28a-A8-2

Effect of circularly polarized light on a magnetization vector in (Ga,Mn)As

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Helicity dependent magnetization switching with circularly polarized, laser pulses was demonstrated a few years ago in out-of-plane magnetized GdFeCo films [1]. The reversal was explained by the combination of ultrafast spin heating and the Inverse Faraday Effect [2,3]; heating samples to temperatures slightly below the Curie point (T_C) is supposed to be important because of the tendency toward diverging susceptibility, yielding sensitive response to the effective magnetic field acting on spins. Besides GdFeCo, influence of optical helicity on a magnetization vector was studied in in-plane (Ga,Mn)As epilayers [4-6], whereas results were not conclusive at that time.

In this study, we show experimentally that, in the out-of-plane $Ga_{0.976}Mn_{0.024}As$ epilayer (T_C ~ 40 K) grown on a $In_{0.1}Ga_{0.9}As$ buffer layer, a magnetization vector can be altered differently with circularly polarized light. The tested sample is unique in sense that it exhibits in-plane anisotropy at T < 20K and out-of-plane anisotropy at T > 20K. Experiments were carried out using a CCD-based mgneto-optical (MO) microscope combined with a circularly polarized, laser pulses of λ = 790 nm, pulse width = 85 fs, and repetition rate= 80 MHz, for excitation. The excitation area was about 500 μm in diameter. Experiments were carried out at T = 25 K with duration of illumination of 1 sec. The contrast obatained after illumination with left-handed (σ^-) light [Fig.1(b)] is almost similar to that of the initially up-magnetized state [Fig.1(a)], whereas the contrast of the entire area (2.5 mm in diameter) is changed slightly after illumination with right-handed (σ^+) light [Fig.1(c)]. Observed results are empahasized in Figs.1(d) and (e) in which the image of Fig.1(a) was subtracted from Figs.1(b) and (c), respectively. Reversed results were obtained when experiments were carried out with initially-down magnetization (not shown). Fig.2 shows the dependence of illumination intensity on resultant image contrast. Results indicate that helicity-dependent change in the contrast occurs within a narrow window, ranging from about 0.7 to 0.8 μJ/cm^2. No change is observed at the intensity of 0.5 μJ/cm^2, whereas helicity-independent change is observed in the image contrast at 0.83 μJ/cm^2. The helicity-dependent change in the image contrast is inferred to the change in a magnetization vector associated with the angular momentum of light. It is worth noting that spots in the central parts of images (500 μm in diameter) could be interpreted in terms of the total demagnetization due to overheating (T_C > 40 K) of the focused area.

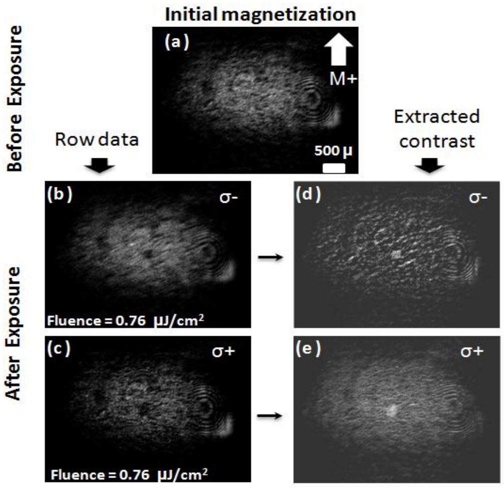

Fig.1 (a) MO image of the initial magnetization magnetized at H=130 Oe: (b) and (c) MO images after illuminating with (σ^-) and (σ^+) light, respectively: (d) and (e) the corresponding images obtained by subtracting image of the initial magnetization.

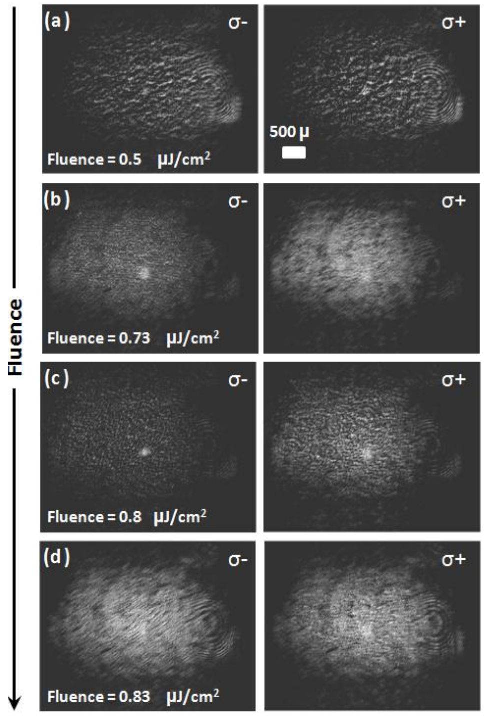

Fig.2 MO images obtained after illumination with σ^- and σ^+ light at different light intensities. Contrast of the initial magnetization was subtracted from raw image data.

[1] C.D. Stanciu *et al.*, PRL. **99**, 047601 (2007).
[2] J. P. van der Ziel *et al*., PRL. **15**, 190(1965).
[3] N. Kazantseva, *et al*., Europhys. Lett. **81**, 27004 (2008).
[4] A. Oiwa, *et al.*, Phys. Rev. Lett. **88**, 137202 (2002).
[5] Y. Mitsumori, *et al*., Phys. Rev. B **69**, 033203 (2004).
[6] T. Kondo, *et al.*, phys. stat. sol. (c) **3**, 4263 (2006).