Ferrimagnetic high magnetization of metastable $ZnFe_2O_4$ nanoparticles dispersed in xerogels induced by femtosecond laser irradiation

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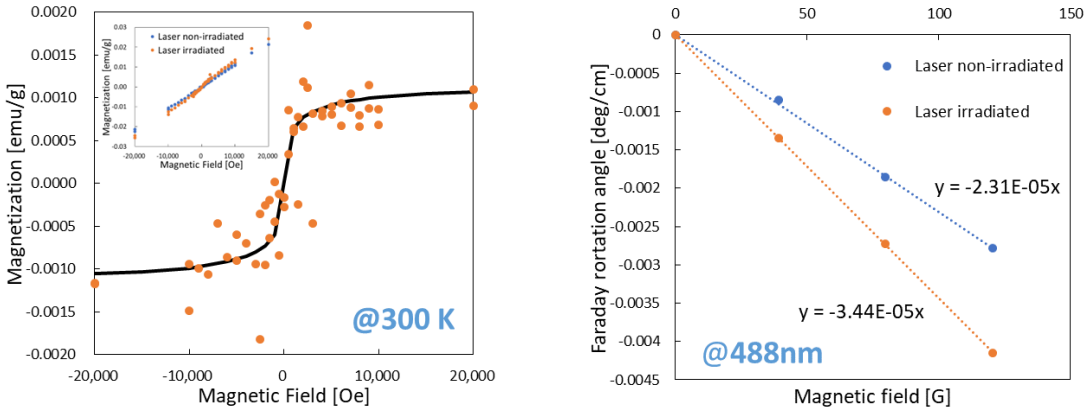
Normal spinel $ZnFe_2O_4$ is an antiferromagnetic material with Neel temperature of 10K. However, it has been reported that the cation distribution of spinel structure becomes random and metastable state by preparing non-equilibrium process such as a sputtering method, resulting in ferrimagnetic high magnetization[1]. In this study, we attempted to induce a magnetic change by metastable phase formation of $ZnFe_2O_4$ nanoparticles by femtosecond laser irradiation inside silica xerogels.

$ZnFe_2O_4$ nanoparticles were prepared by the coprecipitation method. Aqueous NaOH solution was slowly added to an aqueous solution containing $ZnCl_2$ and $FeCl_3$. The particles were then stirred for 100 minutes, centrifuged at 2000 rpm, washed with distilled water, and dispersed in distilled water to improve dispersion by CA coating.Xerogels dispersed with $ZnFe_2O_4$ nanoparticles were prepared using sol-gel method. Subsequently, xerogels were irradiated with a femtosecond laser. The pulse width of the laser used was 150 fs. The repetition frequency was 76 MHz. The pulse energy was 8.6 nJ. Figure 1 (a) plots the magnetic field dependence of the magnetization of irradiated and non-irradiated xerogels. An increase in magnetization and ferrimagnetic saturation magnetization were observed upon laser irradiation. Figure 1 (b) plots the magnetic field dependence of Faraday rotation angle for irradiated and non-irradiated xerogels. Laser irradiation increased the negative rotation angle by 48.9%. This result suggests that a metastable phase of $ZnFe_2O_4$ nanoparticles was induced.



(a) (b)

Figure 1 (a) Difference of magnetic field dependence of magnetization by fs-laser irradiation (inset shows magnetic field dependence of magnetization of fs-laser irradiated xerogel doped with $ZnFe_2O_4$ nanoparticles). (b) Magnetic field dependence of Faraday rotation angle of fs laser irradiated xerogels doped with $ZnFe_2O_4$ nanoparticles.

References:

[1] S. Nakashima, K. Fujita, A. Nakao, K. Tanaka, Y. Shimotsuma, K. Miura, and K. Hirao, Appl. Phys., A Mater. Sci. Process. **94**, 83–88 (2009).