X-rays in 3D

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The ability to co-register multiple 2D imaging techniques is practiced in the materials science community overlaying FT-IR with XRF and/or NIR, overlaying SEM EDS images with Raman, or FT-IR with CT. Overlaying 3D data sets from different instrumentation is in the early stages of development. Typically performed in the medical community, the fusion of PET with MRI can be used to locate and identify abnormalities more accurately for better patient diagnosis. Two important, non-destructive 3D imaging techniques that are used to provide complementary characterization of materials are micro x-ray fluorescence (MXRF) and micro x-ray computed tomography (MXCT). Performed in a synchrotron, these techniques can produce very high resolution (MXCT) and elementally specific (MXRF) information on the sample which can be used to determine both structure and elemental composition.

Laboratory based confocal MXRF and MXCT instruments are used to examine a variety of materials, bulk or structured and finished products. Confocal MXRF uses a broad band x-ray tube source and a fused silica polycapillary to focus the x-rays on the sample. A Si-pin diode detector with a polycapillary is used to collect the fluorescent and scattered x-rays on the detection side. Using an optic on both the source and detector creates a ‘confocal’ volume which can be rastered through the sample; providing elemental data nondestructively in 3D with a resolution of approximately 30 x 30 x 65 µm. Although the technique is slow, each voxel of data is physically measured and collected successively, a 1-mm volume of data requires approximately 24 hours of instrument time; elementally specific information is acquired. Micro XCT uses a micro focus x-ray source to shine a cone beam of x-rays through the sample onto a scintillator and a CCD camera. The sample is rotated while radiographs are collected which are then reconstructed into a 3D rendering of the sample. Using this technique, data sets with sub-micron voxel sizes are possible; no elemental discrimination on the sample is possible. A custom graphical user interface can be used to co-register and overlay these two different data sets in 3D.

In this presentation we will present several examples of materials and manufactured products demonstrating how they are characterized using co-registered 3D x-ray imaging in the laboratory. Samples to be presented include a surface mount resistor and inertial confinement fusion targets. Data will be presented showing how the information from each of the techniques improves the utility of the other.