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Lattice reactions and nanoscale aspects of phase transformations in shape memory alloys

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Shape memory alloys take place in a class of functional materials by exhibiting a peculiar property called shape memory effect. This property is characterized by the recoverability of two certain shapes of material at different conditions. Shape memory effect is based on dual solid state phase transformations, thermal and stress induced martensitic transformation. Thermal induced martensitic transformation occurs on cooling from parent phase region, along with lattice twinning in self-accommodated manner, and ordered parent phase structure turn into the twinned martensite structure. The twinned structures turn into the detwinned martensite structures by means of stress induced martensitic transformation by stressing the material in the martensitic condition. Thermal induced transformation is performed with with cooperative movements of atoms by means of lattice invariant shears, which occur in <110 > -type opposite directions on the {110}-type planes of austenite matrix. The basic processes are the lattice twinning and detwinning processes in shape memory alloys. Deformation of shape memory alloys in martensitic state proceeds through a martensite variant reorientation. The deformed material recovers the original shape on heating over the austenite finish temperature, and cycles between the deformed and original shapes on cooling and heating, respectively, whereas the crystal structure cycles between the twinned and ordered parent phase structures. Microstructural mechanisms responsible for the shape memory effect are the twinning and orientation processes. Therefore, the twinning and orientation processes have great importance in the shape memory behaviour of the materials.

Copper based alloys exhibit this property in metastable β-phase region, which has bcc-based structures at high temperature parent phase field, and these structures martensitically turn into layered complex structures with lattice twinning following two ordered reactions on cooling. Lattice twinning and lattice invariant shears occur in non-uniform way in copper based shape memory alloys, and this process causes to the formation of the long periodic complex layered structures.

In the present contribution, x-ray diffraction, transmission electron microscope and differential scanning calorimeter (DSC) studies were carried out on two copper based ternary alloys. The x-ray diffractograms taken in a long time intervals from the aged specimens at room temperature reveal the structural changes and redistribution of atoms in diffusive manner.

Keywords: Shape Memory Effect, Martensitic Transformation, Lattice Twinning and Detwinning

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