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Production of nanostructured Ni-Ti-Ag alloy by mechanical alloying

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Abstract. Because of corrosion resistance and antibacterial effects, shape memory Ni-Ti-Ag alloy can be considered for different biomedical applications. Mechanical alloying is used to produce nanostructured Ni-Ti-Ag alloy from elemental powders. X-ray diffraction (XRD) and field emission scanning electron microscopy (FESEM) are used to characterize the product. Results show that after 1h milling, homogenous distribution of the elements occurs; while no intermetallic compounds is observed. After 3h milling, titanium dissolves in nickel to form amorphous and nanostructured solid phases. Peaks of B2 phase appear in the XRD pattern after the 3h milling of the powder mixture. Sintering of the 3h-milled mixture at 1223 K leads to the formation of NiTi intermetallic compound; while titanium disappears, the content of the element nickel reduces and grain growth takes place.

Introduction

Nickel–titanium alloy near the equiatomic concentration is well known for its shape memory effect [1]. This alloy has attractive properties such as corrosion resistance [2], good ductility [3] and excellent biocompatibility [4]. Because of corrosion resistance and antibacterial effects of Ni-Ti-Ag shape memory alloy, it has been the subject of a few previous investigations [5–7].

Nanocrystalline intermetallic compounds show considerable strength, high hardness, enhanced ductility as compared to conventional grain-sized materials [5,6]. Diffusion rate in the nanocrystalline materials is generally high. Thus, lower sintering times can be used to make bulk samples out of them [6,7]. These materials have been synthesized by different techniques such as vapor phase condensation, electrodeposition, rapid solidification and mechanical alloying [6]. The advantage of using mechanical alloying lies in its capability to produce bulk quantities of nanocrystalline powder at room temperature utilizing simple equipments [8].

In this paper, production of nanostructured Ni-Ti-Ag alloy from the elemental powders by high energy milling is reported. Effect of mechanical alloying on formation of different phases, solubility and microstructure of the milled and sintered sample are discussed.

Experimental method

Ni, Ti and Ag (48, 48, 4at% respectively) elemental powders are mechanically alloyed in a vibratory disc mill for 3h under argon atmosphere. The amount of energy transferred to the powder in this mill is greater than a planetary or SPEX mill. Ethanol is used as a process control agent (PCA). One milliliter of Ethanol is added to 43g of the initial powder mixture to prevent cold welding and sticking to the walls of the cup and the milling balls. To avoid excessive warming of the powder, after every 30min, milling machine stops and small quantity of powder is taken out for investigation.

After mechanical alloying, milled powders are sintered at 1223K for 3h under argon atmosphere. Characterization of milled powder, is performed by field emission scanning electron microscopy (FESEM) and Formation of NiTi phase is investigated by X-Ray diffraction (with CuKα radiation) analysis. The chemical compositions of raw materials are presented in table 1.