Osman Adiguzel, J Nanomater Mol Nanotechnol 2022, Volume 11

Thermomechanical and thermoresponsive reactions in reversibility of shape memory alloys

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Shape memory alloys are adaptive structural materials and take place in class of called of advanced smart materials by giving stimulus response to changes in the external conditions. These alloys exhibit dual characteristics, shape memory effect and superelasticity with the recoverability of two shapes at different conditions. These alloys are functional materials with these properties and used as shape memory elements in many interdisciplinary fields. Shape memory effect is initiated thermomechanical treatments by cooling and deformation and performed thermally on heating and cooling. Deformation in low temperature condition is plastic deformation, and strain energy is stored in the materials and released on heating by recovering the original shape. Following these treatments, shape of the materials cycles between the deformed and original shapes on cooling and heating in reversible way. This phenomenon is governed by the thermomechanical and thermoresponsive reactions, thermal and stress induced martensitic transformations. Thermal induced martensitic transformations occur on cooling with cooperative movement of atoms in <110 > -type directions on {110} - type planes of austenite matrix which is basal plane of martensite, and ordered parent phase structures turn into the twinned martensite structures along with lattice twinning. The twinned structures turn into detwinned martensite structures by means of stress induced martensitic transformations with deformation. On heating after these treatments, detwinned martensite structures turn into the ordered parent phase structures, by means reverse austenitic structures.

Superelasticity is performed in only mechanical manner by stressing and releasing the material in the parent austenite phase region, and shape recovery occurs instantly and simultaneously by recovering the original shape, after releasing. Superelasticity exhibits the elastic material behavior, but it is performed in non-linear way, loading and releasing paths are different at the stress-strain profile, and cycling loop refers to the energy dissipation. Superelasticity is also result of stress induced martensitic transformation, and the ordered parent phase structures turn into the detwinned martensite structures by stressing.

Copper based alloys exhibit this property in metastable beta-phase region. Lattice twinning is not uniform in these alloys and cause the formation of unusual complex layered structures.

In the present contribution, x-ray diffraction and transmission electron microscopy (TEM) studies were carried out on 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: Shape memory effect, Martensitic transformation, Thermoelasticity, Superelasticity, Twinning, Detwinning.

Recent Publications

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Biography

Osman 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 70 online conferences in the same way in pandemic period of 2020-2021. 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.

Received: December 10, 2021; **Accepted**: December 13, 2021; **Published**: March 21, 2022