

Enhanced Faraday effect in Tb³⁺-doped xerogels by using Femtosecond laser irradiation process

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Noble-metal nanoparticles exhibit localized surface plasmon resonances (LSPR), in which coherent oscillations of the electrons occur due to the resonance with incident light. Due to the enhanced electric field generated by LSPR, magneto-optical properties of the surrounding material are increased. In this study, we have performed fs-laser irradiation inside transparent silica xerogels additionally doped with Ag⁺ ions to enhance the Faraday effect of Tb³⁺-doped paramagnetic xerogels due to LSPR of Ag nanoparticles (NPs).

Tetraethoxysilane, H₂O, EtOH, Tb(NO₃)₃, and the catalyst HNO₃ were mixed and stirred for 30 minutes. To this solution, a prescribed amount of aqueous AgNO₃ solution was added and vigorously stirred again for 1 h. After gelation at room temperature for 2 weeks, transparent dried gels without cracks were obtained. The concentrations of Tb³⁺ and Ag⁺ ions were varied 1.0-7.0 mol% and 0.3-2.0 mol%, respectively. Obtained gels were subsequently dried at 450 °C in an electric furnace to obtain silica xerogel samples. Transparent xerogels were obtained regardless of the amount of Tb ions added. In contrast, optical absorption in the visible light region increased with increasing concentration of Ag⁺ ions. The xerogel samples were irradiated with a regenerative amplified femtosecond laser (Coherent, Legend, λ= 780 nm, repetition rate: 1 kHz, pulse duration: 120 fs). As shown in Fig. 1(a), the optical absorption spectra indicated that the absorption at the wavelength shorter than 500 nm increased, which corresponds to the LSPR of Ag NPs. Figure 1(b) shows the microscopic Faraday rotation angles as a function of magnetic field for the irradiated and non-irradiated areas of the sample. After irradiation, the Faraday rotation angles for the wavelength of 488 nm were enhanced compared with the non-irradiated areas. These results suggest that femtosecond laser irradiation can enhance the Faraday effect by causing the precipitation of Ag NPs inside paramagnetic Tb-doped xerogels.

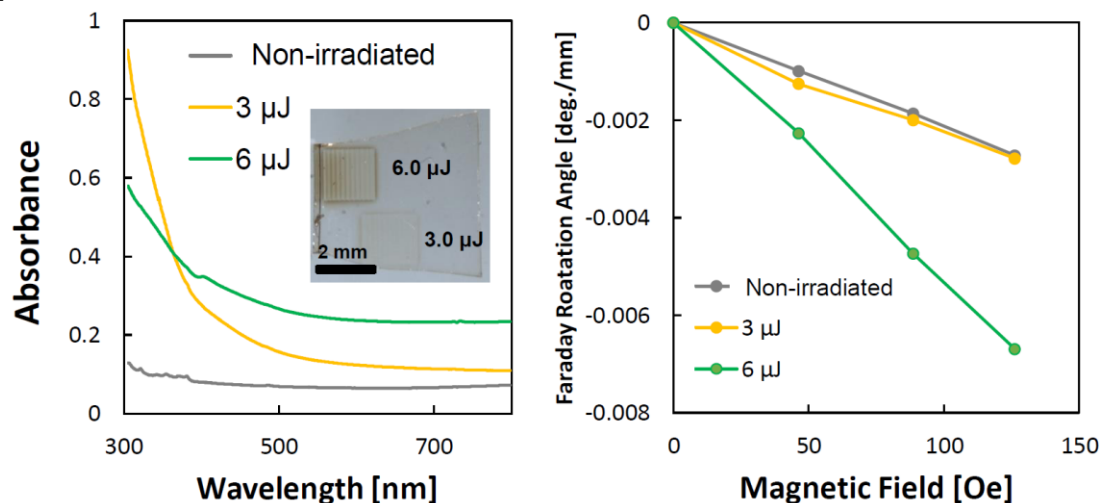


Fig. 1 (a) Optical absorption spectra for laser-irradiated and non-irradiated parts of xerogel samples. (b) Faraday rotation angles as a function of magnetic field for the samples.