[S-13]

Optical and magneto-optical properties of the Mn1-xFex alloy films

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In this study, the structural dependence of the magneto-optical [equatorial Kerr effect (EKE)] and optical [optical conductivity (OC)] properties of the $Mn_{1-x}Fe_x$ alloy films have been investigated. The $Mn_{1-x}Fe_x$ alloy films have been prepared by face-to-face DC sputtering of the Mn and Fe target onto large glass substrates kept at 293 K. The high-angle x-ray diffraction (HAXRD) study shows a bcc structure for the $Mn_{1-x}Fe_x$ alloy films with $x > 0.9$, a mixture of the fcc (r-phase) and bcc (α-Fe phase) structure for $0.65 < x < 0.8$, and a fcc-like structure (r-phase and α-Mn) for $x < 0.65$. It was shown that the EKE signal at 293 K for the $Mn_{1-x}Fe_x$ alloy films can be observed only for $x > 0.50$. All the EKE spectra have nearly the same spectral shape (Fe-like) and differ from each other only in the intensity. The observed experimental EKE spectra for the Fe-rich $Mn_{1-x}Fe_x$ alloys films can be nicely described by the simulated ones made in the framework of the effective medium approximation. The optical properties of all the investigated alloys can be separated into three groups which are related to the different crystalline structures of alloys: the OC spectra for the $Mn_{1-x}Fe_x$ alloys which contains α-Fe phase ($x > 0.65$-0.70) exhibit a noticeable interband absorption peak located at about 2.4 eV; such a peak is completely absent in the r-phase based alloys and the α-Mn based alloys reveal a significant interband absorption peak near 1.4-1.5 eV.

The magnetic structure are rather complicated. Fe-rich $Mn_{1-x}Fe_x$ alloys films which contain α-Fe phase show ferromagnetic (FM) order for $x > 0.80$ with nonlinear behavior of magnetization which abruptly disappears at $x = 0.80$. For $x < 0.32$ and $0.46 < x < 0.67$ compositional ranges, the $Mn_{1-x}Fe_x$ alloys show antiferromagnetic behavior (AF) with different character of AF order (which depends on alloy composition).