Optimization of electrolytic deposition modes of the CoNiP alloy

M.I. Panasyuk[1*], T.I. Zubar[1,2], T.I. Usovich[1], V.A. Fedkin[1], O.D. Kanafiev[1], A.N. Kotelnikova[1], A.V. Trukhanov[1,2,3]

[1] SSPA "Scientific and practical materials research centre of NAS of Belarus", 220072, Minsk, P. Brovki str., 19, Belarus

[2] South Ural State University, 454080, Chelyabinsk, Lenin Prospect, 76, Russia

[3] National University of Science and Technology MISiS, 119049, Moscow, Leninsky Prospekt, 4, Russia

* corresponding author e-mail:: maria.panasiuk.99@gmail.com

Experimental

The CoNiP thin films are electrodeposited on copper wafers using two different electrolytes listed in Table I. The copper substrates are first degreased with Viennese lime followed by immersion in a $(NH_4)_2S_2O_8$+H_2SO_4 bath for 60 seconds to etching. The pH of the solution was adjusted with H_2SO_4 and the solution was maintained at 40°C during deposition without any stirring. The experiment was conducted at 20 and 30 mA cm^{-2}; nickel sheet was used as a soluble anode.

Electrolyte №1		Electrolyte №2	
Chemical/ conditions	Concentration, g/l	Chemical/ conditions	Concentration, g/l
$CoSO_4$	150	$CoSO_4$	150
$NiCl_2$	100	$NiSO_4$	150
$NiSO_4$	50	H_3BO_3	30
H_3BO_3	30	Na_2SO_4	60
NaH_2PO_2	10	NaH_2PO_2	8
pH	2	pH	2

Table I. Bath composition for CoNiP electrodeposits

Surface morphology

Figures 1a and 1b shows SEM images of the surface micromorphology of the electrodeposited CoNiP films with a thickness of 35 μm using different current densities (from electrolyte №1). The CoNiP alloy deposited using a higher current density of 30 mA cm^{-2} have a smaller grain size (approximately 250 nm) than materials deposited using a lower current density of 20 mA cm^{-2} (approximately 500 nm). In both cases, the CoNiP alloy has exhibited dendritic, nodular surface morphology.

For the electrolyte №2, CoNiP deposits were smooth. As the deposit thicknesses increases (from 15 to 35) with increasing current density, the deposits become smoother.

Magnetic properties

Figure 2 shows the hysteresis loops of CoNiP films. Films obtained in electrolyte №2 show a more gradual approach to saturation. In both electrolytes, with an increase in current density from 20 mA cm^{-2} to 30 mA cm^{-2}, an increase in coercivity is observed. In electrolyte №1, when the current density increases, the coercivity increases from 420Oe to 500 Oe. However, the saturation magnetization decreases from 195emu/g to 160emu/g. More impressive values of coercivity are demonstrated by coatings obtained in electrolyte №2. The coercivity reaches values of 10000e and 15000e at current densities of 20 mA cm^{-2} and 30 mA cm^{-2}, respectively. It can also be noted that with an increase in the current density, the saturation magnetization increases almost 2 times: 220emu/g at 30 mA cm^{-2} and 120emu/g at 20 mA cm^{-2}.

