

## 5<sup>th</sup> World Congress on NANOSCIENCE

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### Crystallographic Aspects of Reversibility in Shape Memory Alloys

The shape memory effect is a peculiar property exhibited by a series of alloy systems called shape memory alloys. These alloys are temperature-sensitive materials, and undergo structural changes, with crystallographic reactions called martensitic transformations with the variation of temperature and deformation. The shape memory effect is initiated by cooling and deformation processes and performed thermally on heating and cooling after these treatments. 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 in a reversible way. The shape memory effect is performed thermally in a temperature interval depending on the forward and reverse transformation, on cooling and heating, respectively, and this behavior is called thermoelasticity. The shape memory effect is governed by thermal and stress-induced martensitic transformations. Thermal induced martensitic transformation occurs on cooling with the cooperative movement of atoms in  $\langle 110 \rangle$ -type directions on  $\{110\}$ -type close-packed planes of austenite matrix, by means of shear-like mechanism, and ordered parent phase structures turn into the twinned martensite structure with lattice twinning. Twinned structures turn into detwinned structures by means of stress-induced martensitic transformation with the deformation.

These alloys exhibit another property called superelasticity, which is performed in only a mechanical manner. These alloys are stressed in the parent phase region just over austenite finish temperature and recover the original shape simultaneously and instantly on releasing the external forces. Superelasticity is also the result of stress-induced martensitic transformation, and parent austenite phase structures turn into the fully detwinned martensite with the stressing. Superelasticity exhibits ordinary elastic material behavior, but it is performed in a non-linear way; loading and unloading paths are different at the stress-strain diagram, and hysteresis loop refers to energy dissipation.

Copper-based alloys exhibit this property in the metastable  $\beta$ -phase region, which has bcc-based structures. Lattice invariant shears and twinning are not uniform in these alloys, and the ordered parent phase structures martensitic alloy 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 are completed through 18 layers in direction z, in the 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 superlattice reflections inherited from the parent phase due to the diffusion less character of martensitic transformation. X-ray diffractograms took 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 a diffusive manner.

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

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### **Biography**

Osman Adiguzel is graduated from the Department of Physics, Ankara University, Turkey in 1974 and received Ph D.- 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 shape memory alloys. He worked as a research assistant, 1975-80, at Dicle University and shifted to Firat University, Elazig, Turkey in 1980. He became a 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 at the international and national level as a participant, invited speaker, or keynote speaker with contributions of oral or poster. He served as 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 the pandemic period of 2020-2021. He supervised 5 Ph.D.- theses and 3 M. Sc- theses.

Osman Adiguzel served as 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 the significant contribution of 2 patterns to the Powder Diffraction File – Release 2000. The ICDD (International Centre for Diffraction Data) also appreciates the cooperation of his group and interest in the Powder Diffraction File.

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