3-D Elemental Imaging by Synchrotron Computed Microtomography

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Computed microtomography is the extension to micron spatial resolution of the CAT scanning technique developed for medical imaging. Synchrotron sources are ideal for the method, since they provide a monochromatic, parallel beam with high intensity. At the GSECARS facility at the Advanced Photon Source we have used two methods to obtain quantitative element-specific information from computed microtomography[1]. The principal advantage of computed tomography for elemental mapping is the non-destructive nature of the technique: samples do not have to be physically sectioned.

In **digital subtraction tomography** two data sets are collected, one just above the x-ray absorption edge of the element to be imaged, and the other just below the absorption edge. The contrast in the difference between the two data sets is almost entirely due to the presence of the element of interest. This technique is very rapid because 2-D images are collected with a CCD detector at each projection angle. Because digital subtraction tomography images the difference in attenuation due to the element of interest, the detection limit is a strong function of atomic number, and it is generally limited to elements present at 0.1% or greater. There is also a limitation on the range of elements that can be imaged, since there must be an absorption edge within the x-ray energy range which can penetrate the sample. This is a function of both the size and overall composition of the sample.

In **fluorescence microtomography** a finely focused x-ray beam is used and the fluorescence from one or more elements in the sample is measured, typically with an energy-dispersive detector. This technique can be used to measure elements which are present at ppm concentrations. At each projection angle the line integral of the fluorescence along the beam inside the sample is measured. A single tomographic slice is collected by translating and rotating the sample on a 2-D grid. The spatial resolution of this technique is limited only by the size of the focused x-ray beam, which can be less than 1 micron. A significant requirement of the method is that the absorption of the fluorescent x-rays within the sample must be small. The elements that can be measured are therefore a strong function of the bulk composition and size of the sample.

References

[1] Rivers, M.L., Wang Y., Uchida, T. (2004), *Proceedings of SPIE, Developments in X-Ray Tomography IY*, 5535, 783-791.