Mechanisms of interface kinetics during phase transformation of Shape Memory Alloys

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Abstract

The phase transformation of Shape Memory Alloys (SMA) occurs via the austenite-martensite interface nucleation and propagation. The kinetics of the interface propagation is a key issue in studying the SMA's behaviours as it demonstrates the relation between the phase transformation rate (the interface propagation speed) and the driving force (energy dissipation), which implies the energetic efficiency or the damping performance of the material in the engineering applications (1-4). Although the macroscopic interface kinetics based on phenomenological models have been studied a long time ago, there are only a few concrete experiments that show the meso- and micro-scopic evolution of the propagating interface. Recently, the microscopic evolution with the nucleation/merging/annihilation of various martensite twin laminates was reported at the martensite-austenite interface propagation during the temperature-induced phase transformation of a magnetic shape memory alloy (Ni-Mn-Ga single crystal) (5-9). Compared to polycrystalline SMAs, single crystal SMA can better demonstrate the compatibility between the two transforming phases at the propagating interface, from which the stored energy and the associated energetic driving force can be estimated (3-5, 10). But it is still a challenging task to characterize simultaneously the macroscopic kinetics and the microscopic evolution in the single crystal. In this paper, we synchronize the microscopic observation (twinning/detwinning/phase-transformation) and the macroscopic measurement of the kinetics (the macroscopic interface speed versus the applied temperature/stress/magnetic-field) so as to better understand the mechanism of the phase transformation by the macroscopic interface propagation, which would help material design (modification/improvement on material performance) and engineering applications (tailor-made materials for particular situations).

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