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Nanoscale characterization of thermal and stress induced phase transformations in shape memory alloys

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ABSTRACT

Shape memory effect is a peculiar property exhibited by a series alloy system in the β-phase fields and governed by successive dual thermal and stress induced martensitic transformations. Shape memory effect is initiated by cooling and stressing the material and performed on heating and cooling after these processes. Thermal induced martensitic transformation occurs on cooling along with lattice twinning in crystallographic level on cooling and ordered parent phase structures turn into the twinned martensite structures. Twinned martensite structures turn into detwinned martensite structure by means of stress induced transformation by deforming plastically in a strain limit in martensitic condition. Shape memory alloys are in the fully martensitic state below martensite finish temperature and can be easily deformed through variant reorientation/ detwinning process. Therefore, martensite is called soft phase and austenite is also called hard phase. Thermal induced martensitic transformation is lattice-distorting phase transformation and occurs with the cooperative movements of atoms by means of lattice invariant shear in <110>-type directions on {110}- type close packed planes of austenite matrix which is basal plane or stacking plane for martensite. The {110}-type close packed planes represent a certain plane family including 6 certain planes and martensitic phase occurs as 24 martensite variants. These alloys exhibit another property called superelasticity which is performed by stressing and releasing at a constant temperature in the parent β-phase region. Superelasticity exhibits classical elastic material behavior by recovering the original shape after releasing. Stressing and releasing paths are different at the stress-strain diagram and the cycling loop refers to the energy dissipation. Superelasticity is also result of the stress induced martensitic transformation and ordered parent phase structures turn into the detwinned martensite structures. Copper based alloys exhibit this property in metastable β-phase region, which has bcc-based structures at high temperature parent phase field. Lattice twinning and invariant shears are not uniform in these alloys, and the ordered parent phase structures martensitically undergo the non-conventional complex layered structures on cooling. The long-period layered structures can be described by different unit cells as 3R, 9R or 18R depending on the stacking sequences on the close-packed planes of the ordered lattice. The closepacked planes, basal planes, exhibit high symmetry and short-range order as parent phase. The unit cell and periodicity are completed through 18 layers in direction z, in case of 18R martensite, and unit cells are not periodic in short range in direction z. In the present contribution, x-ray diffraction and transmission electron microscope studies were carried out on two copper based CuZnAl and CuAlMn alloys. These alloy samples have been heat treated for homogenization in the β-phase fields. X-ray diffraction profiles and electron diffraction patterns exhibit super lattice reflections inherited from parent phase due to the displacive character of the transformation. 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; this result refers to the rearrangement of atoms in diffusive manner.

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 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

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 seven years (2014 - 2020) over 70 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. He supervised 5 PhDtheses and 3 M.Sc- theses. Dr. Adiguzel 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.