Abstract

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Lattice Reactions Governing Phase Transformations and Reversibility in Shape Memory Alloys

Osman Adiguzel
Firat University Department of Physics, Elazig, Turkey

Abstract

Shape memory alloys take place in a class of the advanced smart materials by exhibiting a peculiar property, called shape memory effect. These alloys possess two unique abilities: the capacity to recover large strains and to generate internal forces during their activation. This property is characterized by the recoverability of two certain shapes of material at different temperatures. This phenomenon is initiated by thermomechanical processes on cooling and deformation of the material and performed thermally on heating and cooling, with which shape of material is cycled between original and deformed shapes in reversible way. Therefore, this behaviour can be called thermoelasticity. The strain energy is stored after releasing, by keeping the deformed shape, due to the plastic deformation, and these alloys are mainly used as deformation absorbent materials in control of civil structures subjected to seismic events, due to the absorbance of strain energy during any disaster or earthquake. Two successive stimulus-induced structural transformations, thermal and stress induced martensitic transformations govern this phenomenon in crystallographic basis.Thermal induced martensitic transformation is first order lattice-distorting phase transformation and occurs on cooling in the material with the cooperative movements of atoms in <110 > -type directions on the {110} - type planes of austenite matrix, by means of lattice invariant shear, and ordered parent phase structures turn into twinned martensite structures along with lattice twinning reactions. The twinned structures turn into detwinned structures, along with the detwinning reactions, by means of stress induced transformation by stressing the material in the martensitic condition. The elementary reactions which are governing martensitic transformations are lattice twinning and detwinning reactionsThese alloys exhibit another property called superelasticity, which is performed in only mechanical manner with stressing and releasing the material at a constant temperature in parent phase region just over austenite finish temperature and recover the original shape on releasing the stress, by exhibiting elastic material behaviour. Superelasticity is performed in non-linear way; stressing and releasing paths are different in the stress-strain diagram, and hysteresis loop refers to energy dissipation. 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 twinning is not uniform in these alloys, and cause 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. In the present contribution, x-ray diffraction and transmission electron microscopy (TEM) studies were carried out on copper based CuZnAl and CuAlMn alloys. Electron diffraction patterns and x-ray diffractograms taken from the alloy samples 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. This result refers to the rearrangement of atoms in diffusive manner.

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Biography

Dr. Adiguzel 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 were focused on shape memory effect in 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 been retired on November 28, 2019, due to the age limit of 67, following academic life of 45 years. He published over 80 papers in international and national journals; He joined over 120 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 six years (2014 - 2019) over 60 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. Also, he joined over 70 online conferences in the same way in pandemic period of 2020-2021. He supervised 5 PhD- theses and 3 M. Sc- theses.

