Characterizing Hard to Soft Materials with a novel Multiscale, multi-energy X-ray Microscopy (XRM)

ABSTRACT

Lab based X-ray microscopy (XRM) has emerged as an important 3D characterization tool in the past several years, driven by the need for non-invasive and higher resolution imaging for a variety of industrial to academic applications, from material science, geological science, engineered materials to electronic devices. In the nanoscale, resolution of 50 nm has been reported for hard materials with lab nanotomography systems. However, there is still a gap in the non-invasive 3D nanoimaging of soft materials such as carbon fibers, carbon black, polymer to biological tissue and cells because of the lack of contrast with hard X-rays. In this talk we are presenting a novel lab based nanoXRM system comprising multi energies with 8 kV, 5.4kV and 2.7 kV which makes it possible for hard materials (such as rocks, engineered materials, battery and fuel cells) or soft materials (polymers, carbon fibers to biological tissue) to be studied in a single tool and with resolution < 40 nm.

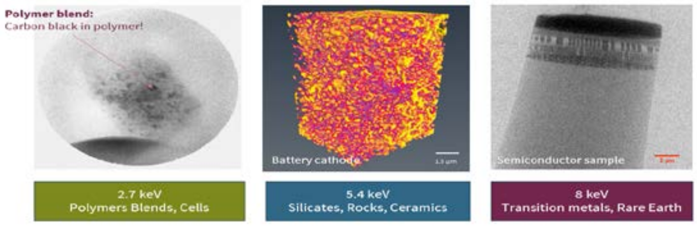

Figure 1: Lab X-ray nanotomography with energy tunability- for Hard to soft Materials

In the larger lengthscale micron to sub-micron resolution XRM, improvements are continued to be made in resolution and throughput. Currently, the best resolution achieved in commercial XRM is around 0.5 um spatial resolution. However, there are still gaps in conventional XRM based on absorption contrast. For example, it is very challenging to image soft materials, such as unstained biological tissue, polymer composites, carbon fibers or the low contrast phases and pores in engineered materials. It is also challenging to differentiate between the multi-phases within a fluid flow experiment. These materials are challenging to characterize regardless of the type of imaging modalities currently available in the lab. This has led to the development of various X-ray phase contrast techniques in the synchrotron and the grating-based Talbot-Lau interferometry seems to be very promising. In this technique, Absorption, Phase and Darkfield/Scattered Contrast images are acquired simultaneously. However, this technique is very challenging to implement in a lab system because the introduction of multiple gratings causes a significant loss of flux and limits its field of view substantially. In this presentation we will discuss how we overcame these issues to successfully integrate Talbot interferometry into our sub-micron resolution XRM. Solutions to challenging imaging problems from carbon fiber reinforced polymers (CFRP), biological tissue, Li-battery cell, to electronic devices will be presented. By combining these two novel XRM in a Central Imaging Lab, we envision multiscale and multienergy tomography can be accomplished for a variety of specimen, regardless of whether they are hard or soft materials.

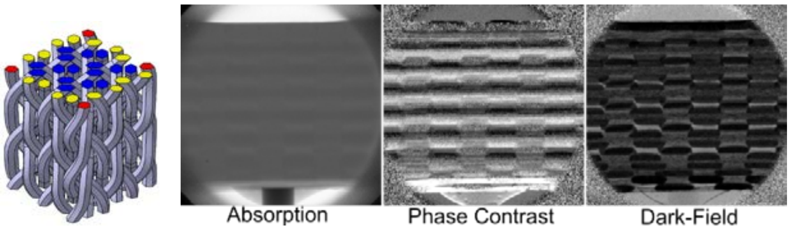

Figure 2: Talbot Tomography of CFRP (Carbon Fiber Reinforced Polymer) with Three Contrast Imaging

SPEAKER'S BIO

S.H. Lau, has over 20 years' experience in microscopy, material characterization and instrumentation in diverse applications from material science research, oil and gas, tissue engineering, geoscience and semiconductor failure analysis,. He has published several papers in material characterization and imaging in the field of X-ray Microscopy. He existed from Xradia after the company was acquired by Carl Zeiss in 2013 to become the latter's X-ray microscopy division. He is now the Vice President of Business Development in Sigray Inc, USA, pioneering the development of ultra brightness, tunable x-ray sources and advanced x-ray optics for lab instrumentation and synchrotron applications