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EFFECT OF ORGANIC ADDITIVES ON THE MAGNETIC PROPERTIES OF NANO CRYSTALLINE HARD MAGNETIC FILMS

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Hard magnetic layers of CoNiP and FePtP have been prepared by electrodeposition and the phase formation, microstructure, grain size and mechanical properties such as residual stress and consequences for the magnetic properties were examined. The magnetic properties of the films are largely influenced by the organic additives such as urea and thiourea. These additives which are added in very low concentration can modify the growth of the alloy deposit. Portions of the additive molecules are codeposited which give a hard, nano crystalline structure. The effect of organic additives on the magnetic properties of CoNiP and FePtP alloy were studied using Vibration Sample Magnetometer. Surface characterization was carried out using X-ray Diffractrometer (XRD) and Scanning Electron Microscope (SEM). The reason for change in magnetic properties and structural characteristics because of the additives are discussed.

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1. Introduction

Electrodeposition of hard magnetic films attracts increasing interest for application as micromagnets in microelectromechanical systems or in the field of high density magnetic data storage. With the progress in the field of Micro ElectroMechanical System (MEMS) technologies[1] there has been growing interest in developing electroplated, nanostructured soft and hard magnetic materials[2] for microactuators, micromotors and microswitches. Recently, much effort is being made to electrodeposits also materials of the group of L10 ordered alloys, like FePt[3,4] and CoPt [5,6], because they exhibit a significantly higher uniaxial magneto crystalline anisotropy. Additives especially organic type plays a major role in the conventional electrodeposition popularly known as electroplating. These additives which are added in very low concentration can modify the growth of the alloy deposit.. In the present study urea has been added as an organic additive. The resultant deposit of FePtP were studied for their properties like magnetic and structural properties.

2. Experimental details

CoNiP magnetic thin films were electrodeposited from a bath containing $CoCl_2$:0.20M, $NiCl_2$:0.20M, NH_4Cl:0.25M, NaH_2PO_2: 0.20 M and 2.5 gl^{-1} of organic additives like urea and thiourea. FePtP films were electrodeposited on polycrystalline Cu substrate from a single bath

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containing : H_2PtCl_6 : .02M, $(NH_4)_2 SO_4$: 0.1 M , $FeSO_4$: .2M, NaH_2PO_2: 0.20M and 2.5 gl^{-1} of urea and thiourea. Films are deposited at 6 mA cm^{-2} in 60 minutes.

The thickness of the deposit was tested using digital micrometer. Magnetic properties of deposited films were studied using vibrating sample magnetometry. X ray diffractometry (XRD) and scanning electron microscopy (SEM) were used to study the structure and morphology of these magnetic films respectively. Percentage of elements such as Fe , Pt and P present in the deposits were obtained using energy dispersive X-ray spectroscopy (EDS).

3. Results and discussion

3.1 Thickness and magnetic properties

Table 1 summarises the effect of concentration of urea and thiourea on the thickness and magnetic properties of CoNiP and FePtP films. In the absence of urea the thickness of the film increased with increase in current density. However the electrodeposited film had relatively poor magnetic properties. With the addition of low concentration of urea and thiourea the deposit characteristics as well as its magnetic properties like coercivity improved significantly.

Table 1 : Effect organic additives on the thickness and magnetic properties of the films

Deposited film	Bath Additive (gl^{-1})		Thickness (µm)	Coercivity (Am^{-1})
	Urea	Thiourea		
CoNiP	0	0	3.7	79,577
	2.5	0	8.0	167,111
	0	2.5	8.1	123,420
	0	0	3.6	100,478
FePtP	2.5	0	6.8	171,887
	0	2.5	6.9	143,239

3.2 Structural analysis

Electrodeposited CoNiP and FePtP films were studied for their structural characteristics using XRD. Hexagonal close packing structure with (201) plane were found in CoNiP. FePtP film was found to have face centered tetragonal structure and exhibited (111) plane as shown in Fig.2

