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Shape Reversibility and Crystallographic Analysis of Structural Transformations in Shape Memory Alloys

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Abstract

A series of alloy systems take place in class of advanced smart materials with adaptive properties and stimulus response to the external changes. Shape memory alloys take place in this group, due to the shape reversibility and capacity of responding to changes in the environment. These alloys exhibit a peculiar property called shape memory effect, which is characterized by the recoverability of two certain shapes of material at different temperatures.

These alloys have dual characteristics called thermoelectricity and super elasticity, from viewpoint of memory behavior. Two successive structural transformations, thermal and stress induced martensitic transformations govern shape memory phenomena in crystallographic basis. Thermal induced martensite occurs along with crystal twinning in self-accommodating manner on cooling and ordered parent phase structures turn into twinned martensite structures, and twinned structures turn into the detwinned structures by stressing material in low temperature condition by means of stress.

Keywords: Martensitic transformation • Shape memory effect • Thermoelectricity

Commentary

Copper wires supply external DC current for SMA springs in the SMAHV. An info current of 1.0–3.0 A was applied to the SMA wire in the SMAHV, and the relocation while diminishing the space of the lumen is video recorded and investigated utilizing Tracker 5.0 (Douglas Brown©). Each pattern of the SMAHV is activated for a time of 8 seconds, with an incitation period of 5 seconds and an unwinding period of 3 seconds. Applying an info current of 1.0–2.0 A to both 100 and 150 µm wire distance across SMA spring in the SMAHV delivered a dislodging of 0.1–0.4 mm, which is exceptionally low and delivers the valve unsatisfactory for CBI process because of its insignificant change in the lumen region. SMA spring in SMAHV applies information current above 3.0 A for both 100 and 150 µm, required longer cooling time for the SMA spring and the SMAHV couldn't get back to its underlying situation in the 3 seconds unwinding period. Because of these disadvantages, SMA spring in the SMAHV applies a current of 2.5 A for both 100 and 150 µm to decide the relocation of the SMA spring based SMAHV.

Super elasticity is performed by stressing and releasing material at a constant temperature in parent phase region, and shape recovery is performed simultaneously upon releasing the applied stress. Super elasticity is performed in non-linear way; stressing and releasing paths are different in the stress strain diagram, and hysteresis loop refers to energy dissipation.

The elementary processes involved in such martensitic transformations are lattice invariant shear, lattice twinning and detwinning. It is well known that crystal twinning and detwinning reactions play a considerable role in shape memory effect and super elasticity. Thermal induced martensitic transformation is lattice distorting phase transformation occur with the cooperative movement of atoms by means of shear like mechanism in 110 type directions on 110 type planes of austenite matrix.

Copper based ternary alloys exhibit shape memory in β-phase field. Lattice invariant shear and twinning is not uniform in copper based shape memory alloys, and cause to the formation of long period layered martensitic structures with lattice twinning on cooling.

In the present contribution, electron diffraction and x-ray diffraction studies performed on two coppers based CuZnAl and CuAlMn alloys. Electron diffraction patterns and x-ray diffraction profiles show that these alloys exhibit super lattice reflections in martensitic condition. Specimens of these alloys aged at room temperature in martensitic condition, and a series of x-ray diffractions were taken duration aging at room temperature. Reached results show that diffraction angles and peak intensities change with aging time at room temperature. In particular, some of the successive peak pairs providing a special relation between Miller indices come close each other, and this result leads to the rearrangement of atoms in diffusive manner

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Conflict of Interest

Author declares there is no conflict of interest.

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