# NANODOMAIN ENGINEERING: MAKING SMART MATERIALS SMARTER

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The unique properties of an important class of smart materials, the ferroics, originate from structural phase transformations with symmetry breaking that produce self-accommodating polydomain structures. Sensing and actuation can be realized simultaneously through domain switching under external fields. Familiar examples include ferroelectrics, ferromagnetics and shape memory alloys, transformation toughened ceramics, and artificial muscles. Even though the micro-domain structures in various ferroic systems have been studied for over a century, the properties of their nano-domain counterparts have not yet been explored till recently. In particular, the discovery of the strain glass state in parallel to relaxor and cluster spin glass has renewed the interest in nano-domain ferroics. Using ferroelastic systems as an example we show in this presentation how to carry out hypothesis-driven fundamental study of defects, transformation pathway and elastic strain engineering to break long-range ordered polytwin domain structure into randomly distributed nano-domains and alter the transformation pathways, rendering the martensitic transformation (MT) continuous. With the aid of computer simulations, we demonstrate that such an apparently continuous MT, unique microstructural state and transformation pathways are actually responsible for a rich variety of unique properties of strain glasses, including superelasticity of nearly zero hysteresis, nearly zero thermal expansion (Invar anomaly) and nearly temperature-independent elastic modulus (Elinvar anomaly), and ultra-low elastic modulus over a wide temperature range. These findings not only shed light on some long-standing puzzles, but also open a new avenue for the development of revolutionary new concepts and new design strategies for the next generation of smart nano-structured materials for a wide range of technological applications.

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