Electrochemical Synthesis of Soft Ferromagnetic Thin Films and Nanostructures for Magnetic Recording and MEMS Application

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Recent trends in magnetic recording and Micro-Electro-Mechanical System (MEMS) technologies favor electrodeposited Soft High Magnetic Moment (SHMM) alloys as the material of choice for fabrication of future magnetic devices [1-3]. The current efforts focus on synthesis of ultimately soft magnetic alloys with the maximum possible magnetic moment (2.4 T CoFe alloys), good corrosion resistance, high resistivity and low stress levels [3]. This seemingly difficult challenge is coupled with ever-continuing drive to miniaturize magnetic devices, bringing the electrodeposition to the level of nano-science [4-6].

In this talk we will review our current understanding of additive role in electrodeposition process of magnetic alloys and nanostructures. The fundamental relation between the additive concentration and additive coverage is discussed as a prelude to further presentation of our results. This talk will highlight the additive incorporation phenomenon and its relevance for magnetic softness, stress, resistivity, morphology control and corrosion properties of CoFe, and CoNiFe films and nanostructures. The emphasis is on linking the additive concentration/design in solution and resulting properties of the magnetic alloys. Analytical models offering qualitative phenomenological description of the additive effect on corrosion potential, stress and coercivity of magnetic alloys are discussed placing the additive adsorption and incorporation phenomena as fundamental origin to the additive action during electrodeposition process.

In the second part of the talk we will focus on importance of the interfacial pH for obtaining good properties of magnetic alloys and nanostructures. The results illustrating incorporation of Fe-oxide species in 2.4 T CoFe alloys are presented. Our attention is focused on presenting phenomenological relation between process parameters such as bulk pH, diffusion layer thickness, current efficiency etc.., and resulting oxygen content in CoFe alloys and their magnetic properties.

In the last part of the talk, the bottom up manufacturing concept for magnetic field sensors based on electrodeposited CoFe/oxide/hydroxide nanocontacts is presented. The oxide incorporation in CoFe ferromagnetic nanocontacts is achieved by precipitation of the iron hydroxide phase Fe(OH)x (x=2, 3) during nanocontact electrodeposition process. The presented results indicate that electrodeposited CoFe ferromagnetic nanocontact is a novel class of materials with potentially large application for magnetic field sensors. The parameters quantitatively defining the performance of the electrodeposited nanocontacts are discussed with intention to elaborate more on advantages and limitation of this novel class of materials and devices.

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