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Lattice reactions governing thermal and mechanical memory in shape memory

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Some materials take place in class of smart materials with adaptive properties and stimulus response to the external changes. Shape memory alloys take place in this group by exhibiting a peculiar property called shape memory effect. This property is characterized by the recoverability of two certain shapes of material at different temperatures. Shape memory effect is initiated by two successive structural transformations, thermal and stress induced martensitic transformations governed by lattice twinning and detwinning reactions, and performed thermally by heating and cooling after these processes. This behavior can be called thermal memory. These alloys possess two unique abilities: the capacity to recover large strains and to generate internal forces during their activation. The basis of this phenomenon is the stimulus-induced phase transformations, martensitic transformations governed by the remarkable changes in internal crystalline structure and properties of the materials. Thermal induced martensitic transformation is first order phase transformation and occurs in the material on cooling, with which ordered parent phase structures turn into twinned martensite structures with lattice twinning. This transformation occurs with cooperative movements of atoms by means of lattice invariant shear in two opposite directions, <110 > -type directions on the {110} - type planes of austenite matrix which is basal plane of martensite. These twinned structures turn into detwinned structures by means of stress induced transformation by stressing the material in the martensitic condition. The microstructural mechanisms governing shape memory effect are the twinning and detwinning processes. These alloys exhibit another property; called superelasticity which is also a result of stress induced martensitic transformation and performed mechanically in the parent austenite phase region. The materials are deformed at a constant temperature in parent phase region, and shape recovery is performed simultaneously upon releasing the applied stress, and complete shape recovery is observed upon unloading. This behavior can be called mechanical memory. 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 process on cooling. Lattice invariant shear is not uniform in copper based shape memory alloys, and these types of shears gives 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. Crystal structure of martensite of these alloys is orthorhombic and basal plane is hexagonal. In the present contribution, x-ray diffraction and transmission electron microscopy (TEM) and differential scanning calorimetry (DSC) studies were carried out on two copper based CuZnAl and CuAlMn alloys. X-ray diffractograms taken in a long time interval show that diffraction angles and intensities of diffraction peaks change with the aging time at room temperature. In particular, some of the successive peak pairs providing a special relation between Miller indices come close each other. This result refers to the rearrangement of atoms in diffusive manner, and hexagonal basal plane structure deviated from normal hexagon.

Biography

Osman Adiguzel has graduated from Department of Physics, Ankara University, Turkey in 1974 and received PhD degree from Dicle University, Diyarbakir-Turkey. He has studied at Surrey University, Guildford, UK, as a post doctoral research scientist in 1986-1987, and studied on shape memory alloys. He worked as research assistant, 1975-80, at Dicle University and shifted to Firat University, Elazig, Turkey in 1980. He became Professor in 1996, and he has already been working as professor. He published over 60 papers in international and national journals; He joined over 100 conferences and symposia in international and national level as participant, invited speaker or keynote speaker with contributions of oral or poster. He served the program chair or conference chair/co-chair in some of these activities. In particular, he joined in last five years (2014 - 2018) over 50 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. He supervised 5 PhD- theses and 3 MSc- theses. He served his directorate of Graduate School of Natural and Applied Sciences, Firat University, in 1999-2004. He received a certificate awarded to him and his experimental group in recognition of significant contribution of 2 patterns to the Powder Diffraction File – Release 2000. The ICDD (International Centre for Diffraction Data) also appreciates cooperation of his group and interest in Powder Diffraction File.

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