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Various Iron-silicide Formation in Fe/Si Multilayered Films

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Fe/Si multilayers films (MLF) can have various iron-silicide interlayers and were recently discovered to have an antiferromagnetic (AF) coupling in the as-deposited state. The ion beam mixing (IBM) allows us to overcome either a thermodynamic or a kinetic barrier by employing the energetic particles, producing compositional and structural metastabiality. The Fe/Si MLF with various sublayer thicknesses were made by RF sputtering onto glass substrates and an IBM was also performed. The structural properties before and after the IBM turned out to be very different. A study of the optical and magneto-optical (MO) properties of the as-deposited MLF allowed us to conclude that neither $FeSi_2$ nor ε-FeSi could be considered as the spacer layer providing the strong AF coupling, but that a B2-phase nonmagnetic metallic FeSi compound is spontaneously formed between Fe sublayers during deposition. The IBM of the Fe/Si MLF has been performed at room temperature (RT) by using Ar^+ ions with an energy of 80 keV, a dose of 1×10^{16} ions/cm^2 and a flux of 1.5×10^{-6} A/cm^2. The structural characterization was performed by using low- and high-angle x-ray diffraction. The magnetic properties were measured at RT by using a vibrating sample magnetometer and ferromagnetic resonance spectroscopy. The ion-beam treatment has led to noticeable changes in the structural and physical properties of Fe/Si MLF : the formation of a new phase which is characterized by a crystalline silicide structure, a low coercivity and a Curie temperature of about 550 K. The obtained results can be explained if a metastable $FeSi_2$ silicide with a B2-type structure is supposed.