Photoinduced Spin Relaxation in Epitaxial MnAs Film

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Epitaxial MnAs film on GaAs substrate is one of the promising systems for future spintronic applications because it has ferromagnetic(FM) properties with well-ordered interfaces at room temperature in spite of the large lattice misfit. This material has been extensively studied for the possible application to magnetic tunnel junctions, spin injection devices, etc., even though a higher Curie temperature is desirable for a stable operation of the devices at room temperature. Apart from its importance in device applications, there is also a tremendous interest in the spin dynamics study of this system. Moreover, the spin precessional motion of the MnAs film becomes an important issue for its ultrafast application.

We investigate the spin relaxation of precessional motion in epitaxial MnAs film on GaAs(001) using all-optical pump-probe technique. For this study, a MnAs film with a thickness of 500 nm was epitaxially grown on a GaAs(001) substrate at 270°C by molecular-beam epitaxy. The detailed growth condition and magnetic properties like M-H hysteresis curve and MFM domain image are described elsewhere.[1]

To observe spin relaxation motion of the sample, all-optical pump-probe technique was used. A dc magnetic field of approximately 2.55 kOe was initially applied at an angle of 13° from the normal direction of the film plane. Due to the competition of the external bias field, internal demagnetizing field, and internal anisotropy field, equilibrium direction of the magnetization vector of the sample was tilted to the normal direction of the film plane. The sample at room temperature was excited by a laser pulse focused with an objective lens (N.A. = 0.3) with an estimated pulse width of 30 fs, a center wavelength of 800 nm from Ti:sapphire laser with a repetition rate of 82 MHz. This pump laser pulse can induce the internal magnetic pulse field generating precessional motion.[2] A frequency-doubled laser pulse with a center wavelength of 400 nm and an average power of approximately 40 μW was used for a probe beam. Polar Kerr signals of the probe beam reflected from the excited sample were recorded at 2-ps intervals. In order to clearly see the precessional component, we decompose the photoinduced polar Kerr signal into the phonon or magnon background signal and the spin precessional signal, respectively. Then, initial amplitude A and exponential decay time τ was extracted from the fitting of the precessional signal with the equation of $A\,\mathrm{Exp}(-t/\tau)$.

Figure 1 shows the initial amplitude and exponential relaxation time of the precessional motions depending on the fluence of the pump beam. As the pump fluence increases, precessional motion decays out more rapidly. It is interesting to see that the relaxation time of the precessional motion clearly changes as the pump fluence increases. Considering the fact that precessional amplitude increases as the pump fluence increases, precessional motion is believed to occur from the torque exerted by the optically-induced internal magnetic field pulse. In addition, this implies that the additional damping in the high fluence mainly stems from the generation of non-uniform spinwave modes from high-angle excitation.[3]

References

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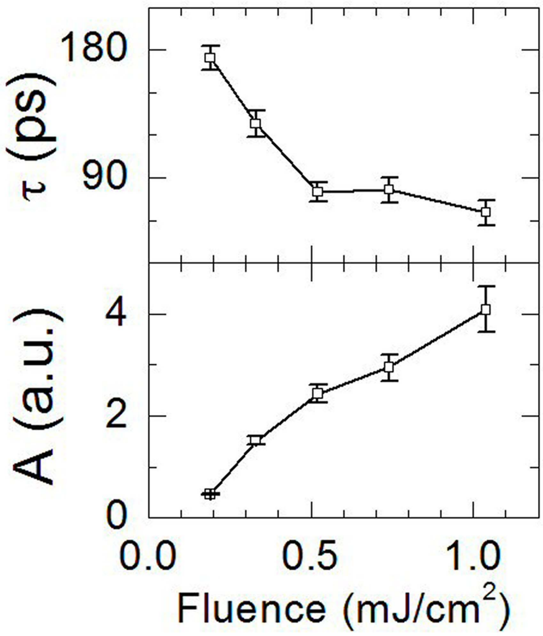

Fig. 1. Relaxation time and initial amplitude of the spin precessional motion are plotted depending on the fluence of the pump beam.