**MATERIALS ENGINEERING**

**SEMINAR**

# "Effects of Processing Techniques on Mechanical Behavior of Zirconia at Microscale"

**By**

**Jaehun Cho**

**Purdue MSE Final Exam**

**Advisor: Professor Xinghang Zhang**

**ABSTRACT**

Zirconium oxide (zirconia, $ZrO_2$) is one of the essential structural ceramics for industrial applications due to its superb strength and fracture toughness. $ZrO_2$ has three main polymorphs: cubic, tetragonal, and monoclinic phase, depending on temperature, type, and concentration of dopants. Stabilized zirconia with metastable tetragonal phase can transform into monoclinic phase with ~ 4% volume expansion under an applied external stress. The tetragonal-to-monoclinic transformation can hinder crack propagations by generating a compressive stress field near crack field, thereby enhancing fracture toughness. In addition, other deformation mechanisms such as dislocation activities, crack deflection, and ferroelastic domain switching can further enhance its deformability. Bulk $ZrO_2$ is typically prepared by sintering at high temperatures over a long period of time. Recently, field-assisted sintering techniques such as flash sintering and spark plasma sintering have been applied to effectively sinter $ZrO_2$. These techniques can significantly decrease sintering temperature and time, and more importantly introduce a large number of defects in the sintered fine grains.

The miniaturization of a specimen's dimension can drastically alter the mechanical properties of materials by increasing the surface-to-volume ratio and decreasing the likelihood of retaining process-induced flaws. The knowledge of mechanical properties of $ZrO_2$ at micro and nanoscale is critical in that superelasticity and shape memory effect of $ZrO_2$ can be utilized for applications of actuation, energy-damping, and energy-harvesting at nanometric scale. Here, we performed in-situ microcompression tests at various temperatures inside a scanning electron microscope to examine mechanical properties of $ZrO_2$ prepared by flash sintering, spark plasma sintering and thermal spray. Detailed microstructural analyses were conducted by transmission electron microscopy. These unique microstructures in $ZrO_2$ prepared by field-assisted sintering largely improved their plasticity. Temperature and processing technique-dependent underlying deformation mechanisms and fracture behavior of $ZrO_2$ are discussed.

**Date: Thursday, June 11, 2020**
**Time: 9:00 AM**
**WebEx 161 889 6755**
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