VirginiaTech

Mechanical Engineering Distinguished Speaker Series

Speaker: **Dr. Joost Vlassak**, Harvard University
When: Thursday, February 6, 3:30-4:30
Where: 310 Kelly Hall

Nano-calorimetry: A New Tool for Materials Development

Calorimetry has long been used to study chemical reactions and phase transitions in materials. The technique finds its origin in the mid-18th century when Scottish physician Joseph Black discovered the notion of latent heat and Lavoisier developed an ice calorimeter to measure the amount of heat given off during combustion of carbon or respiration of living organisms. Since then calorimetry has developed into a sophisticated technique indispensable in chemistry and materials science.

In this seminar, I will show how the same technique can be used to make measurements at the nano-scale. We use micromachining to fabricate arrays of calorimetric sensors that can perform measurements on samples as thin as a few nanometers at rates varying from isothermal to 10^5 K/s. The sensor arrays are ideally suited to explore complex materials systems in a combinatorial approach based on thin-film composition spreads. This methodology is illustrated using high-temperature Ni-Ti-based shape memory alloys. Because of its large dynamic range, nanocalorimetry is also ideal for studying the kinetics of solid-state and solid-gas reactions. We use nano-calorimetry to evaluate the kinetics of solid-state reactions in Zr/B and Zr/B_4C multilayers and demonstrate that ultra-high temperature ceramics such as ZrB_2 and ZrB_2/ZrC alloys can be synthesized at moderate temperatures. The formation reactions typically proceed in two distinct steps: inter-diffusion and amorphization, followed by crystallization. First-principles calculations provide insight in the amorphization processes in the reactive multilayers and confirm the relatively low activation energies associated with the amorphization process.

Professor Vlassak studies the thermo-mechanical behavior of a broad range of engineering materials. He has developed experimental methods to characterize plastic deformation in thin films and coatings, elastic anisotropy in indentation, and fracture of coatings. Experimental research projects focus on the mechanical degradation of the electrodes in lithium ion batteries as a result of lithium insertion, on the swelling and fracture of hydrogels, and on the effects of microstructural length scales on the mechanical behavior of thin metal films. Recently, Professor Vlassak pioneered the use of combinatorial nanocalorimetry for the development and analysis of complex materials systems, including metallic glasses, ultra-high temperature ceramics, and high-temperature shape memory alloys.

Host: Dr. Reza Mirzaeifar (rmirzaei@vt.edu)