5th International conference on CHEMICAL AND PROCESS ENGINEERING

July 25th, 2022 | Webinar

## Shape Reversibility and Multivariant Nature of Martensite in Shape Memory Alloys

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### Abstract

Shape memory alloys are stimulus responsive materials and take place in the class of smart or intelligent materials, by exhibiting a peculiar property called shape memory effect. This phenomenon is initiated on cooling and deformation and performed thermally on heating and cooling. Therefore, this behavior can be called thermal memory and thermo elasticity. This deformation is plastic deformation with which strain energy is stored in the material and released on heating by recovering the original shape, and shape of materials cycles between the deformed and original shapes on cooling and heating in reversible way.

This behavior is governed by crystallographic transformations; thermal induced and stress induced martensitic transformation.

Thermal induced transformation occurs on cooling with cooperative movement of atoms in <110 > -type directions on the {110}-type planes of austenite matrix, which is basal plane of martensite, along with lattice twinning reactions and ordered parent phase structures turn into twinned martensite structures. The twinned martensite structures turn into detwinned structures with deformation, by means of stress induced transformation. The detwinned structures turn into ordered parent phase structure by means of revere austenite transformation on heating. The twinning and detwinning reactions have great importance in the shape memory behavior of the materials. The {110}-plane family has 6 certain lattice planes; {110}, {1 -1 0}, {101}, {1 0 -1}, {011}, {0 1 -1}; and totally 24 martensite variants are obtained by means of the lattice invariant shears on <110 > -type direction on these planes.

These alloys exhibit another property called super elasticity, which is performed in only mechanical manner. The alloys are stressed in parent phase region just over austenite finish temperature and recover the original shape simultaneous and instantly on releasing the external forces. Super elasticity is also the result of stress-induced martensitic transformation, and parent austenite phase structures turn into the fully detwinned martensite with the stressing. Super elasticity exhibits ordinary elastic material behavior, but it is performed in 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 metastable β-phase region, which has bcc-based structures. Lattice invariant shears and 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 diffract grams 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, martensite variants, martensitic transformation, thermo elasticity, super elasticity, lattice 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 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.

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