Ultrafast manipulation of magnetization by terahertz pulses and terahertz devices based on magnetic materials

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The approaches to investigate spin dynamics and properties using the terahertz pulse and terahertz techniques have been studied actively recently [1-15]. Especially, the usage of the magnetic field component of the high intensity terahertz (THz) pulses [1,16-18] is recognized as a powerful tool for investigating spin dynamics via magnetic dipole interaction. Up to now, we have reported some studies using THz magnetic pulse excitation such as ultrafast spin spectroscopy, the circularly polarized THz wave emission, tunable THz absorber and wave plate, and macroscopic magnetic domain control in the nano-magnet ε-Fe_2O_3 and the weak ferromagnet rare-earth orthoferrites [1-15].

In this presentation, we will introduce recent experimental results of the ultrafast coherent control of the macroscopic magnetizations at spin reorientation phase transition [10], and terahertz emitter and detection using the magnetic materials [11-14]. The trial to demonstrate for the ultrafast spin memory and magnetic recording was reported [15]. We used the high intensity THz pulses with the peak electric field of over 300kV/cm corresponding to the magnetic field of 0.1 Tesla for the spin control. The combination of THz and near IR ultrashort pulse excitation can control the direction of the macroscopic magnetization in the magnetic domain after the spin reorientation phase transition for $ErFeO_3$ [10]. The impulsive response of the magnetization in ε-Fe_2O_3 by THz pulse excitation is observed and the fast and decay rate are ~ 400 fs which corresponds to the time duration of the THz pump pulses [15]. The polarity of the faraday signal reverses for the different directions of the bulk-magnetization, and these facts indicate that the signals are ascribed to the ultrafast response of the magnetization.

Our results indicate that the usage of terahertz magnetic field has a high potential to control the magnetization and magnetic domain with the sub-picoseconds time resolution, and will open a door way to ultrafast THz spintronics.

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