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Atomic Scale Reactions in Thermoelastic and Superelastic Behavior of Shape Memory Alloys

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A series of alloy systems exhibit a peculiar property called shape memory effect with chemical compositions in β-phase fields. This phenomenon is performed thermally and mechanically after thermal and thermomechanical processes. These alloys are temperature sensitive materials, and undergo structural changes by means of crystallographic transformations, called martensitic transformations with the variation of temperature and deformation. Shape memory effect is initiated by cooling and deformation processes and performed thermally on heating and cooling after these treatments. Therefore, this behavior can be called thermoelasticity. These alloys exhibit another property called superelasticity, which is performed mechanically by stressing and releasing material in the parent phase region. These behaviors are governed by crystallographic reactions, thermal and stress induced martensitic transformations. Thermal induced transformation occurs on cooling with cooperative movement of atoms in <110>-type directions on {110}-type close packed planes of austenite matrix, by means of lattice invariant shear, along with lattice twinning, and ordered parent phase structures turn into the twinned martensite structure. Twinned structures turn into the detwinned structures by means of stress induced martensitic transformation with the deformation. Strain energy is stored in the material with deformation and released upon heating, by recovering the original shape in bulk level, and cycles between original and deformed shapes on heating and cooling, respectively. Superelasticity is also result of stress induced martensitic transformation and performed mechanically stressing material at a constant temperature in the parent phase region, with which ordered parent phase structures turn into detwinned martensite structures, by means of stress induced transformation. The material recovers the original shape upon releasing by means of reverse austenitic transformation. It is important that stressing and releasing paths are different at stress-strain diagram, and hysteresis loops refers to the energy dissipation.

Copper based alloys exhibit this property in metastable β-phase region, which has bcc-based structures. Lattice invariant shear and lattice twinning are not uniform in these alloys, and the ordered parent phase structures martensitically undergo the non-conventional complex layered structures. 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 unit cell and periodicity is 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 microscopy studies were carried out on two copper based CuZnAl and CuAlMn alloys. X-ray diffraction profiles and electron diffraction patterns exhibit super lattice reflections inherited from parent phase due to the diffusion less character of martensitic 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 a new transformation in diffusive manner.

Keywords: Shape memory effect, martensitic transformation, thermoelasticity, lattice twinning and detwinning.

Recent Publications

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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 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 80 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 seven years (2014 - 2020) over 80 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. He supervised 5 PhD- theses 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.

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