



“Experiments and Models Regarding Strain Dependent Thermal Conductivity and Strength at the Nanoscale and Microscale ”



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Friday, April 29, 2011

3:00 pm, Birck 1001

Abstract:

Silicon micro- and nano-structures are essential in today's integrated circuits and sensors. The functioning and performance of such devices are highly affected by thermal properties. Due to the size effect, the thermal properties of bulk silicon cannot represent those of silicon micro-structures. Furthermore, stress/strain inside the silicon structures can have a significant effect on their thermal properties. The focus of this talk is on discussing models and experiments to understand room to high temperature thermal and mechanical properties of nano- and microstructures. First part of the talk will present first ever nano and micro scale creep measurements in a material at high temperature. Analyses show an interesting coupling between deformation mechanisms that operate at nano- and micron scale at high temperatures. More importantly, analyses point out to interesting thermal and mechanical coupling that exists at such scales and at high temperatures. Based on this motivation, the next part will present first ever measurements of the thermal conductivity of a silicon micro-device under applied compressive stress at 350 . An atomic force microscope (AFM) cantilever made of doped single-crystal Si was used as the sample. The integrated system applied compressive load to the cantilever in the longitudinal direction while supplying heat through heating. The thermal conductivity of the cantilever was calculated using steady state heat conduction equation. The result shows that the measured thermal conductivity of the cantilever is 110 to 140 , accompanying a compressive strain of 0.1% to 0.3%. Finally, some strain dependent thermal conductivity modeling work performed in our group is presented. A most significant result is that in biomimetic materials, strain has insignificant effect on varying thermal conductivity.

Bio: Dr. Tomar received his PhD from the Georgia Institute of Technology-Atlanta, USA in December, 2005. Dr. Tomar has made 70 technical presentations, edited/contributed to 3 books and journal special issues, written 1 book, 45 peer-reviewed international journal publications, 14 proceeding articles, 1 research patent, 2 invention disclosures, and given numerous invited talks at universities as well as international conferences. He serves on editorial board of three international journals focusing on nanotechnology, has served as a peer reviewer for more than 25 international journal publications as well as organized/co-organized five national and international symposia for societies such as the American Society of Mechanical Engineers (ASME), the Materials Research Society (MRS), and the minerals, metals, and materials society (TMS). He has been awarded the Air Force Office of Scientific Research (AFoSR)-Young Investigator Award (2009-1012), ASME Materials Division “Orr” Family award for excellence in failure of materials research (2010), Elsevier-Materials Science and Engineering-C Young Researcher Award for excellence in research at the interface of biology and materials engineering by a researcher under age 35, and TMS Early Career Faculty Fellow Award-Honorable Mention (2010). Funding for his work has come from the National Science Foundation (NSF), the Department of Energy (DoE), ARMY, office of naval research (ONR), and AFoSR. Dr. Tomar is a member of the American Institute of Aeronautics and Astronautics (AIAA), ASME, Society of Engineering Science, and TMS. Besides research Dr. Tomar has been a funding reviewer for two panels at NSF, two panels at DoE, one panel at Swiss National Science Foundation, and one panel at Hong-Kong University of Science and Technology. Dr. Tomar also has been involved in education and its integration with research activities at both grass-root and advanced levels. Dr. Tomar has been an active advocate and participant in establishing a pre-engineering program at West Side High School Gary-IN. He has also been active in integrating diverse groups in technical education both at undergraduate and graduate levels.