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Magnetooptical studies on cobalt substituted MnSb films

M. S. Vijayaraghavan and V. Sivaramakrishnan

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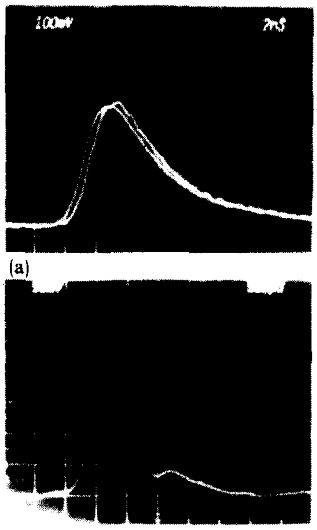

(a)

(b)

FIG. 4. Oscillograms showing (a) the incident pulse and (b) the detection-limited compressed pulse. The dye concentration was 5×10^{-4} M/l of BPBD in ethanol. The horizontal scale for (a) is 2 ns/div, and for (b) is 500 ps/div.

short pulses are expected from an improved version of the above laser at XeCl, KrF, and XeF wavelengths at a repetition rate up to 200 Hz.

Similar results obtained in other rare-gas halide excimer lasers like KrF and XeF and the details of theoretical and experimental investigation carried out will be presented elsewhere.[12]

In conclusion, we have obtained for the first time reliable short pulses from a XeCl laser using saturable absorber dyes. Although the pulse energy produced by the scheme was small when compared to the input energy, the output power remained fairly high because of the pulse shortening. This was found to be reproducible for single shot and repetition rate operation. This technique overcomes the problems of mode-locking excimer lasers, and also offers the unique feature of generating various pulse shapes and pulse durations.

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Magneto-optical studies on cobalt substituted MnSb films

M. S. Vijayaraghavan[a] and V. Sivaramakrishnan
Thin Film Laboratory, Department of Physics, Indian Institute of Technology, Madras—600 036, India

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Optical and magneto-optical studies MnSb films substituted with 20 at. % of cobalt have been carried out. The results suggest the possibility of these being considered as potential candidates for magneto-optic storage.

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Ever since thermomagnetic recording was demonstrated on thin films of MnBi,[1] tremendous interest has been generated on the magneto-optical properties of magnetic materials, especially NiAs-type intermetallic compounds. In order that the materials are suitable for use as magneto-optic file, it must have among others, the following characteristics: (a) large magneto-optic rotation for read-out, (b) high optical absorption coefficient for the thermomagnetic writing process, (c) Curie temperature small enough to avoid large temperature excursions, and (d) small domain size for higher storage density. In keeping with these guidelines, the first material to be proposed was MnBi.[2] Although its specific Faraday rotation and optical absorption coefficient are high, the Curie temperature of about 725 K is quite large for it to be considered as the best magneto-optic file element. Also, another major limitation of MnBi films is the presence of first-order magnetic phase transition near the Curie temperature. Another material that was suggested was MnSb.[3] While films of MnSb do not exhibit any instabilities associat-

[a]Hybrid Circuits Group, Technology Division, Defence Electronics Research Laboratory (DLRL), Hyderabad—500 005, India.

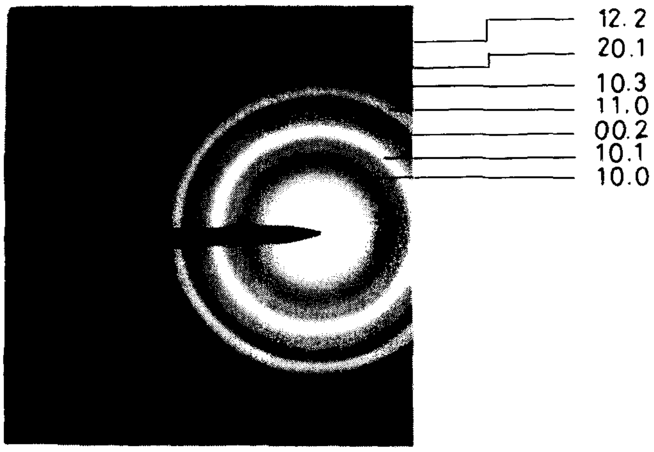

FIG. 1. TED pattern of $Mn_{0.8}Co_{0.2}Sb$ film indicating polycrystallinity.

ed with first-order magnetic phase transition, its Curie temperature of 580 K is still quite high. In an attempt to lower the Curie temperature of MnSb films, the authors have earlier successfully prepared films of MnSb substituted with copper[4] and tin[5] and studied their magneto-optical properties. The present letter deals with the effect of substituting the octahedral interstitial sites of MnSb with cobalt. The film preparation, its characterization, the results of optical, magneto-optical and Curie temperature measurements are discussed. These are later examined for evaluating them for beam addressable magnetic memory devices.

