Microstructural characterization of mechanically alloyed and sintered Ni-48Ti-2Fe and Ni-45Ti-5Fe alloys

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Ni-Ti alloys, also known as nitinol, are based on the martensitic NiTi phase (monoclinic B'19 structure) exhibit unique properties such as shape memory effect and super elasticity, and its martensitic transformation temperature depends on the nitinol composition and processing. Its typical value is a temperature range between 20-50 °C. The use of alloying can contribute to avoid the undesirable Ni_3Ti and $NiTi_2$ formation. According to the isothermal section at 900^{o}C of the Ti-Ni-Fe system, it exists a wide single-phase region extended from the NiTi to FeNi. High-energy ball milling can produce nanomaterials and metastable structures. The present work reports on the microstructural characterization of the Ni-48Ti-2Fe and Ni-45Ti-5Fe alloys prepared by high-energy ball milling and subsequent sintering. The elemental powder mixtures were processed for different times (1, 3 and 5 hours) in a planetary Fritsch P-5 ball mill under argon atmosphere using hardened steel vials (225 mL) and balls (12mm diameter), rotary speed of 200 rpm, and a ball-to-powder weight ratio of 10:1. Green bodies with 10 mm diameter were compacted by axial pressing and sintered at 900^{o}C and 1100^{o}C for 4 h under argon atmosphere. Information on the phase transformations in the milled powders and sintered alloys were obtained by X-ray diffraction, scanning electron microscopy, energy dispersive spectrometry, and thermal analyses (DSC/TG). Only the Ni and Ti peaks were noted in XRD patterns of the Ni-48Ti-2Fe and Ni-45Ti-5Fe powders milled for 5 h. In addition, the major Ni and Ti peaks were broadened and moved toward the indicating that the iron atoms were preferentially dissolved into the Ni lattice to form extended solid solutions. The microstructures of the sintered Ni-48Ti-2Fe and Ni-45Ti-5Fe alloys were mainly formed by the NiTi phase (monoclinic B'19 structure), and their martensitic transformations were close to 50^{o}C.