구리농도에 따른 Fe-Ni박막의 전자기적 특성에 대한 효과

Effect of Cu Dopping in Fe-35%Ni Sheet on Electromagnetic Properties

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초 록: Various concentration of copper was dopped in Fe-35%Ni thin sheet by electroforming and their electromagnetic, surface properties were determined. Microstructure observation by scanning electron microscopy revealed that the thin sheet had columnar grains with about 150 nm long. Phase analysis by X-ray diffractometry revealed that the alloy thin sheets were fine crystalline. The average surface roughnesses measured by atomic force microscopy (AFM) were about 14.38 nm. Nano hardnesses determined by tribo-nano indenter were 4.13 GPa. The surface resistances were 2.28 ohm/sq. The maximum magnetization, residual magnetization and coercive force depended on the copper concentration.

1. 서론

Although Fe-35%Ni thin sheet been attractive attentions for a negligible coefficient of thermal expansion, its low pitting corrosion resistance in high chloride ion environment has been a problem to apply to electronic device [1]. The low corrosion resistance of the Fe-35% Ni alloys can be improved by alloys. Among the many possible alloy elements, copper is one of changeable alloy elements to improve the corrosion resistance and simultaneously to keep invar property. The Fe-35%Ni alloys can be produced by melting and electroforming. Since copper-nickel spinodal decomposition and copper-iron immiscibility exist in Fe-Cu and Ni-Cu binary phase diagrams, the copper content of Fe-Ni alloys should be less 4 wt.%. Electroforming process is preferred to prepare the copper added Fe-35% Ni thin sheet because of un-necessary for additional plastic deformation processes to make thin sheet. However, the electroforming process requires an adequate electrolytic solution for the ion-nickel-copper alloys. Furthermore, optimum fabrication conditions to control ion migration and hydrogen evolution during electro-forming should be determined because the metallurgical parameters like microstructure, composition and surface roughness significantly influence the performance of the Fe-35 %Ni alloys like thermal expansion, electronic conductivity and electromagnetic properties, Although lots of study to improve Fe-35% Ni alloys, little information is available to produce a copper added-invar sheet by electroforming. Hence, the objectives of this study are to fabricate Fe-Ni-Cu thin sheet by electroforming and to study the effect of copper on the characteristics of the Fe-35% Ni thin sheet like electromagnetic properties.

2. 본론

Fe-Ni-Cu thin sheet was prepared by electroforming in iron-nickel-copper sulfate bath at 40℃, pH=2.4 with a rectifier (Jisang-Elec. JS-P100, Korea) at 30-150 mA/cm2,3-15Vfor0.5hr.The iron-nickel-copper sulfate solution was made by agents like FeSO4(DuksanPureChem.,Korea,>99.0%),NiSO4(DuksanPureChem.,Korea,>99.0%),CuSO4 (Duksan Pure Chem., Korea, >99.0%), H3BO3 (Duksan Pure Chem., Korea, >95%), NaCl (Samchun Chemicals, Korea, 35 wt%) with organic additive. Table 1 is the solution chemistry of the iron-nickel-copper sulfate bath. Anode and cathode were 304-stanless steel and palladium coated titanium (Pd-Ti) electrode, respectively.
Microstructure observation and chemical analysis were carried out by scanning electron microscopy (Hitachi S-4300, Japan) and X-ray florescence spectroscopy (i-EDX-150T, ISP, Korea), respectively. Surface roughness of electro-formed sheet was determined by atomic force microscopy (Em4Sys, Nano Xpert-2, Korea). Surface electrical resistance was determined with a 4-points probe (Signatone, SYS-301, USA). The variation of the electromagnetic properties of the Fe-Ni-Cu thin sheet was determined with a vibrating sample magnetometer (LakeShore, VSM-7404, USA). Mechanical properties was measured with a universal test machine (R&B, Micro-load system, Korea).

Table 1. Chemical composition of solution electroformed Cu dopping in Fe-35%Ni sheet [g/L]

FeSO4 · 7H2O	NiSO4 · 6H2O	CuSO4 · 5H2O	H3BO3	NaCl
23	97	1	30	7

3. 결론

The cu added in Fe-Ni-Cu sheet was the higher current density is, the lower Cu concentration is. Surface roughness of Cu added in Fe-Ni-Cu sheet 0, 3, 5 [wt.%] measured 34.02, 94.85 and 166.91 [nm], respectively. The corrosion resistance of Cu added in Fe-Ni-Cu sheets was higher than Fe-Ni sheet. The ultimate tensile strength of Cu added in Fe-Ni-Cu sheets was measured 550 MPa and Fe-Ni sheet was measured 500 MPa. However, nano hardness of all sheets were measured about 3.8 GPa. The cu added in Fe-Ni-Cu sheet was the higher Cu concentration is, the higher maximum magnetization is.

참고문헌

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