

## Crystallographic Transformations and Reversible Characteristics of Shape Memory Alloys



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A series of alloy systems take place in a class of advanced smart materials by giving stimulus response to external effect. Shape memory alloys take place in this group by exhibiting a peculiar property called shape memory effect with the recoverability of two shapes at different conditions. This phenomenon is initiated with thermomechanical treatments on cooling and deformation and performed thermally on heating and cooling, with which shape of the material cycles between original and deformed shapes in reversible way. Therefore, this behavior can be called Thermoelasticity. Deformation in low temperature condition is plastic deformation, with which strain energy is stored in the materials and released on heating by recovering the original shape. This phenomenon is governed by two crystallographic transformations, thermal and stress induced martensitic transformations. Thermal induced martensitic transformations occur on cooling with cooperative movement of atoms in  $\langle 110 \rangle$ -type directions on a  $\{110\}$ -type plane of austenite matrix, along with lattice twinning reaction and ordered parent phase structures turn into the twinned martensite structures. The twinned structures turn into detwinned martensite structures with deformation by means of stress induced martensitic transformations. These alloys exhibit another property called superelasticity. This behavior is performed in only mechanical manner with stressing the material and releasing in elasticity limit in the parent austenite phase region, and shape recovery occurs instantly upon releasing, by exhibiting elastic material behavior. Superelasticity is also result of stress induced martensitic transformation and ordered parent phase structures turn into the detwinned martensite structures with stressing. Lattice twinning and detwinning reactions play important role at the transformations and driven by lattice invariant shears. These alloys have dual memory characteristics, Thermoelasticity and Superelasticity, with these properties.

Copper-based alloys exhibit this property in metastable  $\beta$ -phase region. Lattice twinning and lattice invariant shear is not uniform in these alloys and cause the formation of complex layered structures, The 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.

In the present contribution, x-ray and electron diffraction studies were carried out on copper based CuZnAl and CuAlMn alloys. X-ray diffraction profiles and electron diffraction patterns exhibit super lattice reflection. X-ray diffractograms taken in a long-time interval show that diffraction angles and intensities of diffraction peaks change with the aging duration at room temperature. This result refers to the rearrangement of atoms in diffusive manner.

**Keywords:** Shape memory effect, martensitic transformation, thermoelasticity, superelasticity, twinning, 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 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 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 230 online conferences in the same way in pandemic period of 2020-2024. 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.