Magnetic dynamics study by soft X-ray photoemission electron microscopy

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By combining synchrotron radiation soft X-rays with Photoemission electron microscopy (PEEM), contrast maps based on X-ray absorption fine structures (XAFS) as well as X-ray magnetic circular/linear dichroism (XMCD/XMLD) can be obtained with the spatial resolution in the order of 10-100 nm.

In SPring-8, we possess two PEEM machines. While a spectroscopic photoemission/low-energy electron microscope (SPELEEMIII, ELMITEC GmbH) equipped in BL17SU beamline is widely used for electronic- or magnetic-states analysis of a variety of materials, taking advantage of high spatial resolution and various measurement functions (e.g. nano-XAS, micro-XPS and micro-LEED), a compact and versatile PEEM (PEEMSPECTOR, ELMITEC GmbH) in BL25SU plays an effective role in time-resolved imaging by pump-probe method (time resolution 50-100 ps). So far, we have performed dynamics analysis of magnetic vortex cores excited by pulses or radiofrequencies[1,2], ultrafast magnetization switching dynamics under the excitation by femtosecond laser pulses[3], and so on. Particularly in magnetic dynamics of ferrimagnetic GdFeCo films by pulsed laser excitation, we discovered giant propagating spin waves whose gyration angle reaching ±20°, given that the damping parameter of the magnetizations is suppressed and gyrotropic motion lasts long (that is to say, under the condition not appropriate for "ultrafast" magnetization switching)(Fig.1). These spin waves are suggested to be created as a consequence of strong spin-phonon coupling and further analysis is now in progress.

We are also developing new measurement systems for advanced spectroscopic and dynamics studies. For example, a prototype of complete co-axial sample cartridge for PEEM showed transmission capacity up to 5 GHz. This system is expected to be utilized for e.g. domain wall dynamics analysis or element-selective nano-FMR.

In this talk, principle of time-resolved PEEM using synchrotron radiation soft X-rays and examples of utilization researches as well as recent status of system development will be reviewed.

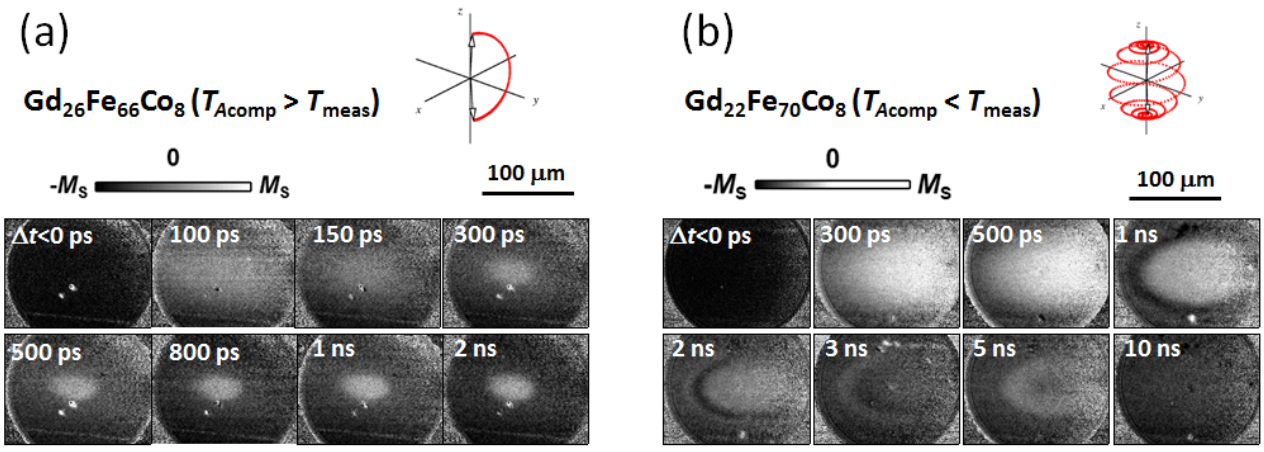

Fig.1 Time resolved Gd_M_5-edge XMCD-PEEM images of GdFeCo films promptly after pulsed laser excitation. (a) swift magnetization reversal (condition of strong precession damping) and (b) long-range spin wave propagation (prolonged spin gyration).

References

1) K. Arai et al. Jpn. J. Appl. Phys. 50 (2011) 053001.
2) T. Ohkochi et al. Jpn. J. Appl. Phys. 51 (2012) 128001.
3) T. Ohkochi et al. Jpn. J. Appl. Phys. 51 (2012) 073001.