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Nanoscale characterization of crystallographic phase transformations in shape memory alloys

Shape memory effect is a peculiar property exhibited a series alloy system in the β-phase fields. Shape memory alloys are sensitive to external condition and temperature, and crystal structure of these alloys change with changing temperature and stressing, by means of crystallographic phase transformations, called martensitic transformations. Shape memory effect is initiated by cooling and stressing, and by means of thermal and stress induced martensitic transformation. Thermal induced transformation occurs as martensite variants with lattice twinning in crystallographic scale on cooling below martensite finish temperature. Twinned martensite structures turn into detwinned martensite structure by means of stress induced martensitic transformation by stressing material in a strain limit in martensitic condition. Shape memory alloys are in the fully martensitic state below martensite finish temperature with fully twinned structure can be easily deformed through variant reorientation/detwinning process. Thermal induced martensitic transformation is lattice-distorting phase transformation and occurs with the cooperative movement of atoms by means of shear-like mechanism. Martensitic transformations occur by two or more lattice invariant shears on a {110}-type plane of austenite matrix which is basal plane or stacking plane for martensite, as a first step, and the transformed region consists of parallel bands containing alternately two different variants. In the martensitic transformation, the lattice of high temperature austenite phase has greater crystallographic symmetry than that of the low-temperature product phase. Copper based alloys exhibit this property in metastable β-phase region, which has bcc-based structures at high temperature parent phase field and these structures martensitically turn into the complex stacking ordered structures with lattice twinning reaction on cooling. Lattice invariant shears are not uniform in copper-based shape memory alloys, and the ordered parent phase structures martensitically undergo the non-conventional complex layered structures on cooling. 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 close packed planes exhibit high symmetry and short-range order as parent phase, but other planes do not exhibit symmetry. The unit cell and periodicity are 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 microscope studies were carried out on two copper based CuZnAl and CuAlMn alloys. These alloy samples have been heat treated for homogenization in the β-phase fields. X-ray diffraction profiles and electron diffraction patterns reveal that both alloys exhibit super lattice reflections inherited from parent phase due to the displacive character of martensitic transformation. X-ray diffractograms taken in a long time, interval show that diffraction angles and intensities of diffraction peaks change with the aging time at room temperature. In particular, some of the successive peak pairs providing a special relation between Miller indices come close each other, and this result leads to the rearrangement of atoms in diffusive manner.

Speaker Biography

Osman Adiguzel graduated from department of physics, Ankara University, Turkey in 1974 and received PhD from Dicle University, Diyarbakir-Turkey in Solid State Physics with experimental studies on diffusion less phase transformations in Ti-Ta alloys in 1980. He has studied at Surrey University, UK, as a post-doctoral research scientist in 1986-1987, and He studied on shape memory alloys. He worked as research assistant, 1975-80, at Dicle University, Turkey. He moved to Firat University in 1980, and became professor in 1996, He published over 50 papers in international and national journals. He joined over 80 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 last three years he joined (2014 - 2016) over 20 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. He supervised 5 PhD-theses and 3 M.Sc.- theses. He served his directorate of Graduate School of Natural and Applied Sciences, Firat University, in 1999-2004. He received a certificate which is being 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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