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Thermo-Mechanical Reactions Governing Reversibility in Shape Memory Alloys

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Introduction

Many alloy systems have different phases at different conditions and these phases are described in phase diagrams as alloy composition-temperature, or composition-pressure dependent. A series of alloy systems exhibit a peculiar property called the shape memory effect at the β-phase region. These alloys are very sensitive to external conditions, and crystal structures turn into other crystal structures by thermal and mechanical reactions on cooling and stress, through crystallographic transformation, thermal and stress-induced martensitic transformations**.** Thermal induced martensitic transformation occurs in atomic-scale on cooling the material from the parent phase region, and interatomic interactions govern this transition. Shape memory is characterized by the recoverability of two certain shapes of material at different temperatures.

These alloys possess two unique abilities: the capacity to recover large strains and to generate internal forces during their activation. The basis of this phenomenon is the stimulus-induced phase transformations, martensitic transitions, which govern the remarkable changes in internal crystalline structure and properties of the materials. Thermal induced martensitic transformations occur along with lattice twinning on cooling from the parent β-phase region and ordered parent phase structures turn into twinned martensite structures. The twinned structures turn into detained martensite structures through stress-induced transformation by stressing the material in the martensitic condition. Thermal induced transformation occurs as martensite variants with cooperative movements of atoms in <110> type directions on the [110] type planes of austenite matrix, using lattice invariant shear. These alloys exhibit another property called superelasticity, which is performed in the only mechanical manner by stressing and releasing the material in the parent phase region just over austenite finish temperature. Super elasticity exhibits ordinary elastic material behaviour and recovers the original shape after release. Super elasticity exhibits nonlinearity, stressing and releasing paths are different at the stress-strain diagram and hysteresis loops refer to the energy dissipation.

Copper-based alloys exhibit this property in the metastable β-phase region, which has bcc-based structures at high-temperature parent phase field. Lattice invariant shear is not uniform in these alloys and gives rise to the formation of layered structures, like 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 through the z-axis in 18R martensite.

In the present contribution, x-ray diffraction and Transmission Electron Microscopy (TEM) studies were carried out on two copper-based CuZnAl and CuAlMn alloys. X-ray diffract grams were taken in a long-time-interval to show that locations and intensities of diffraction peaks change with the aging time at room temperature. Especially, some of the successive peak pairs providing a special relation between Miller indices come close to each other, and this result refers to the redistribution of atoms in a diffusive manner.

Keywords: Shape memory effect; Martensitic transformation; Super elasticity; Twinning; Detwinning, Lattice invariant shear.

Biography

Dr. Adiguzel 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 already been working as a professor. He published

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over 80 papers in international and national journals; He joined over 100 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 seven years (2014-2020) over 70 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. He supervised 5 Ph.D. theses and 3 M.Sc. theses. Dr. 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