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Optical properties of GaAsMn Layers Prepared by Magnetron Sputtering

A. Pulzara-Mora[(1)*], M. Bernal-Salamanca[(1)]M. Melendez-Lira[(2)], A. Rosales-Rivera[(1)] and M. López-López[(2)]

(1) Laboratorio de Magnetismo y Materiales Avanzados, Universidad Nacional de Colombia, Sede Manizales, A.A. 127.
(2) Physics Department, Centro de Investigación y de Estudios Avanzados del IPN, Av. IPN No. 2508, Apartado Postal 14-740 México D.F 07000, México.
* aopulzaram@unal.edu.co

Abstract Thin films of $Ga_xMn_{1-x}As$ alloys were deposited by reactive rf magnetron sputtering on corning glass and GaAs(001) substrates. Optical absorption coefficient spectra obtained from transmission data show a continuous shift of the absorption edge to lower energies with respect to that of gallium arsenide. Raman scattering measurements were performed on $Ga_{1-x}Mn_xAs$ films in a standard configuration. The Raman spectrum shows some new modes in addition to the GaAs-like modes which are observed for a high Mn content. The new vibrational modes observed were assigned to Mn_mAs_n-like modes. The manganese content was measured by secondary ion mass spectroscopy (SIMS).

Diluted magnetic semiconductor (DMS) materials, which combine semiconductors with additional transition metal elements, have become recently particularly attractive for investigations of basic physical properties and for potential applications in spintronic devices [1]. In this work, Raman spectroscopy at room temperature was employed to analyze the structural properties of samples. The 632.8 nm (1.92 eV) line from a He-Ne laser was used as an excitation light source in order to obtain a very short penetration depth, avoiding any Raman scattering from the substrate. We found that for the sample of GaAs (x = 0) taken as reference, the Raman spectra is dominated by the transverse (TO) and longitudinal (LO) modes at 263 and 298 cm^{-1}, respectively. However, for the $Ga_{1-x}Mn_xAs$ samples the TO and LO modes decreased dramatically, and the Mn Raman modes in the range of 100 cm^{-1} and 250 cm^{-1} are evidenced. In order to analyze the vibrational phonon modes in our samples, the Raman spectra in the range of 150 cm^{-1} and 250 cm^{-1} were fitted by using three Lorentzian functions (See Fig. 1). The Mn modes locate at 192.5, 219.2 and 243.8 cm^{-1} seems to be related with interstitial defects or vacancy-related defects. Similar results have been observed in GaAsN [2]. On the other hand, an additional Nobel peak centered around 650 cm^{-1} is observed only for the sample with high Mn content. The integrate intensity of this peak is more sensitive to Mn concentration, but the position of the peak does not depend on the Mn content. By using the reference [2], we found that this peak is located at 601 cm^{-1}, in good agreement with the experimental data (located at 600 cm^{-1}), and it is related with excitations due to Mn_4As localized structures. As far as we know this is the first report for this peak. The integrated intensity of this peak is not sensitive to Mn content, but the peak position depends on the Mn content. By using the mass reduced model we found that this peak is located at 648.7 cm^{-1}, in good agreement with the experimental data located at 650 cm^{-1}, and it is related with clusters due to Mn_mAs_n localized structures. Optical absorption coefficient spectra obtained from transmission data show a continuous shift of the absorption edge to lower energies with respect to that of gallium arsenide, Fig 2.

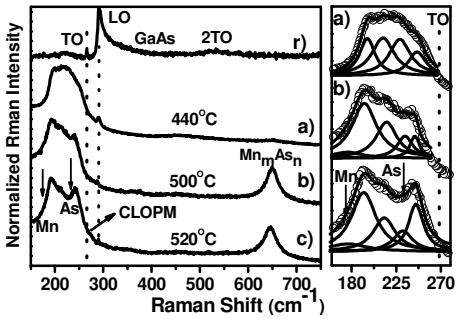

Figure 1: Room temperature Raman spectra (left) of $Ga_{1-x}AsMn_x$ samples grown at temperatures from 440 °C to 520 °C. r) is a GaAs sample taken as a reference. In the right side, we show the best fit of the experimental data (right) by using four Gaussian functions. The arrows indicate the position of Mn and As modes.

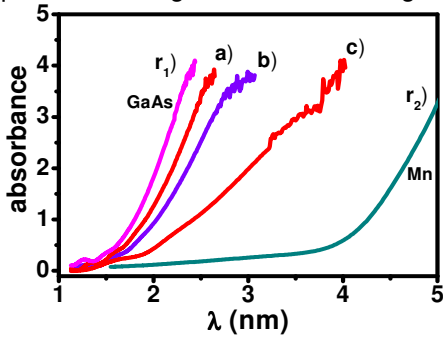

Figure 2: Absorbance as a function of the wavelength for the samples r_1) GaAs, and r_2) Mn, taken as a reference (Tg = 500°C). a), b) and c) correspond to the $Ga_{1-x}Mn_xAs$ samples grown at 440 °C, 500 °C and 520 °C, respectively.

References

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