APPLICATION OF SCANNING TRANSMISSION X-RAY MICROSCOPY IN NATURAL SCIENCE

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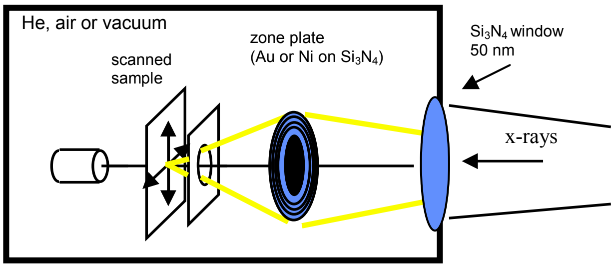

Figure 1. STXM basics.

Scanning x-ray transmission microscope (STXM) became during last few years an important tools in applying soft x-ray spectroscopy to many scientific disciplines. When STXM is placed on a modern beamline of the third generation synchrotron it allows for chemical characterization of materials and processes on 20 nm scale. It is a microscope, thus it produces images, but its strength is ability to do high quality spectroscopy on that scale.

In STXM x-rays are focused using a Fresnel zone plate and the sample is mechanically scanned in the zone plate focal plane. Transmitted x-rays are detected by a single element detector and the detector signal as a function of the sample position constitutes an image. Recording images at different x-ray energies around absorption edges of a given element allows obtaining spectroscopic information for each of image pixels [1].

At the Advanced Light Source there are three STXMs. One is placed on a bending magnet beamline and operates between 250 eV and 600 eV. The most versatile one is on the 11.0.2 beamline with an elliptically polarizing undulator as a source and operates between 80 eV and 2100 eV. This x-ray range covers absorption edges of most common elements. The third STXM is a portable microscope which can be used on many different beamlines.

Resolution of a STXM depends on the used zone plates. Current ALS zone plates can resolve details smaller than 20 nm. Samples preparation can be similar to that for a TEM, but because the sample can be at full atmospheric pressure of He (or air for some x-ray energies) they can be "wet", fully hydrated, a huge advantage for biological or environmental sample studies.

The 11.0.2 STXM can take advantage of elliptically polarized light. Magnetic sensitivity is provided by the X-ray Magnetic Circular Dichroism (XMCD) effect of resonance x-ray absorption at the absorption edges. As such, it is an element specific magnetization measurement with high sensitivity. It is possible to measure a single monolayer of element with full spatial resolution. This is well illustrated in studies of ferromagnetic effect of carbon [2]. Elemental specificity of the measurements allow on separate characterization of different layers in complex structures. By measuring a sample in few different orientations with respect to the x-ray beam it is possible not only to obtain a value of magnetic moment but also its direction on scale of 20 nm.

The x-ray beam has a time structure of bursts with a duration of 70 ps and frequency 500 MHz. Fast, direct x-ray photon detection using an avalanche photodiode results in about 100 ps time resolution of the measurements. The magnetization dynamics studies on sub-micrometer complex samples are one of the most unique applications of the STXM. Detail motion of vortex core under various excitations can be observed [3]. Imaging of spin transfer switching gave new insights into a combined role of spin transfer and charge current in the switching process.

STXM found a very wide application in polymer science, where a high chemical sensitivity combined with a good spatial resolution and relatively low radiation damage makes it a very important tool in studies today's complex polymers. Other common applications are environmental studies, especially of a role of bacteria.

References

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