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Design of Microsystems: Insight from a Materials Reliability Perspective

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Abstract
Robust, reliable design of microelectromechanical systems (MEMS) requires knowledge of the fundamental material properties and mechanisms of failure. While many of the MEMS fabrication techniques originated in the microelectronics industry, there are several reliability concerns in MEMS that do not exist in microelectronics, such as mechanical strength, toughness, elasticity, wear resistance, and fatigue tolerance. In conventional structures ranging from aircraft engines to artificial heart valves, structural materials have been engineered over decades to meet such performance requirements; development of *reliable* MEMS materials has been much more limited. Recent efforts to examine the mechanical properties of microsystem structural materials have revealed several unforeseen design pitfalls. In some cases the relative importance of failure mechanisms change at the microscale, and in other cases new failure mechanisms emerge that were not possible at the macroscale. To illustrate this point we will draw from several examples of microsystem applications: a single crystal silicon low-G accelerometer, a Ni-based MEMS accelerometer, and a Ni-Mn electrical contact spring. Motivated by these applications, fundamental material performance studies have revealed new insight in mechanisms for fatigue crack initiation, the role of nano-scale grains in suppressing fatigue failure, microplastic ratcheting phenomena, unexpected strength-process interactions in polycrystalline silicon, and the important role of process-induced stress concentrations. An understanding of these and other microscale degradation mechanisms will enable both robust design of MEMS devices and the development of improved materials and fabrication processes for MEMS applications.

Speaker's Brief Biography
Brad L. Boyce received the B.S. degree in metallurgical engineering from Michigan Technological University in 1996, and the M.S. and Ph.D. degrees in materials science and engineering from the University of California at Berkeley in 1998 and 2001, respectively. Dr. Boyce is a Principal Member of the Technical Staff at Sandia National Laboratories in Albuquerque, New Mexico. His primary research interests are in mechanical performance and reliability of structural materials and MEMS materials. Dr. Boyce is a Key Reader for *Metallurgical Transactions*, and a former Hertz Fellow. Dr. Boyce chaired the 2005 Rio Grande Symposium on Advanced Materials, and was a co-organizer of the 2005 TMS Symposium on "Mechanical Behavior of Thin Films and Small Structures".

Friday, October 13, 2006

2:30 – 4:00 PM

2:30-3 is social time in ROGERS HALL 226;
seminar begins *promptly at 3 PM* in ROGERS HALL 230

Coffee and tea will be served

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