Mesoscale Priority Research Direction

Advanced Characterization of Mesoscopic Materials

Opportunity

Combining a knowledge of the atomic, electronic, and thermodynamic properties of a system as derived from new methods of characterization is essential for bridging the gap between nano and mesoscale phenomena and being able to design novel structures for various applications from spintronics to energy production to environmental control.

Meso Challenge

As an example, in spintronics, nanoscale multilayer structures must be integrated into mesoscale multi-material ensembles capable of memory and logic. Performance is critically linked to the individual elements and the interfaces between them. The same is true for many mesoscale energy and environmental systems.

Approach

Our approach is based on combining advanced characterization methods using x-ray and photoelectron scattering, spectroscopy and microscopy, as well as micro- and nano-calorimetry. A more capable x-ray microscope with full-field time-resolved imaging and dedicated facilities for standing-wave hard x-ray photoemission and resonant x-ray scattering will be combined with more accurate modeling of both scattering and spectroscopy.

Impact

The development and combined application of these new tools and modeling capabilities will permit characterizing and designing mesoscale materials and structures from the atomic to the micron scale, not only in spintronics, but in other areas such as photovoltaics, batteries, and fuel cells.

References:
Hellman et al., Rev. Sci. Inst. 79, 053902 (2008); Fischer, Mat. Sci. & Eng.-Reports 72, 81 (2011);
Kortright et al., J.Magn. & Magn. Mat. 319, 13 (2007); Fadley, J. Electron Spectr. 178–179, 2 (2010).

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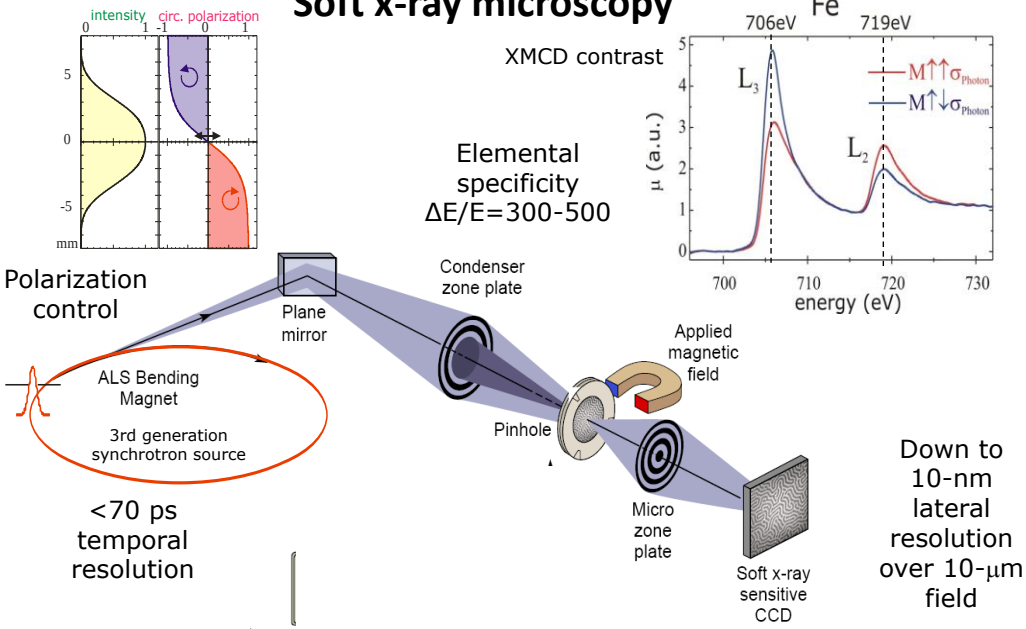
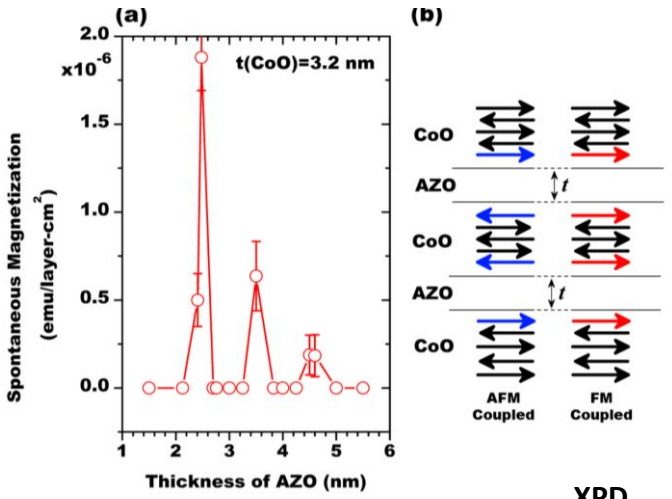
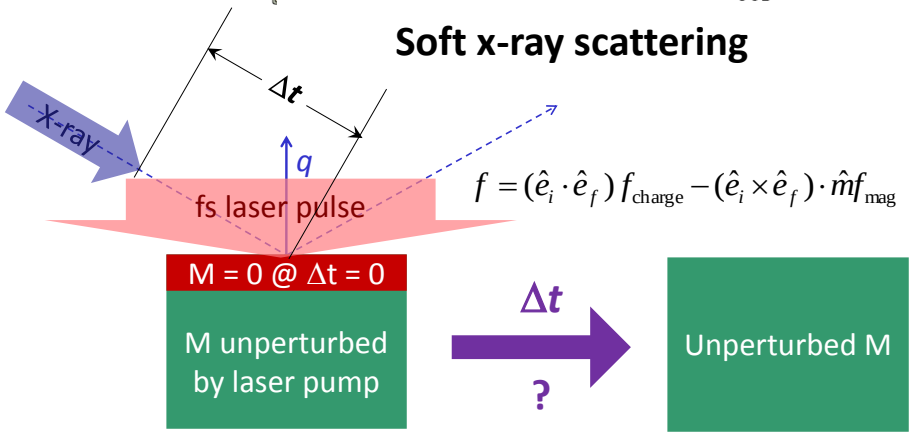
Soft x-ray microscopy