Films of $Mn_{0.8}Co_{0.2}Sb$ were prepared by flash evaporation on the lines adopted by Hashimoto[6] for MnSb. The powder samples of this compound were earlier prepared by subjecting the stoichiometric mixture to a series of heat treatments in induction furnace. A vibrating spatula was used to drop the powder sample onto a tungsten filament maintained at a temperature of 1300 °C. The substrates were well-cleaned cover glass slips maintained at room temperature during deposition. Transmission election diffraction (TED) of the films shown in Fig. 1 points at the formation of stoichiometric films and the results of x-ray diffraction on thick films also support this. The composition of the films was also independently confirmed by electron microprobe analysis, and the deviation from bulk composition was well within the experimental errors involved, and there was reasonable uniformity in composition throughout the area scanned.

The polar Faraday rotation F and optical absorption coefficient α of $Mn_{0.8}Co_{0.2}Sb$ films were measured at room temperature and Fig. 2 shows the wavelength dispersion of these parameters. A broad peak centered at about 5500 Å marks the Faraday rotation curve while the optical absorption spectrum exhibits no noticeable feature. The polar hysteresis curve shown in Fig. 3 gave a low value of coercive field and remanent rotation confirming that the magnetization direction is in the film plane. The variation of specific saturation Faraday rotation with temperature gave a value of 445 K as Curie temperature which is in agreement with the corresponding value for the bulk sample.

The film neither deteriorated with time nor did the post-deposition annealing help in significantly improving Faraday rotation. Also, no significant change in Faraday rotation was noticeable even after a few weeks of exposure to

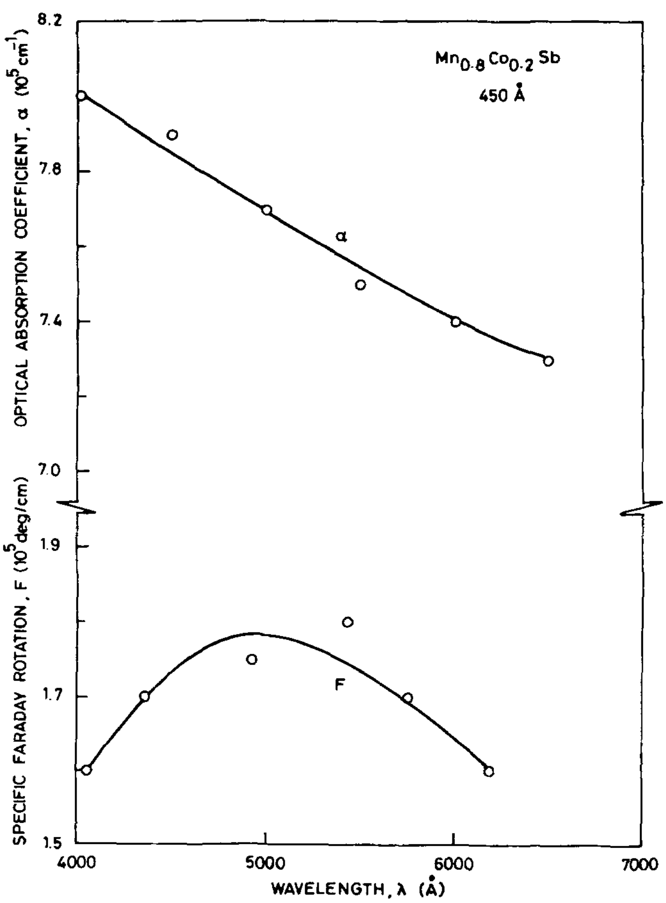

FIG. 2. F and α vs λ for $Mn_{0.8}Co_{0.2}Sb$ film.

