

ELECTRODEPOSITION OF MAGNETIC CoNiP THIN FILMS FROM VARIOUS PLATING BATHS

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Introduction

There have been a number of investigations using electrochemical processes to develop CoNiP magnetic thin films that exhibit a wide range of magnetic properties [1-4]. Electrodeposited soft and hard magnetic materials have been incorporated into MEMS devices including microactuators, sensors, micromotors and frictionless microgears [5, 6]. The type of metal salt used to prepare the plating bath affects the microstructure and magnetic properties of the metal deposits [7, 8]. CoNiP thin films have been electrodeposited from buffered solutions of the metal salts of chloride, sulfate and sulfamate [9].

The objective of this paper is to study and directly compare the influence of the solution anions, chloride, sulfate and sulfamate, with equivalent solution composition and plating conditions on the resulting deposit content and magnetic properties.

Experimental

NaCl, Na₂SO₄ and NaNH₂SO₃ were used as supporting electrolytes, respectively, with boric acid as pH buffer. Solution pH was adjusted with KOH or the respective acids- HCl, H₂SO₄ and NH₂SO₃H. Electrodeposition conditions were 10mA/cm², pH3 and room temperature without stirring.

The effect of varying the NaH₂PO₂ concentration from 0.009 to 0.283M on the deposit content, current efficiency and magnetic properties was examined. CoNiP films were electrodeposited on brass panels and a nickel sheet was used as the anode.

Deposit content of Co and Ni was analyzed with atomic absorption spectrophotometry. P content in the deposits was determined by colorimetry using the molybdate-vanadate method [4]. Magnetic properties were measured with a vibrating sample magnetometer (Model 880, ADE Technologies Inc.). X-ray diffractometer (Model 42202) Norelco, North American Philips Co., Inc.) was used to measure deposit structure.

Results

Fig. 1 shows the dependence of deposit P content of electrodeposited CoNiP films and current efficiency on NaH₂PO₂ concentration from chloride, sulfate and sulfamate baths. Deposit P contents increased sharply with low NaH₂PO₂ concentration, and then gradually increased with increasing NaH₂PO₂ concentration. Electrodeposition of CoNiP is strongly influenced by anions with the sulfate baths giving the highest P content and current efficiency compared to sulfamate and chloride baths, SO₄²⁻ > NH₂SO₃⁻ > Cl⁻.

Electrodeposits from sulfate baths showed a maximum coercivities (H_{c,⊥} = 640 Oe and H_{c,||} = 450 Oe with 0.047M NaH₂PO₂ and then decreased with increasing NaH₂PO₂ concentrations. Parallel squareness

exhibited a decrease from 0.73 to 0.48 with increasing NaH₂PO₂ concentration to 0.047M and then gradually decreased.

Parallel and perpendicular coercivities of electrodeposits from sulfamate baths increased sharply with increasing NaH₂PO₂ concentration from 0 to 0.009M, then reached a plateau (H_{c,⊥} = 1200 Oe and H_{c,||} = 1060 Oe. Parallel squareness exhibited increasing NaH₂PO₂ concentration up to 0.02814.

Electrodeposits from chloride bath exhibited an initial increase in coercivities and then leveled off (CH_{c,⊥} = 1960 Oe, H_{c,||} = 1057 Oe) with 0.047M NaH₂PO₂. Parallel squareness decreased monotonically from 0.5 to 0.18 with increasing NaH₂PO₂ concentration.

CoNiP electrodeposited from chloride baths exhibited an hcp structure with (002) preferred orientation and had a smooth surface with cracks. Deposits from sulfamate baths showed similar structure characteristics with a denser crack pattern. A (002) preferred orientation was not observed for the porous deposits from sulfate baths.

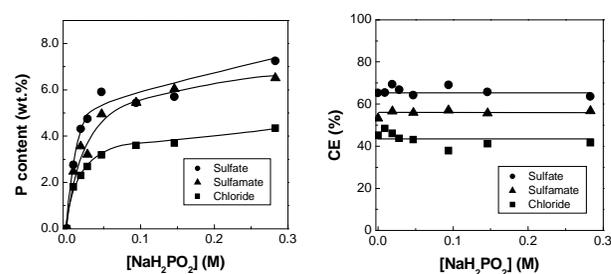


Fig. 1: Dependence of deposit P content (a) and current efficiency (b) of CoNiP electrodeposits on NaH₂PO₂ concentration (deposit thickness: 0.63 μm).

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