Title: Interface dynamics of phase transforming materials

Subfield: Mechanics, Materials Science and Thermodynamics.
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Phase transformation such as the ice-liquid-vapor transition of water is indispensable in our living world. In fact, the phenomenon of phase transformation also governs the important properties/behaviors of many engineering materials such as the normal↔superconudcting transition in superconductors, the paramagnetic↔ferromagnetic transition in magnets, and the austenite↔martensite transition in Shape Memory Alloys (SMAs). By definition, phase transformation always induces sudden changes in some of the material properties such as the electrical resistance in superconductors, the spontaneous magnetic polarization in magnets, and the atomic-lattice symmetry (usually accompanied with macroscopic deformation) in SMAs. These sudden changes imply complicated evolution paths (dynamics) of the material microstructures, influencing the material macroscopic behaviors and the associated engineering applications.

As shown in the figure below of our recent study on the phase transformation of SMAs in single-crystal and polycrystalline forms, the sudden changes in the atomic lattice leads to the jump in the mesoscopic and/or macroscopic deformations, generating various interfaces (from very small sharp needles/laminates to macroscopic austenite-martensite diffuse zone) [1-5]. The dynamics of these interfaces governs the material thermo-mechanical behavior (stress-strain and temperature responses) [6-8], the material robustness (fatigue resistance) [9] and the energy efficiency (energy dissipation) [3, 10]. In this PhD study, the student will perform more experimental observations on the pattern evolution with high-speed and high-resolution cameras to characterize the dynamics at both micro- and macro-scales. Then, advanced mathematical models will be developed to reveal the relation between the dynamics and the material global behaviors so to propose guidelines to design robust and efficient materials for various applications such as the robust bio-medical SMA devices, the solid-state cooling with SMA's elastocaloric and magnetocaloric effect (new type refrigerator to avoid the environmental harm from the traditional refrigeration), high-frequency large-stoke actuators, etc.

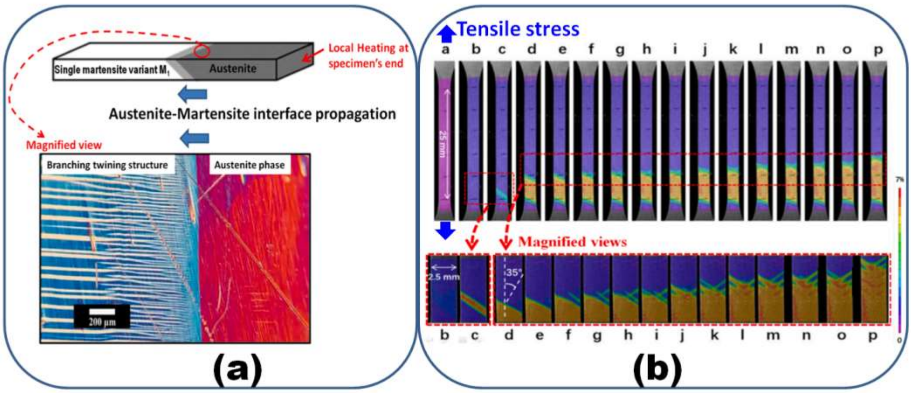

Figure 1: **(a)** Heating-induced phase transformation with branching/laminated interface propagation in single crystal; **(b)** stretch-induced phase transformation with branching interface propagation in polycrystalline SMA.

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