Micron-scale Confocal X-ray Fluorescence Microscopy Using Collimating Channel Arrays

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Confocal X-ray Fluorescence Microscopy (CXRF) employs overlapping focal regions of two x-ray optics—a condenser and collector—to directly probe a 3D volume in space. Until recently, the exclusive choice for the collection optic for CXRF has been a polycapillary, owing to its large solid angle of collection. In recent years, collimating channel arrays (CCAs) [1], have emerged as a practical, higher-resolution alternative to polycapillaries for CXRF. CCAs, designed and fabricated at CHESS consist of micron-scale, lithographically-fabricated arrays of collimating channels (Fig. 1), all directed towards a single source position. Compared to polycapillaries, the spatial resolution of these optics is both smaller and nearly energy-independent, greatly enhancing the potential range of application of CXRF. In particular, employing CCAs enables confocal XRF with a critical dimension of approximately 2 microns at energies ranging from 2-30 keV. Since 2014, CXRF with CCAs as the collection optic has been offered for general users at APS ID20, resulting in publications on a wide variety of topics, from biology to cultural heritage [2-4]. After reviewing the principles and applications of CXRF with CCAs as well as CCA fabrication, current development efforts will be discussed. In addition to efforts to improve the solid angle of collection and thus the efficiency of CCA-based CXRF, we have recently demonstrated CXRF with a subset of detection elements comprising a 384-element Maia detector. A custom holder for the CCA is designed to mate to the beveled exit window of the Maia detector, and includes manual degrees of freedom to allow the CCA array to be aligned to the aperture in the Maia. After this initial manual alignment, the holder can be removed and replaced, allowing switching between 2D and 3D modes within 5-10 minutes. Detailed initial results will be presented, in addition to remaining challenges, prospects for improved performance, and potential applications.

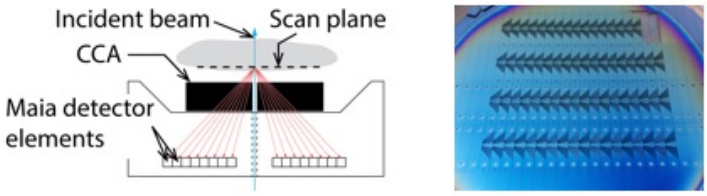

Figure: (left) schematic of a CCA in conjunction with a Maia detector, showing the geometry of operation. (right) photograph of patterned, etched, Maia CCAs.

References

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