Nanocrystalline magnetic shape memory alloys: Ni-Mn-(In,Sn)

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Abstract

Since martensitic transformation from cubic $L2_1$-type crystal structure to orthorhombic four-layered martensite (4O) was observed in Heusler alloys of the ternary system $Ni_{50}Mn_{50-x}Sn_x$ [1], important attention has been devoted to investigate structural transformations, magneto-elastic and magnetocaloric properties in these Ga-free ferromagnetic shape memory alloys (FSMA) [2-3]. The studies concluded that these materials are prospective for the development of magnetically driven actuators and working substances for magnetic refrigeration. One option is to produce nanostructured composites with polymer matrices containing FSMA particles. FSMA powders have been developed by crushing of bulk, by spark erosion of bulk or by mechanical alloying from elemental powders, flakes or fibres. In this work, we produce nanocrystalline alloys of the Ni-Mn-(In,Sn) quaternary system by crushing the arc-melted bulk material and by mechanical alloying of ribbon flakes previously obtained by melt-spinning. These procedures offer the possibility to obtain nanocrystalline powdered shape memory alloys that can be the metallic reinforcement of a nanostructured composite with polymer matrix. Structural characterization was performed by X-ray diffraction. Morphology was followed by scanning electron microscopy coupled with EDX microanalysis. As an example, the figure shows the SEM micrograph of one powdered-like sample. Thermal analysis was performed by means of differential scanning calorimetry.

At room temperature, all X-Ray diffraction patterns showsthe austenite structure. Shape memory alloys exhibit a reversible austenite-martensite phase transition. This transformation is a first order phase transition which takes place by the difussionless shearing of the parent austenitic phase. By lowering the temperature the austenite phase transforms into a tetragonal orthorhombic or monoclinic martensite ordered by domains [2,3]. Crushed and milled materials shows lower enthalpy and entropy changes during the structural austenite-martensite transformation. Furthermore, it is known that annealing can increase both thermodynamic parameters in magnetic shape memory alloys [4]. Nevertheless, thermal treatment favors the crystalline growth and the loss of the nanocrystalline behavior.

References

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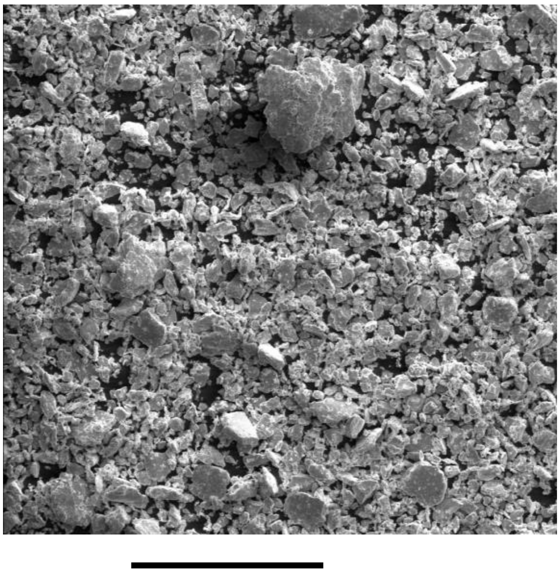
Figure



20 µm