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Exothermic and Endothermic Characterization of Reversibility in Shape Memory Alloys

Osman Adiguzel
Department of Physics, Firat University, Elazig, Turkey

A series of ally systems called shape memory alloys exhibit a peculiar property called shape memory effect with special chemical compositions in the β-phase fields. These alloys are energetic materials and sensitive to the change of temperature and stressing. This phenomenon is initiated by cooling and deformation processes and performed on heating and cooling after these treatments, with which shape of the materials cycles between original and deformed shapes. Therefore, this behavior can be called thermoelasticity. This phenomenon is governed by successive crystallographic transformations, thermal and stress induced martensitic transformations. Thermal induced transformations are exothermic reactions and occur on cooling with the cooperative movement of atoms in <110 > -type directions on {110}-type planes of austenite matrix, along with lattice twinning, and ordered parent phase structures turn into twinned martensitic structure. Twinned structures turn into detwinned martensite by means of stress induced martensitic transformation with deformation in martensitic state. Also, detwinned structure turn into ordered parent phase structure on heating by means of reverse austenitic transformation, which is an endothermic reaction, and ordered parent phase structure turn into ordered parent o-phase structure. Forward martensitic and reverse austenitic transformations are solid state reactions; these reactions do not occur at the equilibrium temperature at Gibbs Free Energy Temperature Diagram and a driving force is necessary for the transformations. These alloys exhibit another character, called superelasticity, which is performed with mechanically stressing the material in elasticity limit at a constant temperature in parent phase region, and shape recovery occurs instantly upon releasing. Superelasticity is governed by stress induced transformation, and ordered parent phase structure turns into the fully detwinned martensite structure with stressing. The crystal structure cycles between the parent phase structure and detwinned martensite structures on stressing and releasing. Twinning and detwinning reactions play important role in crystallographic transformations, and they are driven by lattice invariant shears. Copper based alloys exhibit this property in metastable beta-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 complex layered structures.

In the present contribution; x-ray and electron diffraction studies were carried out on two solution treated copper based CuZnAl and CuAlMn alloys. Electron and x-ray diffraction exhibit super lattice reflections. Specimens of these alloys were aged at room temperature, and a series of x-ray diffractions were taken at different stages of aging in a long-term interval. X-Ray diffraction profiles taken from the aged specimens in martensitic conditions reveal that crystal structures of alloys chance in diffusive manner, and this result refers to the stabilization.

Key words: Shape memory effect, martensitic transformation, thermoelasticity, superelasticity, twinning and detwinning.

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 studies were focused on shape memory effect in shape memory alloys. His academic life started following graduation by attending an assistant to Dicle University in January 1975. He became professor in 1996 at Firat University in Turkey, and retired on November 28, 2019, due to the age limit of 67, following academic life of 45 years. He supervised 5 PhD- theses and 3 M. Sc- theses and published over 80 papers in international and national journals; He joined over 120 conferences and symposia in international level with contribution. He served the program chair or conference chair/co-chair in some of these activities. Also, he joined in last six years (2014 - 2019) over 60 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. Additionally, he joined over 180 online conferences in the same way in pandemic period of 2020-2023.

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)