Spring 2009 Seminar

MECHANICS RESEARCH COMMUNICATIONS

Elsevier Distinguished Lecture

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11:30 a.m. – 1:00 p.m.
Guttenberg Information Technologies Center (GITC) – Room 3730

Thermal Barrier Coatings in Gas Turbine Engines: The Role of Fracture of Metal/Ceramic Interfaces

An overview introduction to thermal barrier systems used in the hottest sections of turbine engines and power generators will be presented. One of the most important thermal barrier systems for the turbine blades fails by delamination at the interface between the thermally grown oxide, alumina, and the metal layer that bonds the ceramic thermal barrier to the superalloy blade. The Al2O3/bond coat interface is a relatively brittle one starting life with a toughness (adhesive energy/area) of $50 J/m^2$. This implies that the atomistic energy of separation is enhanced by about a factor of 10 by crack tip plasticity occurring on the metal side of the interface. In service, the interface accumulates atomistic contaminates which can reduce the intrinsic atomistic separation energy and interface strength. Thus, both the intrinsic toughness and strength of the interface change with time affecting the durability. The Al2O3/bond coat interface will be used to motivate issues related to understanding and modeling the fundamental mechanics of interface fracture. The talk will describe an effort that is focused across the entire set of scales of this problem, atomistic to blade scale, and on both theoretical and experimental aspects. Central to the effort is a mechanics model of interface fracture that incorporates micron-scale plasticity and a cohesive law governing interface separation. Atomistic calculations of the separation energy and interface strength provide the parameters of the cohesive law. Trends in macroscopic interface toughness with changes in atomistic separation characteristics are related to crack tip plasticity.

John Hutchinson grew up in a small town in Southern New Jersey and received his undergraduate education in engineering mechanics at Lehigh University in 1960. He received his graduate education at Harvard University and joined the faculty there in the Division of Engineering and Applied Sciences in 1964 after a post-doctoral period at the Technical University of Denmark. He is currently the Abbott and James Lawrence Professor of Engineering at Harvard. Hutchinson, his students and collaborators work on problems in solid mechanics concerned with engineering materials and structures. Examples of ongoing research activities include: (1) efforts to extend plasticity theory to the micron scale, (2) development of a mechanics framework for assessing the durability of thermal barrier coatings for gas turbine engines, (3) development of blast resistance sandwich plate structures, and (4) the mechanics of thin films, coatings and multilayers. Hutchinson is a Fellow of ASME and a member of both the National Academy of Engineering and the National Academy of Sciences. He has received several honors and awards for his contributions to applied mechanics, including the Prager and Timoshenko Medals and honorary doctoral degrees from universities in the US and abroad.

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