Soft Magnetic Property of Electrodeposited Nickel-Tungsten Alloys

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Abstract

Nickel-tungsten alloy ($Ni_{85}W_{15}$) containing up to 15% tungsten has been electrochemically synthesized. Crystal grain size decreased and the lattice constant increased with increasing in tungsten content in deposit. The Nickel-tungsten alloy contains nano-size crystals. Magnetic coercive force of the alloy decreased down to around 20 Oe with increase in tungsten content and the soft magnetic property was improved.

Keywords: *electrodeposition, nickel, tungsten, magnetic property, nano-crystal*

Introduction

Melting temperature of metallic tungsten is more than 3600 K and is the highest in all of the metals. Tungsten alloys show excellent physical and chemical properties, however, the production process usually requires high temperature and high vacuum conditions. Although tungsten can not electrodeposit independently from an aqueous solution, it can co-electrodeposit with the iron-group metals, such as nickel, cobalt, and iron as fine crystalline alloy even in room temperature. The Ferro-magnetic materials with super fine crystals or amorphous state show excellent soft magnetic properties, that can be applied to high sensitive magnetic field sensors [1, 2]. In this study, the structure and soft magnetic property of electrodeposited nickel-tungsten alloy was investigated.

Experimental

Nickel-tungsten alloy was electrodeposited from an aqueous solution containing nickel sulfate, sodium tungstate, and sodium citrate. Copper sheet and gold wire were used as a cathode and an anode, while Ag/AgCl electrode was used as the reference electrode. The alloy composition was determined by energy dispersive X-ray spectrometry (EDX). Crystal Structure of the alloy was analyzed by X-ray diffraction (XRD) using a Cu-Kα radiation (λ=1.54 nm). Magnetization curves of the alloys were measured by vibrating sample magnetometer (VSM).

Results and Discussion

Figure 1 shows XRD patterns obtained from electrodeposited pure nickel film (Ni) and nickel-tungsten alloy films (Ni-W). The XRD pattern for pure Ni corresponds to (111) reflection planes of fcc Ni phase consisted from large crystals. The (111) peaks for Ni-W alloys became broader and shifted to lower diffraction angle with an increase in the tungsten content in the alloy. These results correspond that the crystal grain was refined and the lattice constant was increased with increase in tungsten content. This also confirms that nickel and tungsten forms the alloy solid solution. $Ni_{85}W_{15}$ alloy consists of very small crystals with the diameter of several nano-meters or amorphous state.

Figure 2 shows the dependence of tungsten content in the electrodeposited alloy on the magnetic coercive force. The coercivity of Ni was around 100 Oe. With increasing in tungsten content, the coersivity decreased down to around 20 Oe.

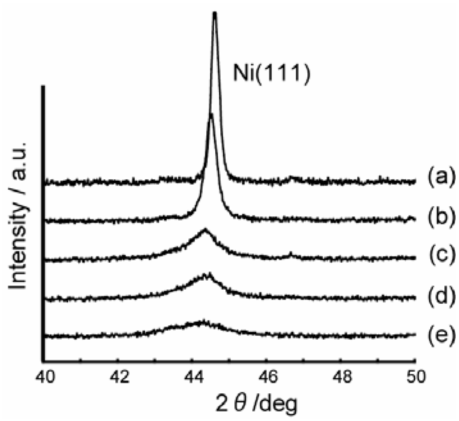

Fig.1 XRD patterns of pure Ni and Ni-W alloys. W content: 0 at.%(a), 2 at.%(b), 7 at.%(c), 11 at.%(d), 15 at.%(e).

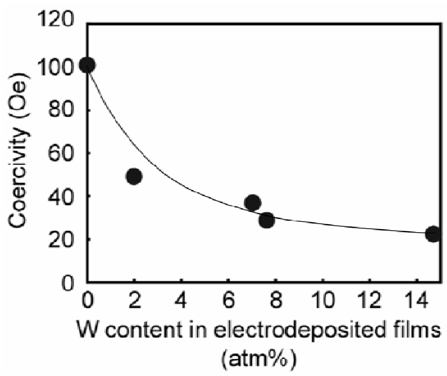

Fig.2 Relationship between tungsten content in electrodeposited alloy and magnetic coercive force of Ni-W alloys.

Conclusion

Crystal grain size of Ni-W alloys decreased and the lattice constant increased with increasing tungsten content in deposition. Nickel and tungsten formed a solid solution. Magnetic coercive force of the alloy decreased down to around 20 oersteds with increase in tungsten content since the magnetocrystalline anisotropy decreased due to the decreasing crystal grain size.

Acknowledgements

This work was supported in part by TDK Corporation, Mitutoyo Association for Science & Technology, Yazaki Memorial Foundation for Science & Technology, Research Foundation for Materials Science, Japan Society for the Promotion of Science (Grant-in-aid for Scientific Research C : No.19560734).

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