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Development of a Wide-Range X-ray Emission Spectroscopy Measurement System with Transition Edge Sensors and Microwave Multiplexed Readout

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High-resolution X-ray emission spectroscopy (XES) can offer element-specific insight into the oxidation state and chemical environment of a compound through energy shifts in emission peaks and their minor satellites. Compared to X-ray absorption spectroscopy, emission spectroscopy is less developed from both a theoretical and practical standpoint, and the ~ 1 eV shifts demand detectors with high energy resolution and high efficiency. As part of the LANL Hyperspectral X-ray Imaging (HXI) project, we are commissioning a workstation for high-resolution X-ray emission spectroscopy of samples from 0.2 – 15 keV using transition edge sensors (TESes) to catalog the variation of peak and satellite shifts and develop accurate theoretical models applicable to XES. The TES detector array from NIST is installed in a High Precision Devices model 107 cryostat with 128-channel microwave multiplexed readout. The 240-pixel array is an equal mix of low- and high-dynamic range pixels to cover the full energy range to 15 keV, with 2 eV FWHM resolution at 1.25 keV on the low-range pixels and an expected 5 eV resolution at 6 keV for the high-range pixels. A mix of low- and high-range pixels may be bonded to the 128-channel readout. A UHV sample chamber attached to the bottom of the cryostat holds multiple sample stubs for X-ray excitation with either low- or high-energy X-ray generators (maximum emission of 15 keV and 50 keV respectively). The sample chamber vacuum is isolated from the cryostat vacuum by a LuxelHT window that (combined with three 100 nm-thick Al IR filters) gives 5.2% transmission at the 277 eV C K line. This system will allow the XES measurement of a wide range of transition metal and actinide samples with simultaneous access to multiple metal and ligand emission bands to support the analysis of HXI data from the future HXI project SEM/TES.

Less than 5 years of experience since completion of Ph.D

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