Exploring nanomagnetism with soft X-ray microscopy

Peter Fischer

Center for X-ray Optics, Lawrence Berkeley National Laboratory
1 Cyclotron Road, Berkeley CA 94720, USA,
PJFischer@lbl.gov

The challenge to modern magnetic microscopies is provide both spatial resolution in the nanometer regime, a time resolution on a ps to fs scale and elemental specificity which allows to study multicomponent magnetic nanostructures and their ultrafast spin dynamics which is of both fundamental and technological interest.

Magnetic transmission soft X-ray microscopy is a powerful novel technique that combines X-ray magnetic circular dichroism (X-MCD) used as huge and element specific magnetic contrast mechanism with high spatial and temporal resolution. Fresnel zone plates used as X-ray optical elements provide a spatial resolution down to currently <15nm which approaches fundamental magnetic length scales such as the grain size and magnetic exchange lengths [1,2]. As a pure photon-in/photon-out based technique the images can be recorded in external magnetic fields giving access to study magnetization reversal phenomena on the nanoscale. Circularly polarized X-rays are available at current synchrotron sources with an inherent time structure which is only limited by the lengths of the electron bunches in the storage ring.Thus fast magnetization dynamics with 70ps time resolution can be performed with a stroboscopic pump-probe scheme [3].

In this talk I will give an introduction into high resolution magnetic soft X-ray microscopy and review its outstanding capabilities with respect to lateral and temporal resolution by selected examples on magnetic multilayers, nanostructured systems, nanowires and nanoparticles [4].

I will point out the perspectives of magnetic soft X-ray microscopy aiming for <10nm spatial and fs time resolution which will be feasible with the next generation of X-ray optics and at high brillant fs X-ray Sources such as X-ray Free Electron Lasers where single shot images of fs spin dynamics can be envisioned.

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