Diamonds for X-ray lensens

JJ X-ray A/S design, produce, and install hardware for X-ray and neutron sources. They are in the process of developing compound refractive lenses (CRLs) of diamond which has the potential of improving the beam quality on X-ray beamlines and could be a vital component in the next generation of X-ray instruments at synchrotron sources and free electron lasers. In this project, researchers from University of Copenhagen and Technical University of Denmark collaborated with JJ X-ray to study X-ray lenses made of diamond. The usefulness of diamonds of different type and price was studied, and diamond lenses produced by laser ablation were investigated with Small-Angle X-ray Scattering (SAXS) and X-ray micro Computed Tomography (CT) to determine if they meet the quality requirements necessary to provide good lenses for X-ray beamlines.

Challenge

In order to lower the price of CRLs made from diamond, yellow diamonds containing nitrogen inpurities, can be used. However, it could be a concern that these less pure diamonds produce parasitic scattering, that could be problematic for their use in X-ray optics. In order to obtain a comparable quality, JJ X-ray improved the laser ablation process to produce the lenses more reliably and faster. SAXS was used to investigate the scattering of the lenses, while X-ray CT was used to study the shape and surface roughness of the lenses in a 3D volume.

Collaboration

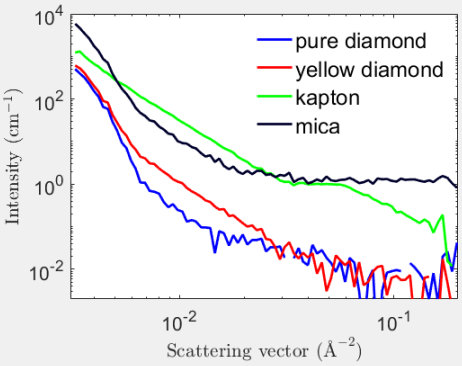
In order to analyse the lenses, JJ X-ray entered a collaboration with the Niels Bohr Insitute at University of Copenhagen and the 3D Imaging Centre at DTU.

Results

In small-angle X-ray scattering (SAXS) experiments at the Niels Bohr Institute, scattering of cheap yellow diamonds was compared to that of pure diamonds, and to other materials that are often found in an X-ray beam. This parasitic scattering should be minimized as much as possible, and the experiments show that in many cases the cheaper yellow diamonds will provide a sufficiently low background. Estimating the surface roughness in the CT images is challenging as the roughness is on the same scale as the best achievable resolution with in-house micro CT measurements at the 3D Imaging Centre at DTU. Validating the lens shape however, is feasible and can be achieved by fitting the CT data with the intended lens shape. Both analyses techniques therefore showed that JJ X-ray managed to produce new high-quality lenses from yellow diamonds

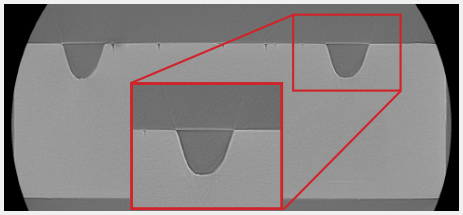
Perspectives

While SAXS has shown that the yellow diamonds are a promising material, CT has shown to provide a method of quickly evaluating the lens shape and thus its potential for the application in X-ray optics.



Small-angle X-ray scattering of a yellow diamond compared to pure diamond and other materials.

3D image of a lens array produced in a cheap yellow diamond.



Cross sectional 2D image of CT data seen from the side including a zoom onto a single lens.

In the LINX project, researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques. The Niels Bohr Institute at University of Copenhagen contributes with their expertise in small-angle scattering techniques.

Read more

linxassociation.com

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LINX Linking Industry to Neutrons and X-rays
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