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Study the formation of microstructure for highly reversible martensitic materials

Abstract

Martensitic materials, traditionally known as shape memory alloys, are exploited for many new applications in microelectronics and energy conversion devices when the change of lattice parameters is linked to the sensitivity of multiferroic properties. However the functionalities of these martensitic materials usually degrades significantly after only few transformation cycles. The origin of such degradation comes from the formation of microstructure consisting stressed-transition layers due to lattice mismatch at heterophase boundaries. It has been proven that when the lattice parameters satisfy a set of kinematic conditions of compatibility, both hysteresis and reversibility can be optimized, thus long life-time is achieved for these applications. New allows discovered by satisfying these conditions exhibit exceptional reversibility and low hysteresis, i.e. zero functional migration up to millions cycles [Song et al., Nature (2013) and Chluba et al., Science (2015)]. In sharp contrast to ordinary martensitic materials, a variety of hierarchical microstructures arises in these highly reversible materials: riverine curved interfaces, sharp zig-zag interfaces as well as large single variant bands. In addition, the material loses the usual reproducibility and acoustic emission traces from cycle to cycle.

Here, we would like to present the formulation of the geometric conditions of compatibility and their roles in discovering highly reversible materials. We have developed an approach for observation of the formation of interface by *in situ* micro-Laue scan. Combined with the theoretical calculation, the mysteries of unusual hierarchies in the highly reversible material can be understood.