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Design, Fabrication, and Testing of Refractive Axicons for X-ray Microscopy Applications

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Full-field Transmission X-ray Microscopy (TXM) is a powerful imaging technique widely used in material, energy, and biological sciences. Synchrotron-based TXM systems offer exceptional spatial resolution in the tens of nanometers range, along with remarkable three-dimensional non-destructive nanoimaging capabilities. A crucial component in TXM setups is the condenser, which can be of different type such as glass capillaries or diffractive beam shaping condensers. This optical component is responsible for converging the x-ray beam to illuminate the sample area.

With synchrotron facilities worldwide undergoing upgrades towards low-emittance sources, TXM systems face new challenges and opportunities. Shrinking x-ray beam dimensions demand innovative approaches in fabricating condenser elements to match their reduced size effectively. Additionally, reduced beam divergence from these advanced sources may constrain the numerical aperture of TXM systems, potentially affecting overall resolution.

This study introduces a novel approach utilizing refractive axicons to shape the incoming x-ray beam, matching it with the combined ring-shaped aperture of a condenser and the central stop. Through a comprehensive design approach, incorporating analytical methodologies and numerical simulations, we demonstrate the efficacy of cone and sawtooth axicons in shaping x-ray beams for optimal performance across a range of photon energies and source sizes.

Experimental validation, conducted at the TOMCAT beamline of the Swiss Light Source, showcases the practical implementation of cone and sawtooth axicons manufactured via cutting-edge two-photon polymerization 3D printing techniques. Our results indicate the relative merits of each axicon design, highlighting factors such as sensitivity to photon energy drifts and intensity distribution uniformity. Importantly, these findings serve as a blueprint for designing and optimizing TXM systems tailored for next-generation light sources, including upcoming facilities like I-TOMCAT and others undergoing synchrotron upgrades worldwide, to empower the broader synchrotron community in harnessing the full potential of TXM for advanced scientific investigations.

Reference

I plan to submit also conference proceedings

No

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