(ICACC-S9-023-2024) Exploring Shape Memory and Superelastic Transformations in Bulk-Scale, Porous Zirconia

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Shape memory materials can undergo reversible, diffusionless martensitic transformations that enable them to exhibit shape memory or superelastic behavior. Although shape memory alloys are more commonly commercialized, shape memory ceramics such as ceria-stabilized zirconia can also take advantage of this martensitic transformation. However, the volume expansion that accompanies the martensitic transformation in zirconia limits the exploitation of superelastic and shape memory behaviors in polycrystalline systems, as the change in volume causes stress mismatch at grain boundaries that leads to cracking and failure. To prevent this premature failure, this work utilizes freeze casting to create a network of honey-comb-like pores. By increasing the ratio of surface area to volume in this manner, the volume expansion of the martensitic transformation is accommodated in a polycrystalline system. Shape memory and superelastic behavior can then be explored over several cycles, using X-ray diffraction and Raman spectroscopy to track the extent of the transformation over millimeter- and micrometer-scale volumes. Additionally, the use of Raman spectroscopy to track the martensitic transformation presents opportunities both to monitor shape memory and superelastic behaviors in-situ, and to more closely examine the effect of pore wall thickness on the shape memory and superelastic behaviors.