Magnetic Property of Electrodeposited Ni-W, Ni-Mo and Ni-Cr Alloys

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Abstract

Ni-W, Ni-Mo and Ni-Cr nano-crystalline alloys have been electrochemically fabricated from aqueous solution. With increasing in W, Mo and Cr content in deposit, the crystal grain size decreased and the lattice constant increased. The deposited alloys composed of nano-crystalline γ solid solution, which was thermodynamically non-equilibrium phase. With increase in W, Mo and Cr content in deposit, magnetic coercive force of the alloy decreased down to around 10 Oe.

Keywords: *electrodeposition, Ni, W, Mo, Cr, magnetic property, nano-crystal*

Introduction

W, Mo and Cr alloys show excellent physical and chemical properties, which can be applied to excellent wear-resistance, heat-resistance and corrosion-resistance materials. Conventionally, the production process of W, Mo and Cr bulk alloys requires high temperature and high vacuum conditions. On the other hand, W, Mo and Cr can co-electrodeposit from an aqueous solution with the iron-group metals, such as Ni, Co, and Fe as fine crystalline alloys even in room temperature. Super fine crystalline or amorphous state alloys based on iron-group metals show an excellent magnetic property with high permeability, which can be applied to high sensitive magnetic field sensors [1, 2]. In this paper, the crystal structure and soft magnetic property of electrodeposited Ni-W, Ni-Mo and Ni-Cr alloys were studied.

Experimental

Ni-W (Ni-Mo) alloy was electrodeposited from an aqueous solution containing $NiSO_4$, Na_2WO_4 (Na_2MoO_4) and citric acid, while Ni-Cr alloy was electrodeposited from an aqueous solution containing $NiCl_2$, $CrCl_3$, H_3BO_3, $HCOONH_4$ and H_2NCH_2COOH. was used as, while Cu sheet, Au wire and Ag/AgCl electrode were used as a cathode, an anode and a reference electrode. The alloy composition was determined by EDX and crystal structure of the alloy was analyzed by XRD. Magnetic hysteresis loops of the alloys were measured by VSM.

Results and Discussions

XRD patterns obtained from electrodeposited pure Ni, Ni-Mo (a), Ni-W (b) and Ni-Cr (c) alloy films were shown in Fig.1. The main peaks in XRD patterns obtained from pure Ni corresponds to (111) reflection planes of fcc Ni phase composed of large crystals. The γ (111) peaks obtained from Ni-Mo, Ni-W and Ni-Cr alloys became broader and shifted to lower diffraction angle with an increase in Mo, W and Cr content in the alloy. These results suggest that the crystal grains are refined and the lattice constant is increased with increase in Mo, W and Cr content. Ni-23at%Mo, Ni-15at%W and Ni-3at%Cr alloys consisted of very small crystals with the diameter of several nano-meters.

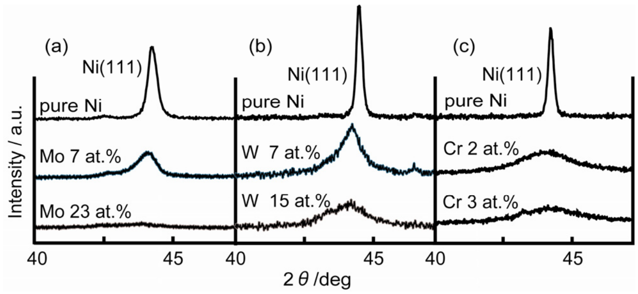

Fig.1. XRD patterns obtained from electrodeposited pure Ni, Ni-Mo, Ni-W and Ni-Cr alloys.

Dependence of Mo, W and Cr content in the electrodeposited alloys on the magnetic coercive force is shown in Fig.2. With increasing in Mo, W and Cr content, the coersivity decreased down to around 10 Oe, while that of pure Ni was ca. 100 Oe.

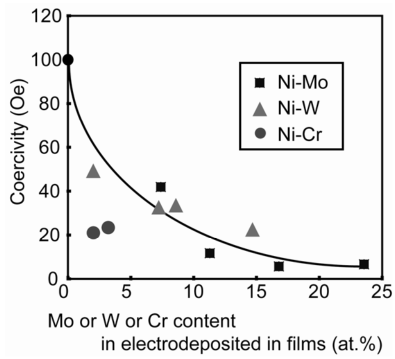

Fig.2. Relationship between Mo or W or Cr content in alloys and coercivity.

Conclusions

With increasing W, Mo and Cr content in deposits, crystal grain size of Ni-W, Ni-Mo and Ni-Cr alloys decreased and the lattice constant increased. These alloys formed a γ solid solution with nano-crystals. Since the magneto-crystalline anisotropy energy decreased due to the decreasing crystal grain size, magnetic coercive force of these alloys decreased down to ca. 10 Oe with increase in W, Mo and Cr content.

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