Phase Transition and Stacking Ordered Nature of Martensite in Shape Memory Alloys

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Shape memory alloys have a peculiar property, shape memory effect. These alloys return to previously defined shapes when they are subjected to variation of temperature after deformation at low temperature phase. The shape memory effect is facilitated by martensitic transformation, and shape memory properties are intimately related to the microstructures of the alloy in crystallographic level. Martensitic transformations occur with the cooperative movements of atoms on {110}-type planes of parent phase by means of lattice invariant shear on cooling from high temperature parent phase region. Twinning and detwinning processes can be considered as elementary processes activated during the transformation. These processes are responsible for shape memory effect, as well as martensitic transformation.

Copper based alloys exhibit this property in β - phase field, which possess simple bcc- structures at high temperature austenite phase. As the temperature is lowered, austenite phase undergoes martensitic transition following two ordering reactions, and microstructural changes in microscopic scale govern this transition. Lattice invariant shear occurs in-homogeneously in non-uniform way and causes to the formation of long period stacking ordered structures. Inhomogeneous shears occur in two opposite directions, <110 > -type directions on {110}-type plane of austenite matrix. These shears can be called as {110} <110 > -type mode and give rise to the formation of layered structures, like 9R or 18R depending on the stacking sequences on the close-packed planes of the ordered lattice. The periodicity and unit cell are completed through 18 layers in direction z in 18R case.

The basic microstructural mechanism responsible for the shape memory effect is martensite detwinning process. The twinned martensites turn into the detwinned martensites with the deformation at low temperature martensite condition, and the material crystal cycles between twinned and detwinned structures on cooling and heating. Therefore, the twinning and detwinning is essential process as well as martensitic transformation in reversible shape memory effect.

In the present contribution, x-ray diffraction and transmission electron microscopy studies were carried out on two copper based CuZnAl and CuAlMn alloys.

Key Words: Martensitic transition, shape memory effect, stacking sequences, twinning, detwinning layered structures.