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Martensitic Transformation in Granular Shape Memory Ceramic Packings

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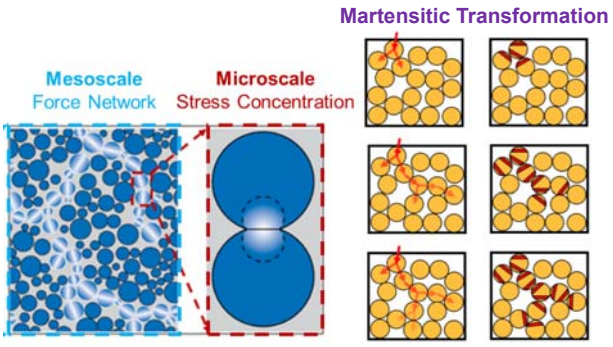
Abstract

Stress-induced martensitic transformation can occur in granular shape memory materials when individual particles experience high stresses and transform from a high-symmetry austenite phase to a low-symmetry martensite phase. This involves a highly heterogeneous distribution of the driving force and very low mechanical constraint for martensite nucleation, so the transformation behavior can be dramatically different from the well-documented case of monolithic solids. In this work, we investigate the stress-induced martensitic transformation in granular shape memory ceramic packings, which consist of single-crystal micro-particles of ZrO2-12at%CeO2 and ZrO2-15at%CeO2. Through in situ neutron diffraction, we study how the phase fraction, lattice strain, and integral peak broadness evolve during external loading, unloading, and subsequent heating. Several peculiar features are discovered, including (i) a continuous mode of transformation with a wide range of transformation loads, (ii) co-evolution of the packing structure, contact deformation, and martensitic transformation, and (iii) a strong correlation between the peak broadening and the transformed phase fraction. In addition, we show the first direct evidence of reversible stress-induced martensitic transformation in granular materials. We finally discuss the mechanism for martensite nucleation and growth in granular packings and show how that leads to the observed transformation characteristics.



Biography

Hunter Rauch has been pursuing his PhD since August of 2016 and hopes to graduate in 2020. He works in Dr. Hang Yu's group where he primarily researches shape memory ceramics. Hunter's first first-author paper is in review and this year he plans to submit three more on similar topics. He has presented his research on the martensitic transformation in granular zirconia at MS&T for the last two years, and he is a co-author on several papers concerning solid-state metal additive manufacturing. With his collaborators Hunter is currently researching 3D printed structural and functional composite materials in addition to his ceramics project.