

*Colloquium Sponsored by the School of Materials Science & Engineering*

## **At and Below Nanoscale: Phenomena Affecting the Microstructure and Toughness of Silicon Nitride Ceramics**

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### **ABSTRACT**

Silicon nitride ceramics containing elongated grains can be toughened through processes that are similar to those in fiber-reinforced ceramics. However, the desired elongated grain shape is modified by rare earth or group III elements used as densification additives, but the mechanisms behind this had eluded us. Experiments did reveal that the growth in the c-axis direction was likely controlled by diffusion and, thus, could be rapid. On the other hand, growth in the a-axis direction was most affected by the additives and actually inhibited by certain elements. Recent theoretical studies predict that anisotropic grain growth is controlled by differences in the segregation and adsorption of specific elements to the prismatic planes. These theoretical predictions for the rare earth elements are confirmed by atomic resolution scanning transmission electron microscopy (STEM) observations. Recent STEM results also indicate that the silicon nitride surface can act as a template for the formation of ordered clusters extending into the thin (< 2 nm) amorphous intergranular films. As in the case fiber-reinforced ceramics, the elongated grains must also partially debond/separate from the matrix ahead of the crack tip in order to serve to toughen the ceramic. This process is now known to be influenced by the additives used. Current studies reveal that the debonding process can be enhanced by changes in the crystalline-amorphous interface and/or the amorphous network induced by the additive elements. Thus, one can now begin to build a basis for tailoring not only the formation of the reinforcing grains but also the debonding process by through the additives used to densify the silicon nitride ceramics. The research was sponsored by the Division of Materials Sciences and Engineering, U. S. Department of Energy, under Contract No. DE-AC05-00OR22725 with UT-Battelle.

### **Biography**

Dr. Becher is a Corporate Fellow and Research Group Leader at the Oak Ridge National Laboratory. The research of the Ceramics Science and Technology Group concentrates on the mechanical behavior and transport properties of ceramic material; his own research on the influence of compositional and microstructural characteristics. During his career, he has authored more than 250 technical publications. He is a Past President of the American Ceramic Society and an ACerS Fellow. He is the recipient of an Alexander Von Humboldt Foundation Research Award for Senior Scientists and currently serves as an Associate Editor of the Journal of AcerS and on the National Materials Advisory Board of the National Academies. He received his Ph. D. from North Carolina State University with major in Ceramic Engineering and his B.S. and M.S. degrees from University of Missouri-Rolla in Metallurgical Engineering.

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5:00 PM – Room 200 – Olin Hall  
Refreshments Following Seminar