RESEARCH AND CHALLENGES IN APPLIED MECHANICS

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The United States Government pursues diligent funding of basic research because it confers a preferential economic advantage[1]. The National Science Foundation (NSF) has supported basic research in engineering and the sciences for more than half a century and will continue this mandate in the future. The National Institute of Standards and Technology (NIST) conducts research in science and engineering in supports of its mission to develop and apply technology, measurements and standards. Considerable research funding will be directed towards nanoscale technology, information technology (IT), and bioengineering research. The challenge to the mechanics and materials research community is to determine the most needed and/or fruitful avenues of research within these broad-based and diverse research areas. In this presentation, results of relevant NSF workshops on research needs in solid mechanics for nanoscale technology, multiscale modeling and durability predictions will be presented. Examples of cutting-edge applied mechanics projects at NIST will also be given.

NSF, with the help of researchers from universities and national laboratories, organized a Workshop on Nano- and Micro-Mechanics of Solids for Emerging Science and Technology, which was held at Stanford University in October 1999. Important problems in nanomechanics arise, for example, in thermo-mechanical behavior of thin films with nano-structures; nano-indentation; nano-tribological response of solids; and failure processes of micro electromechanical systems (MEMS). One of the needs is to model material behavior over the full range of length and time scales, from short-term nano/micro-scale behavior, through meso-scale and macro-scale behavior into long-term structural systems performance. With the availability of advanced computing and new developments in material science, researchers can predict the structure, processing and manufacture of materials with designed performance and mechanical properties. Also, NSF recently announced a program [NSF 01-157] to catalyze synergistic science and engineering research in emerging areas of nanoscale science and technology, including: biosystems at nanoscale; nanoscale structures, novel phenomena, and quantum control; device and system architecture; design tools and nanosystems specific software; nanoscale processes in the environment; multi-scale, multi-phenomena modeling and simulation at the nanoscale.

Through industry workshops, internal initiatives and the NIST Advanced Technology Program, NIST has research activities to develop and promote measurements, standards, and technology in nanoscale science, IT and biotechnology. One of these research activities is to use high-efficiency combinatorial approaches to characterize and develop new materials. For example, the next generation of electronic components will require new low-k dielectrics or other novel thin films to be integrated into their construction. In developing these new materials, it is important to assess the adhesion reliability in a fast, practical and reproducible fashion. A debonding simulation program was developed at NIST to prove the feasibility of a highly efficient combinatorial or multivariant approach to a thin film adhesion test methodology (edge delamination). This approach can construct the failure map as a function of temperature and film thickness in one-step for a thin film (in the sub-micron range) bonded to a substrate. The failure map is used to investigate the reliability of interface, and such information about the interface integrity is more practical for product development than a fundamental adhesion measurement (e.g., bond energy). The initial experimental implementation of the combinatorial concept for characterizing the thin film adhesion as a function of temperature and film thickness shows promising results.

[1] Wong, E. "An Economic Case for Basic Research", *Nature*, Vol. 381, pp.187-188, May. (1996).

[2] Martin Y.M. Chiang, Wen-li Wu, Jianmei He, Eric. J. Amis, Combinatorial Approach to the Edge Delamination Test for Thin Film Reliability

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