Shape Memory Phenomena and Multilayered Nature of Martensite in Copper Based Shape Memory Alloys

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A series of alloy system take place in a class of advanced functional materials due to stimulus response to external effect. Shape memory alloys take place in this class by exhibiting a peculiar property called shape memory effect. This phenomenon is characterized by the recoverability of two certain shapes of material in reversible way at different conditions. These alloys are used as shape memory devices in many fields from medicine, metallurgy, building industry. These alloys have dual characteristics called thermoelasticity and superelasticity in memory manner and governed by thermal and stress induced martensitic transformations and performed thermally and mechanically. Shape memory effect is initiated by cooling and deformation and performed thermally in a temperature interval on heating and cooling after first cooling and stressing processes, and this behavior is called thermoelasticity. Superelasticity is performed by stressing and releasing material in a constant temperature in parent phase region. For the Superelasticity, materials are stressed in the elasticity limit in the parent phase region and, shape recovery is performed instantly and simultaneously upon releasing the applied stress. Thermal induced martensitic transformation occurs on cooling with cooperative movements of atoms by means of lattice invariant shears in two opposite directions, <110 > -type directions on the {110} - type planes of austenite matrix and ordered parent phase structures turn into the twinned martensite structures, and the twinned structures turn into the detwinned structures by means of stress induced martensitic transformation, by stressing material in the martensitic condition. Movements of atoms are result of lattice invariant shears and confined to interatomic distances. Therefore, martensitic transformations are diffusionless transformations.

Copper based alloys exhibit this property in metastable β-phase region, which has bcc-based structures at high temperature parent phase field. Lattice invariant shear and lattice twinning are not uniform in these alloys and give rise to the formation of layered structures, like 3R, 9R or 18R depending on the stacking sequences on the close-packed planes of the ordered lattice. The unit cell and periodicity are completed through 18 layers thorough z-axis in 18R martensite.

In the present contribution, x-ray diffraction and transmission electron microscopy (TEM) studies were carried out on copper based CuZnAl and CuAlMn alloys. X-ray diffraction and electron diffraction patterns exhibit superlattice reflection. X-ray diffractograms taken in a long-time interval show that locations and intensities of diffraction peaks change with the aging time at room temperature, and this result refers to the redistribution of atoms in diffusive manner.