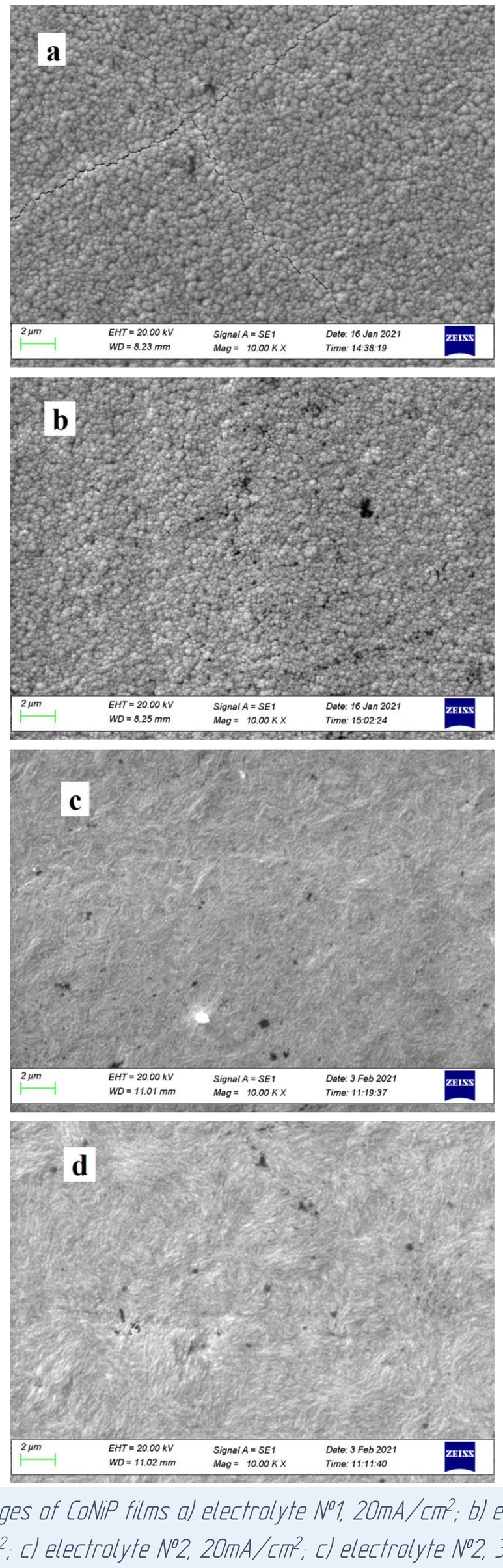

Fig. 1. SEM images of CoNiP films a) electrolyte №1, 20mA/cm^2; b) electrolyte №1, 30mA/cm^2; c) electrolyte №2, 20mA/cm^2; c) electrolyte №2, 30mA/cm^2

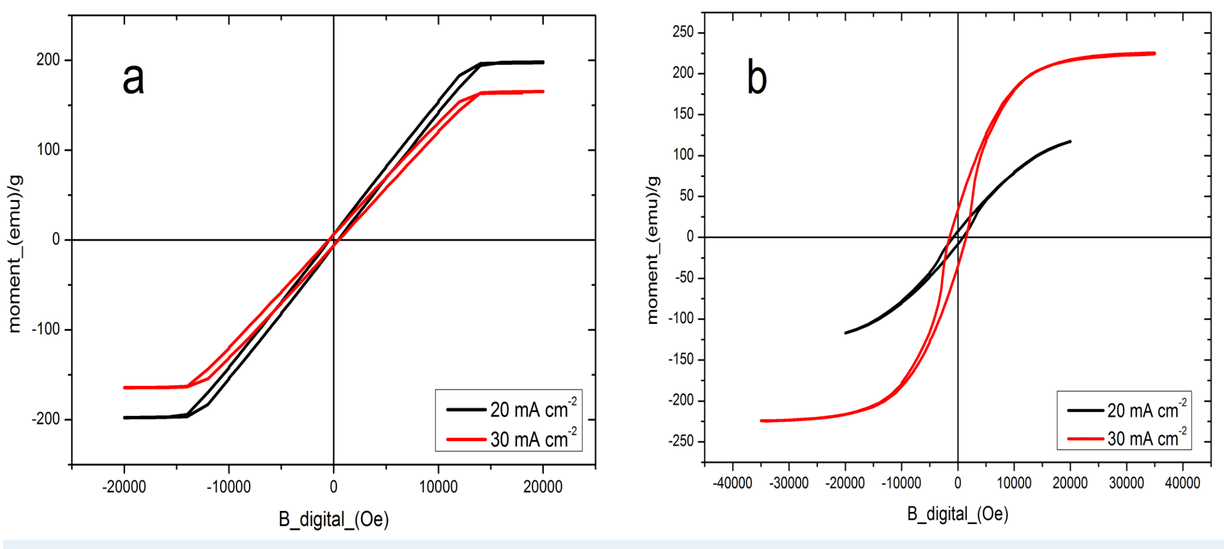

Fig. 2. Perpendicular hysteresis loops for CoNiP films a) electrolyte №1; b) electrolyte №2