**Novel, High Brightness X-ray Source and High Efficiency X-ray Optics for a New Generation of X-ray Instrumentation**

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In the past two decades, laboratory x-ray analysis equipment has made significant strides, particularly toward higher resolution capabilities [1-2]. The major bottleneck to continued advances to simultaneously achieving higher sensitivity, resolution, and throughput is the relatively low flux of x-rays at the sample, particularly for micro-characterization techniques such as SAXS, high resolution XRD, microXRF, and x-ray microscopy [3]. We present two major innovations: a microfocus x-ray source (FAAST™) and a high resolution, high efficiency double paraboloidal x-ray mirror lens to enable delivery of flux comparable to third generation bending magnet synchrotrons.

The patent-pending Sigray FAAST™ (fine array anode source technology) x-ray source features an anode comprised of arrays of microstructured metal (e.g. Cu, Au) x-ray emitters embedded in a diamond substrate, which enables highly localized and large thermal gradients to passively and rapidly cool the metal microstructures as x-rays and heat are generated under the bombardment of electrons. Electron power densities of over 4X can be achieved on the target in comparison with conventional solid metal targets for the case of copper – and even greater for metals of lower thermal conductivity. The thermal advantages of the anode design will enable the use of many elements that were previously considered unfeasible as x-ray source materials, and therefore will enable access to new x-ray characteristic lines to optimize performance in monochromatic x-ray analysis. The source enables linear accumulation of x-rays along a set of microstructures, which further increases the substantial brightness gain.

We will also discuss advances made to Sigray’s proprietary high resolution double paraboloidal x-ray mirror lens designs, which enable <8 µm focusing onto a single spot with high efficiency. These x-ray mirror lenses were designed to preserve the brightness of the new, ultrahigh brightness sources, including: Sigray’s FAAST™ source, transmission nanofocus sources, laser plasma sources, and liquid metal jet anode x-ray sources, in transporting the X-ray beam from source to sample. The optics performance will be reviewed, particularly in regard to key optics performance attributes needed for optimization in microanalytical applications, including: transmission efficiency, numerical aperture (NA), FWHM of point spread function, working distance, focus chromaticity, energy bandpass, energy transmission, percent of source brightness preservation, and phase space acceptance.

Examples of the unique advantages of the paraboloidal x-ray mirror lenses include that they produce a single, fixed focal spot over a wide band of x-ray energies, unlike many commonly employed non-imaging x-ray optics such as polycapillary x-ray optics (which produce concentric “focal spots” of sizes inversely proportional to x-ray energy). This achromatic nature is essential for enabling high accuracy in microanalytical measurements using polychromatic laboratory x-ray sources, as many well-developed algorithms for applications such as microXRF, microXRD, and microSAXS assume a single focal spot at the sample. In addition, another key benefit of the double paraboloidal x-ray mirror lens is its constant magnification, even for off-axis x-rays, providing significant advantages over optics such as ellipsoidal single-bounce imaging optics. Future potential developments of the x-ray source and the optics designs will be discussed, including further resolution improvements and low x-ray energy optics capabilities, such as focusing of low keV x-rays for excitation of low Z elements and the L&M lines of higher Z elements.