Technion – Israel Institute of Technology
Faculty of Mechanical Engineering

MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, May 12th 2022 at 13:00, D. Dan and Betty Kahn Building, Auditorium 1.
Online: https://technion.zoom.us/j/98723703351

High-rate phase transformation in shape memory alloys: from small-scale kinetics to actuator design

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Shape memory alloys (SMA) are smart materials that undergo a martensitic phase transformation between two solid phases. SMA-based actuators provide a unique combination of large stresses and strains that result in work-per-volume larger by more than two orders of magnitude than all other active-material actuators. However, conventional SMA actuators suffer from slow actuation time. The question "how fast can the martensitic transformation be?" appears in any text book on introduction to materials science or on solid-solid phase transformations, but its answers are typically obscure or experimentally unvalidated.

I will introduce an experimental investigation of the martensitic transformation at high driving forces through tracking the microstructural evolution at the micrometer and microsecond scales. A unique experimental system employing microsecond-scale time-resolved x-ray diffraction (XRD) at synchrotron radiation along with high-bandwidth force measurements allow us to identify three stages of the transformation occurring at different times and length scales. A continuum model was formulated based on the empirical observation and fitting of the calculations to experimental results support a suggested kinetic relation and the existence of a new type of a highly energetical macroscopic phase front. A second XRD investigation at higher energy synchrotron radiation allow for both a time- and depth-resolved investigation of the transformation. Results show an order of magnitude improvement in the detected onset of the transformation time, raising new questions on the effects of the material microstructure on the evolution of the phase transformation.

Finally, we apply the obtained knowledge to formulate design guidelines for high-rate SMA actuators that have great potential for fast applications that require large forces. Further, we develop simulations of actuator response that can serve as accurate design tools; and map actuator performance into three regimes that enable users to quickly evaluate the expected output of their system.

Note: the seminar will be given in English

Seminars Coordinator: Assoc. Prof. Matthew Suss.