Science at FELs
2014 at Paul Scherrer Institute

PAUL SCHERRER INSTITUT PSI

Contribution ID: **3** Type: **Contributed Talk**

Imaging ultrafast demagnetization dynamics after a spatially localized optical excitation

Monday, 15 September 2014 14:35 (25 minutes)

Ultrashort, coherent x-ray pulses of a free-electron laser are used to holographically image the femtosecond magnetization dynamics within a magnetic domain pattern after creation of a localized optical excitation.
The time resolved experiment was carried out at the DIPROI beamline at the free electron Laser facility FERMI in Trieste, Italy. Circularly polarized, coherent, 100 fs long, soft x-ray pulses tuned to the M-edge of Cobalt at 20.8 nm were used to image the magnetic domain pattern via Fourier Transform holography exploiting x-ray circular magnetic dichroism. The sample consisted of a magnetic Co/Pd multilayer on a gold mask with an elliptical object hole (2.4x1.2μm²) and reference holes with 50 nm diameter. The synchronized infrared pump pulses, incident under 45 deg., were reflected and focused by the curved shape of the elliptical object hole leading to a standing wave with a pronounced electric field enhancement with a spatial extent of approx. 150x150nm².
With a sub-100 nm spatial resolution we observed a laterally confined reduction of the magnetization within a couple of hundred femtoseconds followed by its recovery on a slower time scale. Additionally, the experimental results show evidence of a spatial evolution of magnetization, which we attribute to ultrafast transport of non-equilibrium spin polarized electrons for early times and to a fluence dependent re-magnetization rate for later times.

C. von Korff Schmising et al., PRL 2014 (in press)

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Session Classification: Condensed Matter 1

Track Classification: Condensed Matter