強磁性絶縁体 $BaFeO_3$ 薄膜の時間分解 X 線磁気円二色性の観測, 時間分解共鳴軟 X 線散乱で見た $La_{1/3}Sr_{2/3}FeO_3$ 薄膜における磁気秩序の超高速融解

Time-resolved x-ray magnetic circular dichroism in ferromagnetic insulating $BaFeO_3$ thin films, and ultrafast melting magnetic ordering in $La_{1/3}Sr_{2/3}FeO_3$ thin films observed by time-resolved resonant soft x-ray scattering

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High-valent iron oxides [*e.g.* $BaFeO_3$ (Fe^{4+}), $La_{1/3}Sr_{2/3}FeO_3$ ($Fe^{3.67+}$)] are interesting due to various magnetic phases[1,2]. Insulating $BaFeO_3$ thin films have a ferromagnetic phase below T_c =111 K, while $La_{1/3}Sr_{2/3}FeO_3$ thin films show spin orderings (SO) of $\boldsymbol{q}_{SO}$ = (1/61/61/6), below T_{CD} = 190 K accompanied by charge ordering (CO) of $\boldsymbol{q}_{CO}$ = (1/31/31/3). We carried out pump-probe time-resolved x-ray magnetic circular dichroism (XMCD) measurement on $BaFeO_3$ thin films, and resonant soft x-ray diffraction (RSXD) measurement on $La_{1/3}Sr_{2/3}FeO_3$ thin films in order to investigate the spin dynamics in those compounds. The experiments were conducted at UE56-1_ZPM in BESSY II in Berlin in Germany.

XMCD signals were collected by reflected x-ray from the thin film. The photon energy was fixed to 714 eV for XMCD, corresponding to the maximum of Fe 2*p* XMCD. The pump laser fluence was changed from 3.3 mJ/cm^2 to 10 mJ/cm^2. With the pump power lower than 5 mJ/cm^2, we observed slow demagnetization in $BaFeO_3$ thin films of ~ 150 ps, corresponding to the typical demagnetization time in insulators. There was no change in reflectivity intensity. In higher fluence than 6.6 mJ/cm^2, we observed fast demagnetization faster than time resolution of 70 ps in both reflectivity and XMCD. The unusual fast changes in reflectivity and XMCD intensities for an insulator suggest insulator-to-metal transition in $BaFeO_3$ thin films.

RSXD measurement on $La_{1/3}Sr_{2/3}FeO_3$ thin films used the laser slicing technique, which provides the time resolution of 130 fs. Delay scans for SO peak are probed by soft x-ray ($h\nu_{probe}$ = 710 eV, Fe 2$p_{3/2}$ resonance), with various pump fluences of Ti-sapphire laser ($h\nu_{pump}$ = 1.55 eV). The time constants of decay of SO for each fluence are faster than the time resolution of 130 fs. This unusual fast demagnetization originates from the charge redistribution in CO. This research was supported by MEXT through the XFEL Priority Strategy program.

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