Short Article

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Smart Material 2021: Shape Reversibility and Thermoresponsive Reactions in Shape Memory Alloys - Osman Adiguzel, Turkey

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Abstract

Some materials take place in class of advanced smart materials with adaptive properties and stimulus response to the external changes. Shape memory alloys take place in this group by exhibiting a peculiar property called shape memory effect which is is a temperature dependent phenomenon with shape reversibility and thermoresponsive reactions. This phenomenon is initiated by cooling and deformation processes and performed thermally by heating and cooling. These alloys are deformed plastically in low temperature condition, with which strain energy is stored and released on heating with thermoresponsive reaction by recovering the permanent original shape. These alloys have dual characteristics called thermoelasticity and superelasticity. These phenomena are involved in thermoresponsive reactions, martensitic transformation on cooling and reverse austenitic transformation on heating. Thermoelasticity is governed by thermal and stress induced martensitic transformations on cooling and stressing the material, and performed thermally on heating and cooling after these processes. Therefore, this behavior is called thermoelasticity. Thermal induced martensite occurs along with lattice twinning and ordered parent phase structures turn into twinned martensite structures by means of lattice invariant shears, and these structures turn into detwinned martensitic structures with deformation by means of stres induced transformation. Lattice Twinning occurs in two opposite directions, <110 > -type directions on the {110}-type plane of austenite matrix in self-accommodating manner. The twinning occurs with internal stresses, while detwinning occurs with the external stresses. Twinning and detwinning processes can be considered as elementary processes activated during the transformations.

Superelasticity is governed by stress induced transformation by stressing and releasing materials at a constant temperature in parent phase region. Shape memory effect is performed in a temperature interval after first cooling and stressing processe, whereas superelasticity is performed mechanically in a constant temperature in parent phase region. Deformation at different temperature exhibits different behavior beyond shape memory effect and superelasticity. Copper based alloys exhibit this property in metastable beta-phase region, which has bcc based structures at high temperature parent phase field. Lattice invariant shear is not uniform in copper based alloys and cause the formation of complex layered structures, like 3R, 9R or 18R structures depending on the stacking sequences on the close-packed planes of the ordered lattice with lattice twinning. The periodicity and unit cell is completed through 18 layers in z-direction in case of 18R martensite structure. In the present contribution; x-ray and electron diffraction studies were carried out on copper based CuZnAl and CuAlMn alloys. Electron and x-ray diffraction exhibit super lattice reflections. Specimens of these alloys were aged at room temperature, at which both alloys are in martensitic state, and a series of x-ray diffractions were taken at different stages of aging in a long-term interval. X-Ray diffraction profiles taken from the aged specimens in martensitic conditions reveal that crystal structures of alloys chance in diffusive manner, and this result refers to the stabilization.

Key words: Shape memory effect, martensitic transformation, thermoelasticity, superelasticity, 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. 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 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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