a significant improvement in the deformability of both SC TiO2 and Al2O3, by 10% and 6-7.5% at room temperature, respectively. Furthermore, the introduced defects lead towards an increase in deformability at higher temperatures and a decrease in the critical resolved shear stress (CRSS) required to initiate plastic deformation is seen. This method shows potential in providing a first-of-a-kind scalable and general approach towards achieving enhanced plasticity in ceramics at room temperatures, making them more versatile for engineering applications.

Technology Validation:

-In situ microcompression tests of single crystals were performed at variable temperatures

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-Transmission electron microscopy (TEM) was performed to image defect formation of single crystals

-Scanning electron microscopy (SEM) was used to analyze compression tests and determine microstructure deformation of the ceramic at elevated temperatures

Advantages:

-Increased plastic deformability

-Improved ductility

-Generalized technique for multiple classes of ceramics

Applications:

-Semiconductor materials

-Traditional ceramic material

TRL: 4

Intellectual Property:

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