



Bulk and nano scale aspects of thermoelasticity and superelasticity in shape memory alloys

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Abstract

Some materials take place in class of smart materials with adaptive properties and stimulus response to the external changes. Shape memory alloys take place in this group by exhibiting dual thermoelastic and superelastic characteristics. These alloys have shape reversibility character, and shape of material cycled between original and deformed shapes at different condition in the bulk level. Shape memory effect is initiated by cooling and deformation the material and performed thermally on heating and cooling after first cooling and stressing treatments. Therefore, this behavior is called thermoelasticity. Superelasticity is another property and performed in only mechanical manner. These alloys are stressed in the elasticity limit in parent phase region just over austenite finish temperature and recover the original shape on releasing the external forces.

These phenomena are result of crystallographic transformations in the materials, called martensitic transformations. Shape memory effect is governed by thermal and stress induced martensitic transformations. Thermal induced martensitic transformation occurs on cooling along with lattice twinning and ordered parent phase structures turn into twinned martensite structures; these twinned structures turn into detwinned martensite structures by means of strain induced martensitic transformation with deformation in martensitic state. 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 normal elastic material behavior, but it is performed in non-linear way; loading and unloading paths are different, and hysteresis loop reveals energy dissipation. Thermal induced martensitic transformations occur with cooperative movement of atoms by means of lattice invariant shears in $\langle 110 \rangle$ - type planes on $\{110\}$ - type planes of austenite.

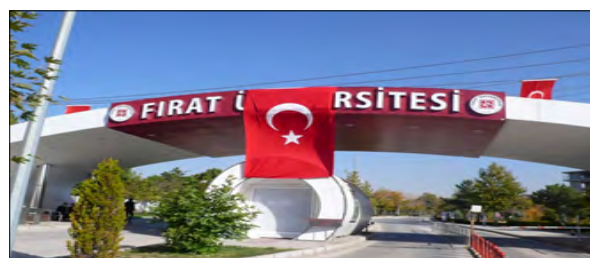
Copper based alloys exhibit this property in metastable β' - phase region, which has bcc-based structures at high temperature parent phase field. Lattice invariant shear and twinning is not uniform in copper alloys and they give rise to the formation of unusual layered complex structures, like 3R, 9R or 18R structures depending on the stacking sequences, with lattice twinning. 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 displacive character of martensitic transformation.

Keywords: Thermoelasticity, superelasticity, shape memory effect, martensitic transformation, twinning, detwinning.

Biography

Adiguzel O 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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