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A lateral-configuration-type spin photodiode consisting of a ferromagnet – semiconductor junction

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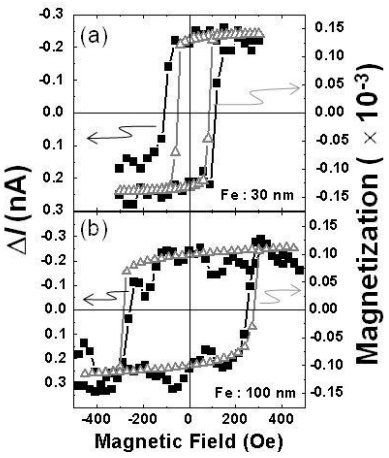
A ferromagnet–semiconductor junction exhibits spin-dependent transport due to the difference in the density of states between spin-up and spin-down electrons around the Fermi level at the junction [1]. Combining the spin-dependent transport at the junction and the optical selection rule for circularly polarized light (CPL) in a semiconductor, the experiment of vertical-configuration-type spin photodiode was reported [2]. In this experiment, a high external magnetic field was applied to force the spin axis of the in-plane ferromagnet parallel with the pointing vector of vertically impinging light. It is desired to study the way of detecting optical helicity without using an external magnetic field for actual applications. Reported in this paper is a lateral-configuration-type CPL detector in which CPL impinges on a cleaved sidewall of the device and satisfies the condition of spin axis matching between light and the remnant state of a thin ferromagnetic layer.

A sample consists of an Au/Ti layer, a Fe layer, an ultra-thin crystalline AlO_x layer, and an AlGaAs/InGaAs double heterostructure. The AlO_x/AlGaAs/InGaAs structure was grown on a *p*-type GaAs (001) substrate by molecular beam epitaxy [3]. Both Fe and Au/Ti protection layers were deposited by electron-beam evaporation. A linearly polarized cw-laser light beam with wavelength λ = 785 nm and power P = 20 mW was modulated by the photo-elastic modulator (PEM) to yield CPL of alternating helicity, and was impinged on the cleaved $(1\bar{1}0)$ sidewall of the sample. Helicity-dependent photocurrent was measured by the lock-in technique referring the PEM modulation frequency of 50 kHz.

Helicity-dependent photocurrent component ΔI has been observed in the light-lateral-illumination configuration. Shown in Figs. 1(a) and (b) are the magnetic field dependence of ΔI at 5 K of two devices with different Fe layer thicknesses of 30 nm and 100 nm, respectively, together with the 5-K magnetization hysteresis curves measured by a SQUID magnetometer. The polarity of ΔI switches between positive and negative with sweeping external magnetic fields, which resembles magnetization hysteresis loops of constituent Fe layers. This fact strongly suggests that the ΔI is attributed to spin-dependent transport across the ferromagnet/insulator/semiconductor junction. The ΔI data at high temperatures will be shown at the time of presentation [4].



Figs. 1: Field dependence of helicity-dependent photocurrent component ΔI and magnetization for two devices with different Fe layer thicknesses of (a) 30nm and (b) 100nm.

References

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