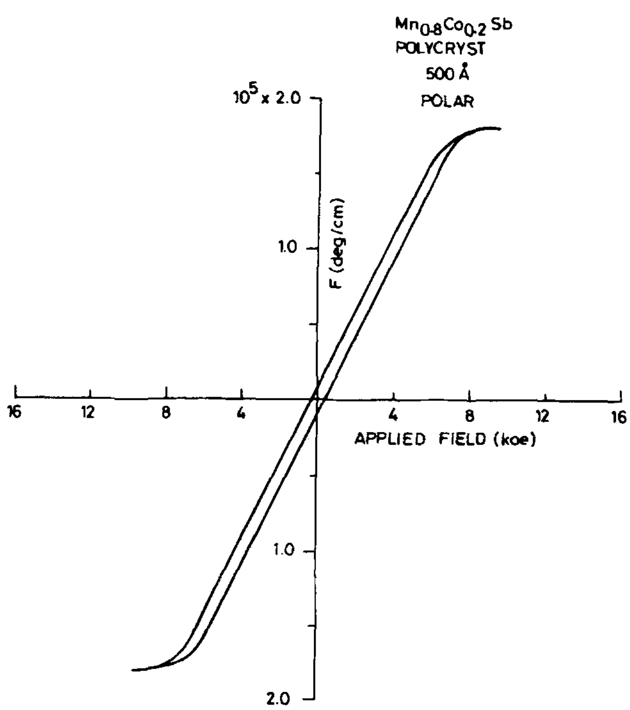

FIG. 3. Polar hysteresis loop of $Mn_{0.8}Co_{0.2}Sb$ film.

TABLE I. Magneto-optic memory materials.

Material	T_c (K)	Absorption coefficient $\alpha(10^5\ cm^{-1})$	Saturation Faraday rotation $F(10^5$ deg/cm)	Figure of merit $(2F/\alpha)$ (deg)	Ref.
Mn_5Ge_3	310	3.5	1.4	0.8	7
CrTe	334	2	0.5	0.5	8
Fe_5Si_3	390	3.7	0.5	0.3	9
MnSb	583	8.2	2.8	0.7	3
$Mn_{0.8}Co_{0.2}Sb$	445	7.5	1.8	0.5	Present work

highly humid atmosphere, after deposition.

In conclusion, the films of $Mn_{0.8}Co_{0.2}Sb$ could be formed by flash evaporation. Structure studies point to the formation of stoichiometric films. The efficient use of a laser for thermomagnetic writing requires that the materials have a large absorption coefficient at the laser wavelength. When one laser is used for both reading and writing, the wavelength of the beam must be properly chosen to reach a compromise for the magnitudes of the material properties. It is commonly accepted that a value of approximately 1° for $(2F/\alpha)$ would be adequate for read-out. This calls for a value of $\alpha \geqslant 10^5\ cm^{-1}$ and $F \geqslant 10^5$ deg/cm and both to be achievable at room temperature and in the convenient visible laser wavelength region. From Fig. 2 one can notice that Faraday rotation for $Mn_{0.8}Co_{0.2}Sb$ films has a maximum value of 1.8×10^5 deg/cm at a wavelength of about 5500 Å and the optical absorption coefficient of $7.5\times 10^5\ cm^{-1}$. Also the performance factor $(2F/\alpha)$ has a maximum value of 0.5 deg at this wavelength, and is about 20% more than the corresponding value at 6328 Å. These data suggest that the characteristics at the argon-ion laser wavelength of 5145 Å could be utilized more efffectively to get a large read-out signal-to-noise ratio than the He-Ne laser wavelength.

Table I gives a comparison of the characteristics of some typical films having the direction of magnetization in the film plane and whose operating wavelength and temperature are 5500 Å and 20 °C, respectively. The value of T_c for cobalt-substituted MnSb film is comparable. As regards packing density where the requirement of small domain size arises, it can be pointed out that the domain size (d) may be written as

$$d \propto (A/\sigma\lambda)^{1/2},$$

where A is the ferromagnetic exchange coupling constant and σ is the planar stress induced during film formation. Seshu Bai[10] report for the films of $Mn_{1-x}Co_xSb$ $(0\leqslant x\leqslant 0.3)$ a sudden slump in A value and a corresponding increase in $(\sigma\lambda)$ value after a critical composition given by $x_c = 0.15$. From the above relationship this result suggests that for compositions $x_c > 0.15$ in $Mn_{1-x}Co_xSb$, one could expect films to have small domain size, which is the reason for choosing a composition $Mn_{0.8}Co_{0.2}Sb$ for the present investigation.

A study of Table I indicates that the films of $Mn_{0.8}Co_{0.2}Sb$ have higher Faraday rotation, optical absorption coefficient, and comparable figure of merit and Curie temperature than other materials except MnSb. Coupled with the fact that the domain size can be small and the films are fairly stable against moisture, $Mn_{0.8}Co_{0.2}Sb$ films appear quite attractive as reliable mangeto-optic storage medium.

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