How Can One See Nanomagnets?

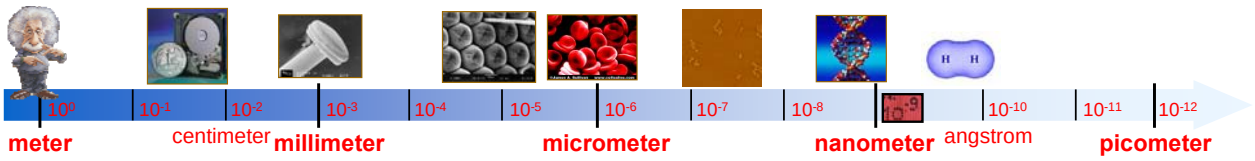
Imaging of nanostructured magnetic materials by Photoemission Electron Microscopy

X. M. Cheng, X. F. Han, and David J. Keavney
X-ray Science Division, Advance Photon Source

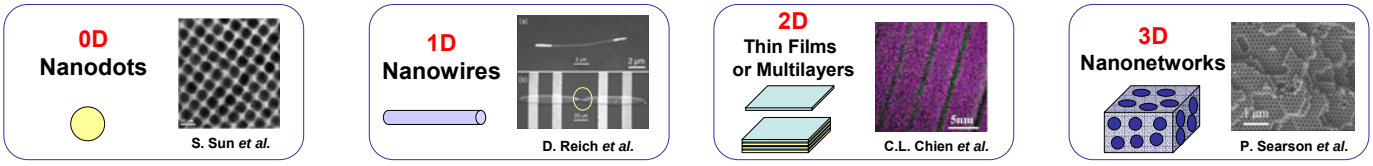
Nanomagnets have been of great interest because of their promising applications in data storage and biomedical engineering. Direct observation of nanostructured magnetic structures is the key to developing and exploring novel magnets. Photoemission electron microscopy (PEEM) can be used to image the magnetic configuration of nanostructured magnetic materials with varying shapes, sizes and chemical components. Time resolved PEEM is a powerful tool for studies on dynamics of nanostructured magnetic materials.

Nano : the prefix for 10^{-9}

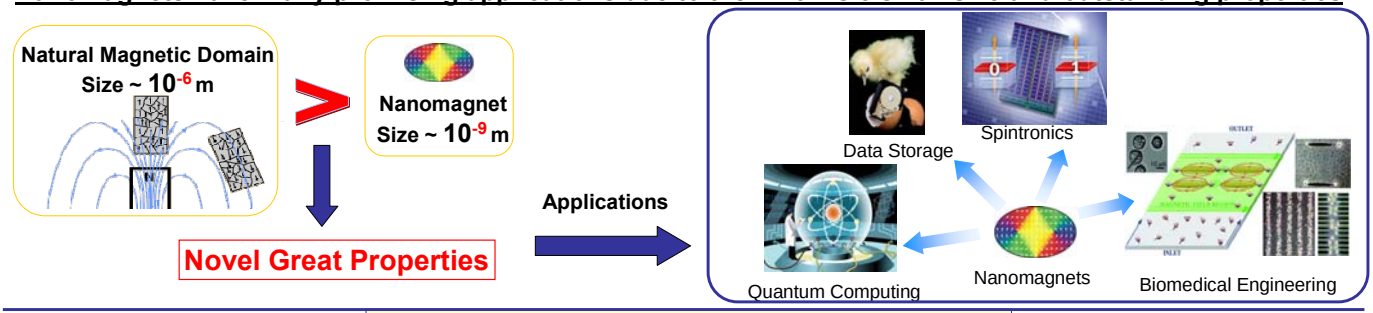
Why Nanomagnets?



Nanomagnets: Magnetic materials with one or more dimensions reduced to nano-scale



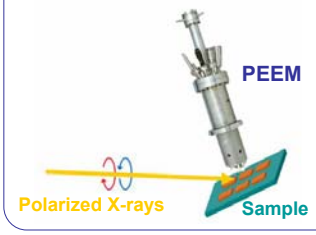
Nanomagnets have many promising applications due to their intrinsic small size and outstanding properties



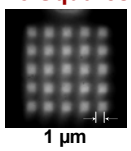
How to See Nanomagnets?

PEEM Imaging of Magnetic Nanostructures

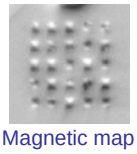
Photoemission Electron Microscope (PEEM)
-- one type of electron microscope, which can image nano-scaled magnetic structure when using polarized X-rays to excite electrons from sample surface.



Co Squares

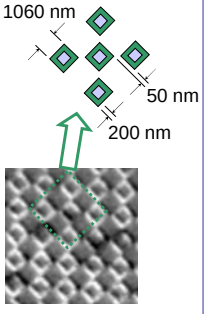


Chemical map



Magnetic map

NiFe Rings

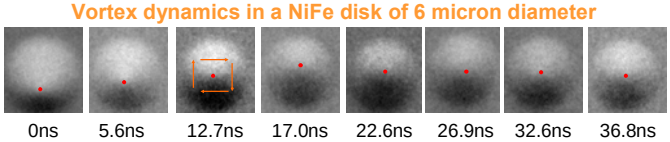


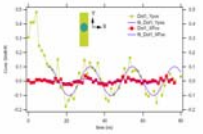
- ❑Chemical and Magnetic Contrast
- ❑~100 nm spatial resolution

Time Resolved PEEM Studies of Vortex Dynamics

PEEM at Advanced Photon Source (APS)/4IDC can image super fast dynamic process because the synchrotron X-ray at APS has the working mode with the pulse as short as 90 picoseconds (ps).

Vortex dynamics in a NiFe disk of 6 micron diameter





Magnetic Vortex State

The spins in a micron scaled magnetic disk can form a Vortex state.

Conclusions

- ❑ PEEM can be used to image nanomagnets with about 100nm spatial resolution.
- ❑ Time resolved PEEM can be used to study magnetic dynamic process with 100 ps temporal resolution.

References:
For recent time resolved PEEM work, see S.B. Choe et al., Science **304**, 420(2004) and K.Yu. Guslienko et al., Phys. Rev. Lett. **96**, 067205(2006).
For more information on PEEM at APS/4IDC, see http://www.aps.anl.gov/Sector4/science/programs/peem.php

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