NITRIDED FeB AMORPHOUS THIN FILMS FOR NANO ELECTROMECHANICAL SYSTEMS (NEMS)

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Amorphous alloys present high electrical resistivity, good mechanical properties, improved corrosion resistance, soft magnetic response, high magnetic moment and Curie temperatures, and great ability to tailor their magnetic properties with continuous composition variations over a broad range. Previous experiments performed in Fe-based primary alloys have demonstrated the strong dependence of their magnetic properties on the Fe-partner concentration. It is well known the dependence of the magnetic properties of amorphous Fe_xB_{100-x} [1-3] and of crystalline Fe_yN_x [4-7] films on the boron and on the nitrogen concentration, respectively. Moreover, some studies have been done in Fe-B-N ternary alloys in which boron and nitrogen have been implanted in pure Fe films at different fluencies [8], in amorphous Fe-B-N alloys grown by co-sputtering onto a BN and a pure Fe target [9] and in crystalline Fe-B-N films prepared by reactive RF magnetron sputtering [10]. These studies show the variation of structural, electrical and corrosion resistance properties as a function of the nitrogen concentration for amorphous films, as well as, the dependence of the magnetic properties on the nitrogen concentration for crystalline films with a concentration of Fe higher than 80 at%.

The objective of this paper is to study the dependence of the magnetic and magnetoelastic properties of Fe-B-N ternary alloys on the Nitrogen concentration. Fe-B-N amorphous films have been grown by DC sputtering of a $Fe_{80}B_{20}$ target in a mixture of Argon and Nitrogen atmospheres for different nitrogen partial pressures on glass and on <100>Si substrates. For comparison an amorphous Fe-B film was also grown. It is demonstrated that nitrogen incorporates into the amorphous lattice while preserving the amorphous structure, modifying their composition and magnetic properties. The amount of nitrogen that incorporates into the amorphous structure is measured to scale approximately linearly with the nitrogen partial pressure during growth. X-Ray Diffraction data show that for low deposition times (t<10 min) all the samples are amorphous while for longer deposition time a crystallization of the structure is observed due to the heating during the deposition. XPS data reveal that N preferentially bond to B, giving rise to B_xN_y and an iron-rich $Fe_{80}B_{20}$ films. The atomic percentage of B_xN_y increases with increasing the nitrogen concentrations.

A ~20% increase of both the saturation magnetization and the saturation magnetostriction constant are found for the composition $Fe_{0.74}\ B_{0.18}\ N_x$, when x is around 7 to 9%, when compared to pure $Fe_{80}B_{20}$ amorphous films. These films are grown at moderated ~2-3% nitrogen partial pressures by triode DC sputtering.

Because their high magnetostriction coefficient and their magnetic softness, these materials offer great potential for the incorporation into micro and nano magneto mechanical devices as actuators.

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Figures:

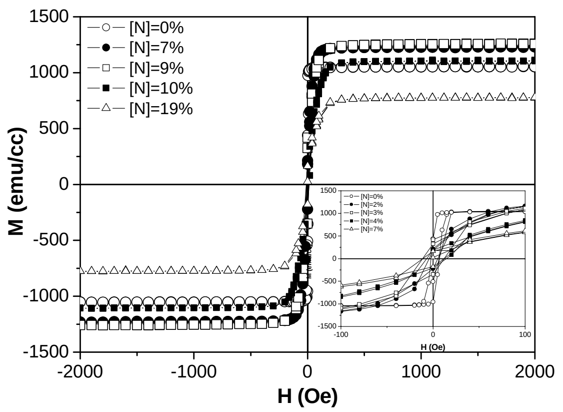

Figure 1. Magnetization measurements using a SQUID magnetometer for a Fe-B reference sample (open dots) and for Fe-B-N samples with different nitrogen concentration: [N]=7% (filled dots), [N]=9% (open square), [N]=10% (filled square), [N]=19% (open triangles).

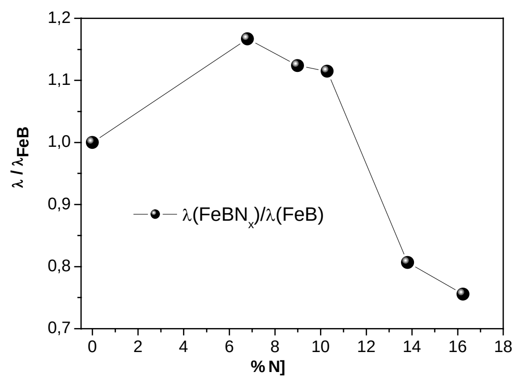

Figure 2. Magnetostriction values for Fe-B-N samples with different nitrogen concentration normalized to the magnetostriction value for a Fe-B film versus the nitrogen concentration in the samples.