Observation of all-optical switching in Gd/Co ferrimagnetic multilayers by a femtosecond laser pulse

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Development of new high-speed magnetization reversal technology is essential for further increasing the speed and energy efficiency of nonvolatile magnetic memories. In recent years, all-optical switching (AOS) using ultrashort pulse laser has attracted extensive attention due to its potential for realizing ultrafast magnetic memory with speed order of picoseconds and low energy consumption[1)]. Until now, research on AOS has been focused on the ferrimagnetic GdFeCo alloy[2)], but this alloy has problems such as difficulty in controlling the composition-dependent AOS properties and low spin polarization, which harm its application to AOS memory. The development of novel materials capable of AOS is thus anticipated. In this study, we report our recent research activities on achieving AOS in an artificial ferrimagnetic Gd/Co multilayers as novel candidate material for AOS memory applications.

Multilayer thin films consisting of Ta(3 nm)/Pt(3 nm)/Co(0.8 nm)/Gd(3 nm)/Pt(3 nm) with perpendicular magnetic anisotropy were prepared on a thermally oxidized silicon substrates (Fig. 1a) by magnetron sputtering. The AOS experiment was performed using an ultrashort pulse laser with pulse width of 280 fs and wavelength of 1050 nm. The change of the magnetic state before and after the irradiation of the pulse laser was taken by magneto-optical Kerr effect (MOKE) microscope. Fig. 1b shows the differential MOKE image which presents the difference on magnetic state before and after the 1st pulse irradiation, where a bright contrast indicates that magnetic state changes by the single pulse irradiation. Fig. 1c shows the differential MOKE image which presents the difference on magnetic state of the irradiated area after the 1st pulse and 2nd pulse irradiation, where a dark contrast indicates the magnetization changed again after the 2nd pulse irradiation. If we process the differential MOKE image by subtracting the original state from the state after the 2nd pulse irradiation which was shown in Fig. 1d, we found no contrast in the differential image, which confirms the magnetization of the irradiated area was completely recovered after the 2nd pulse irradiation. Those results demonstrate a perfect AOS was achieved in Gd/Co ferrimagnetic multilayers. The energy density dependence of AOS and possible application to AOS magnetic memory will be discussed in detail.

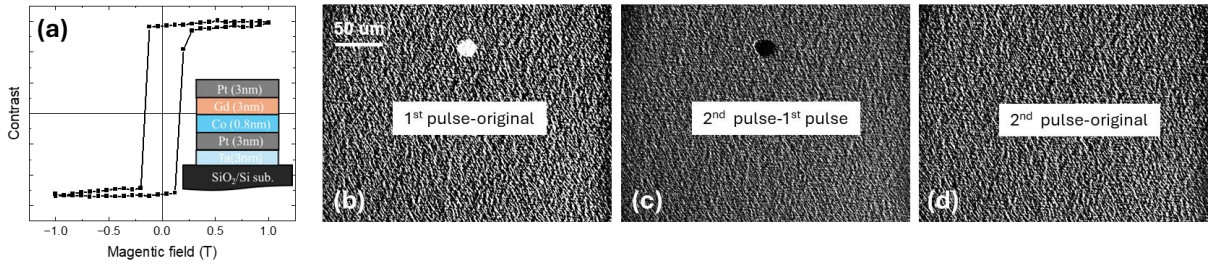

Fig. 1 a) Out-of-plane hysteresis loop taken by MOKE; b)-d) Differential MOKE images.

Reference:

1) A. V. Kimel and Mo Li, Nat. Rev. Mater. **4**, 189 (2019)
2) C. D. Stanciu, F. Hansteen, A. V. Kimel, A. Kirilyuk, A. Tsukamoto, A. Itoh, and Th. Rasing, Phys. Rev. Lett. **99**, 047601 (2007)