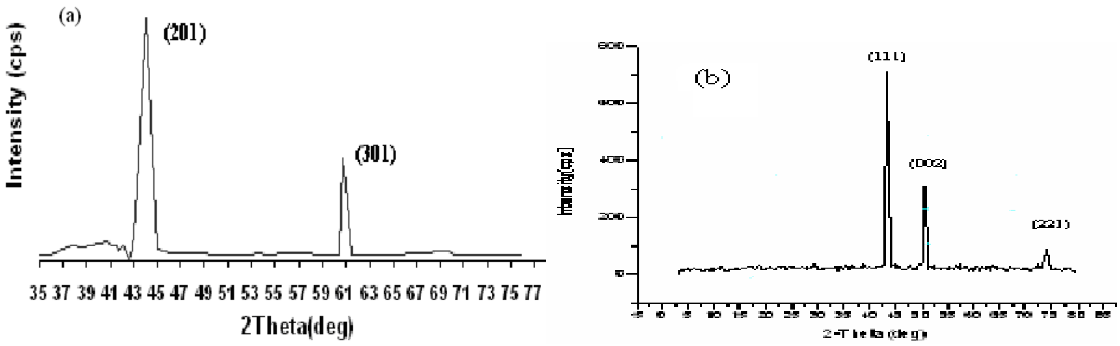

Fig.1 XRD patterns of CoNiP and FePtP thin films.

Table 2:Effect organic additives on the structural properties of the films

Deposited film	Bath Additive (gl^{-1})		Internal stress (MPa)	Crystalline size (nm)
	Urea	Thiourea		
CoNiP	0	0	120	60
	2.5	0	110	50
	0	2.5	115	58
	0	0	140	29
FePtP	2.5	0	130	23
	0	2.5	133	27

3. 3 Morphological observation

Electrodeposited CoNiP and FePtP films were subjected to SEM as shown if Fig.2. The film deposited without organic additive was cracked because of phosphorous content The film with very low concentration of phosphorous , appeared to have a crevice pattern. The film obtained from a bath contained 5.0 g/l urea was cracked through substrate due to stress of the film.

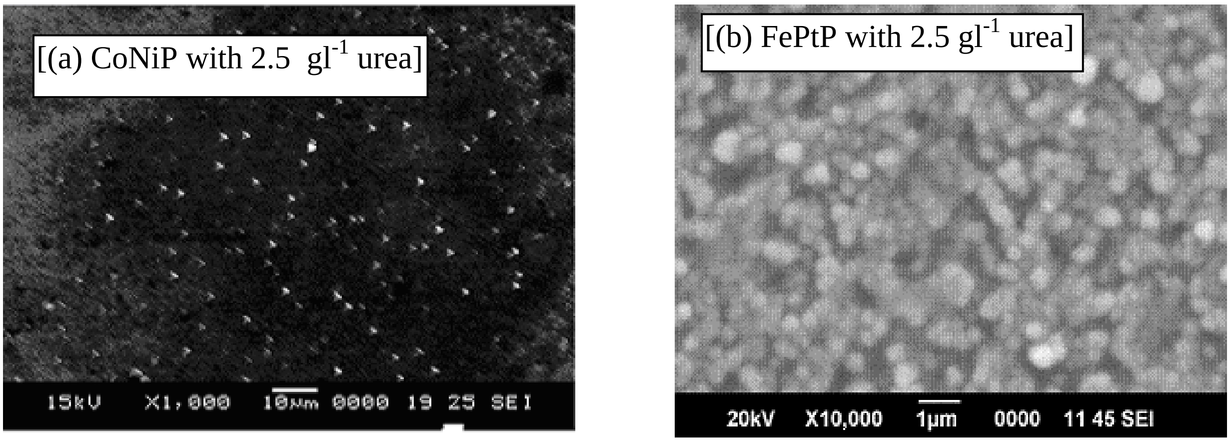

Fig.2 SEM images of CoNiP and FePtP thin films

4. Conclusions

CoNiP and FePtP films with high hard magnetic properties can be obtained by galvanostatic electro deposition process. The current density for the deposition was 6 mA cm^{-2} . Addition of urea increased the coercive value of the film. The high coercive value obtained in this work was 171,881 Am^{-1} This is because the urea molecules are found to have leveling effect which ensures uniform orientation of crystals during electrodeposition. 2.5gl^{-1} of urea was found to be the optimum concentration in the bath in order to obtain a CoNiP and FePtP films with improved magnetic and structural properties which can be used in MEMS devices .

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