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Influence of Additive Adsorption on Properties of Pulse Electrodeposited High Magnetic Moment CoFeNi and CoFe Alloys

Stanko R. Brankovic, Natasa Vasiljevic and Earl C. Johns

Seagate Research Center
1251 Waterfront Place
Pittsburgh PA, 15222

Stanko.R.Brankovic@Seagate.com

Organic additives have been commonly used in the electrodeposition of magnetic alloys for many years[1]. The properties of magnetic alloys are found to be critically dependent on the choice of one or more additives used in the electrodeposition process. Besides a commonly seen action of leveling and brightening of the deposit, the benefit of additives in plating bath was also attributed to the reduction of the grain size and the improvement in the crystal structure of the deposit[2,3], stress reduction[4], suppression of hydrogen evolution[4], and improved corrosion resistance of the deposit[5]. Depending on the particular additive used and the conditions at the electrochemical interface during the electrodeposition process, different atomic interstitials like S, C, O, B… or their intermetalic compounds are found in the magnetic films. Their amount can be as high as several atomic percents (at%) or barely detectible with conventional analytical techniques. Since the presence of small amounts of foreign atoms in the crystal lattice of magnetic alloys[6] are sometimes crucial or detrimental for desired magnetic properties and crystal structure[3,5], it is very important to understand the correlation between the parameters defining the additive adsorption on metal surface, their leveling and brightening action and the rate of their incorporation in the deposit.

In this talk we will present the results for additive adsorption on the CoFeNi and the CoFe surface. We will show that the potential of the maximum additive adsorption and coverage of the CoFeNi surface is also the potential of maximum incorporation of additives in the deposit. The additive related inclusion content of S, C, and O in the CoFeNi deposit is measured by Secondary Ion Mass Spectroscopy and correlated to the conditions at the electrochemical interface during the pulse current stage (Figure 1). We will discuss the mechanisms of additive incorporation in terms of the dominant parameters of the process like pulse current, j_{pulse}, and dominant conditions at the electrochemical interface defining additive coverage, $\theta_{additive}$. Furthermore, the leveling action of additives and their role as a suppressor of hydrogen evolution reaction will be considered on the example of CoFe alloy deposition in the structures for Tb/in^2 recording density. We will describe the optimal conditions for the electrodeposition at the nanoscale as a trade off between several beneficial actions of additives, each having an important role in overall deposition process (Figure 2).

References

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[6] Foreign elements (inclusions) are considered the ones that are not metal in origin.

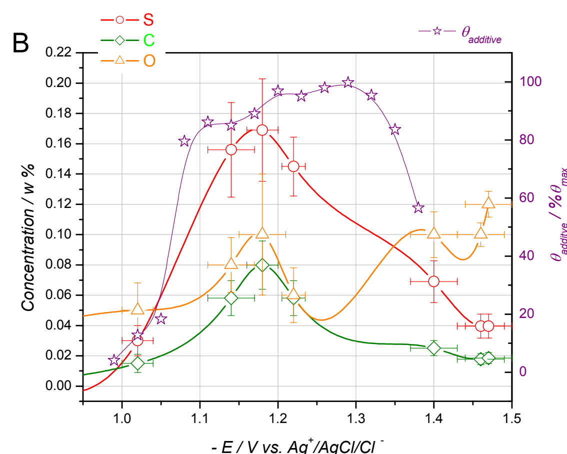

Figure 1. Inclusion content in pulse deposited CoFeNi alloy (left axis) and additive coverage of the CoFeNi surface (right axis) as a function of the potential of the electrode surface during the pulse current stage.

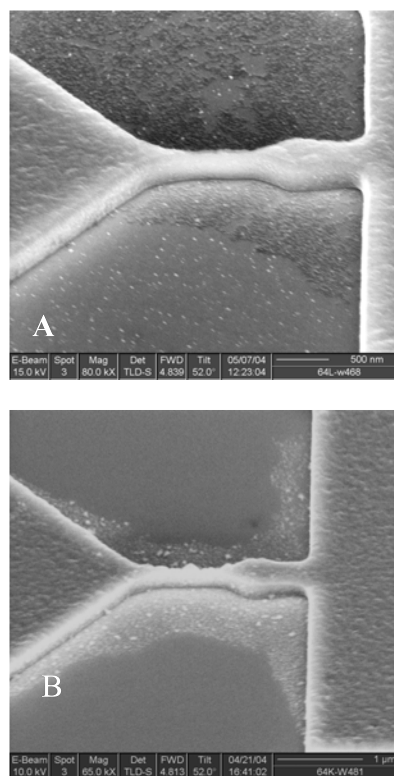

Figure 2. The 2.4 T CoFe top pole structures: (A) 60 nm wide, 6:1 aspect ratio structure, magnification 80,000 x, and (B) 60 nm wide, 4:1 aspect ratio structure, magnification 65,000 x. The difference in surface roughness across the pole axes for images A and B is related to the different content of additives and potential of the electrode surface during the pulse current stage.