Vol. 80 (1991) *ACTA PHYSICA POLONICA A* No 3

Proceedings of the XX International School of Semiconducting Compounds, Jaszowiec 1991

TEMPERATURE AND INTENSITY DEPENDENT FARADAY ROTATION IN $Hg_{1-x}Mn_xTe$ AT CO_2 LASER WAVELENGTHS

L. KOWALCZYK, R.R. GAŁĄZKA

Institute of Physics, Polish Academy of Sciences
Al. Lotników 32/46, 02-668 Warszawa, Poland

Faraday rotation in $Hg_{1-x}Mn_xTe$ ($x = 0.11$) has been investigated experimentally over the temperature range from $T = 8$ K to 250 K using a Q-switched CO_2 laser. Due to the exchange interaction between mobile carriers and localized Mn ions, dramatic enhancement of Verdet coefficient at low temperatures has been observed. The values of Verdet coefficient $V = 5585$ rad T^{-1} m^{-1} at 8 K and $V = 1745$ rad T^{-1} m^{-1} at 80 K have been obtained for $Hg_{0.89}Mn_{0.11}Te$ at 10.6 μm. The dependence of Faraday rotation on intensity of laser radiation has been observed. Intensity dependent Faraday rotation shows saturation for high laser power. Intensity induced rotation is qualitatively attributed to the dispersion associated with saturable absorption of laser radiation. The results obtained in this work indicate that $Hg_{1-x}Mn_xTe$ is a suitable material for Faraday rotator at CO_2 laser wavelengths for high power laser beam.

PACS numbers: 78.20.Ls, 75.30.El

The interband Faraday rotation in $Hg_{1-x}Mn_xTe$ ($0.3 \leq x \leq 0.5$) was previously reported [1], and there was shown that Faraday rotation may be successfully used for observing the paramagnetic-to-spin-glass phase transition.

This paper presents the results of investigations of Faraday rotation in $Hg_{1-x}Mn_xTe$ with low Mn content ($x = 0.11$). The measurements were performed over the range of temperature 8 K–250 K and $Hg_{0.89}Mn_{0.11}Te$ was in paramagnetic phase. The sample was placed in a variable-temperature optical cryostat in magnetic fields $H \leq 0.5$ T and illuminated by linearly polarized light emitted by a Q-switched CO_2 laser. A second linear polarizer was placed behind the sample in order to analyze the value of the rotation of the polarization plane. The value of energy gap for $Hg_{1-x}Mn_xTe$ was slightly greater than the energy of laser radiation. Figure 1 shows the value of Verdet coefficient as a function of temperature

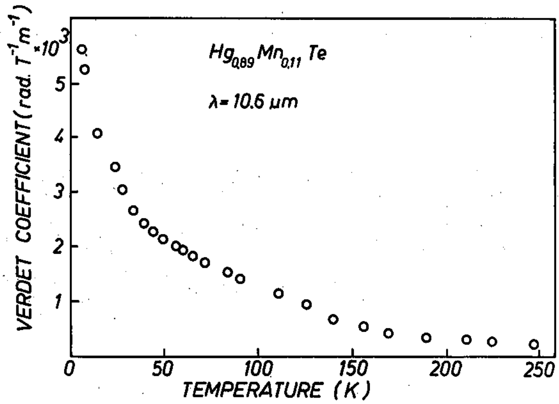

Fig. 1. Temperature dependence of Verdet coefficient in $Hg_{0.89}Mn_{0.11}Te$ for 10.6 μm.

for $Hg_{0.89}Mn_{0.11}Te$. Dramatic enhancement of Verdet coefficient at low temperatures is observed, due to the exchange interaction between mobile carriers and localized Mn ions. The value of Verdet coefficient at 8 K is $V = 5585$ rad T^{-1} m^{-1}. The value of absorption coefficient α for $Hg_{0.89}Mn_{0.11}Te$ at CO_2 laser wavelength ($\lambda = 10.6$ μm) has been measured, and the figure of merit $V/\alpha = 148$ rad T^{-1} is obtained at 8 K. Such a great value of figure of merit suggests a possibility of applying $Hg_{1-x}Mn_xTe$ crystals to CO_2 laser isolator devices. From this point of view there was a necessity to perform measurements of Faraday rotation as a function of laser intensity. The dependence of Faraday rotation on intensity of laser radiation is shown in Fig. 2. As the laser intensity on HgMnTe is raised, the Faraday rotation first slightly decreases and afterwards is insensitive to the change of laser power. This behavior can be qualitatively explained in terms of the dispersion associated with saturable absorption of laser radiation.

The origin of the interband Faraday effect is the splitting of the interband transitions in magnetic field. For photon energies close to the energy band gap, the Faraday rotation is given by [2]:

$$\Theta_F = \frac{lE}{2\hbar c}\frac{\partial n}{\partial E}\Delta E$$

where $\partial n/\partial E$ describes the dispersion of the refractive index, ΔE is the energy difference between band gap transitions observed in two circular polarizations, l is the distance in the medium traversed by the light, E is the photon energy, $\hbar$ and c have their normal meaning. Decreasing of value $\partial n/\partial E$ with increasing laser intensity leads to decreasing of interband Faraday rotation. It can be seen from Fig. 2 that the process of saturation of the interband transitions occurs at relatively low intensities of laser radiation.

In conclusion, the results obtained in this work indicate that $Hg_{1-x}Mn_xTe$ is a suitable material for Faraday rotator at CO_2 laser wavelengths for high-power

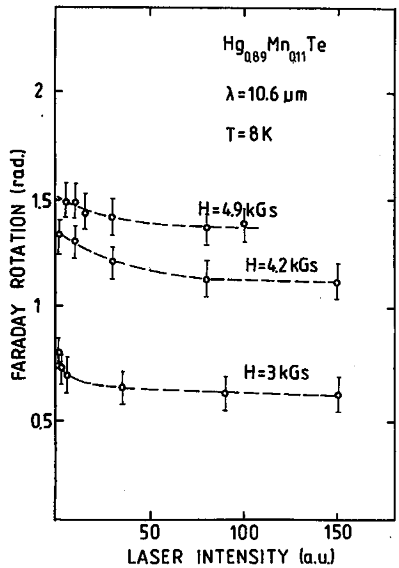

Fig. 2. Faraday rotation in $Hg_{0.89}Mn_{0.11}Te$ as a function of laser intensity at 10.6 μm in different magnetic fields.

laser beam. Infrared Faraday isolator with low insertion loss can be designed for operation at 5 kGs — a field which can be easily achieved with a permanent magnet.

References

[1] A. Mycielski, C. Rigaux, M. Meanet, T. Dietl, M. Otto, *Solid State Commun.* **50**, 257 (1984).

[2] D.U. Bartholomew, J.K. Furdyna, A.K. Ramdas, *Phys. Rev. B* **34**, 205 (1986).