Micro- and nano-calorimetry/magnetometry

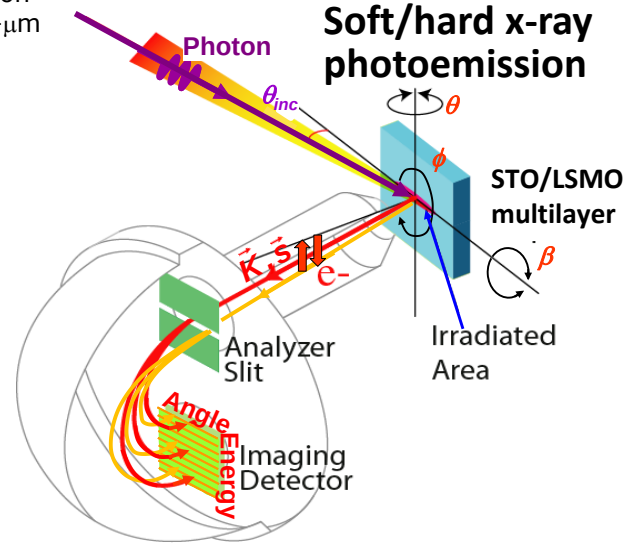


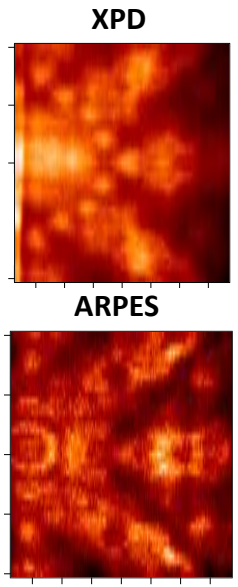
Soft x-ray scattering



$$f = (\hat{e}_i \cdot \hat{e}_f) f_{charge} - (\hat{e}_i \times \hat{e}_f) \cdot \hat{m} f_{mag}$$

Soft/hard x-ray photoemission





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