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Microstructural properties of electrochemically prepared Ni–Fe–W powders

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HIGHLIGHTS

- ► Electrodeposition Ni–Fe–W powder from ammonium citrate electrolyte (500–1000 mA cm^{-2}).
- ► Powder contains amorphous matrix and embedded nanocrystals 3.4 nm.
- ► Chemical composition Ni–24%Fe–11%W do not depend upon current density and electrolyte temperature.
- ► Two particle shapes: large cauliflower-like particles and small dendrite particles.
- ► Smaller powder particles are formed at higher temperatures and at higher current densities.

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ABSTRACT

A nanostructured Ni–Fe–W powder was obtained by electrodeposition from ammonium citrate electrolyte within the current density range of 500–1000 mA cm^{-2} at the electrolyte temperature of 50 °C –70 °C. XRD analysis shows that the powder contains an amorphous matrix having embedded nanocrystals of the FCC solid solution of iron and tungsten in nickel, with an average crystal grain size of 3.4 nm, a high internal microstrain value and a high density of chaotically distributed dislocations. EDS analysis exhibits that the chemical composition of the Ni–24%Fe–11%W powder does not depend upon current density and electrolyte temperature due to the diffusion control of the process of codeposition of nickel, iron and tungsten.

SEM micrographs show that the electrodeposition results in the formation of two particle shapes: large cauliflower-like particles and small dendrite particles. The cauliflower-like particles contain deep cavities at hydrogen evolution sites. Cavity density increases with increasing deposition current density. Smaller powder particles are formed at higher temperatures and at higher current densities.

During the first heating, relative magnetic permeability decreases reaching the Curie temperature at about 350 °C and after cooling exhibits a 12% increase due to the performed relaxation process. Following the second heating to 500 °C, the magnetic permeability of the powder is about 5% lower than that of the as-prepared powder due to crystallization of the amorphous phase of the powder and the crystal grain growth in FCC phase.

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1. Introduction

Nanostructured powders of different alloys are widely used in novel technologies due to a unique combination of electrical, magnetic, catalytic, corrosion and other properties [1–5]. Powders having specific properties can be successfully obtained by electrochemical deposition [6–10].

The electrodeposition technique has significant advantages over other methods for the synthesis of nanocrystalline materials [11,12]. This technique offers the excellent possibility to obtain such materials which have high purity, different structure and morphology. The chemical composition, phase structure, size and shape of electrochemically obtained powders depend on current density, bath composition, temperature and circulation rate of the solution, nature of the cathode and the ratio of the nucleation rate to the deposit growth rate [6–12]. The electrolytic powder production method usually yields well pressable and high purity products that have desired chemical composition. Therefore, different electrolysis regimes can be used now to obtain powders with engineered

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