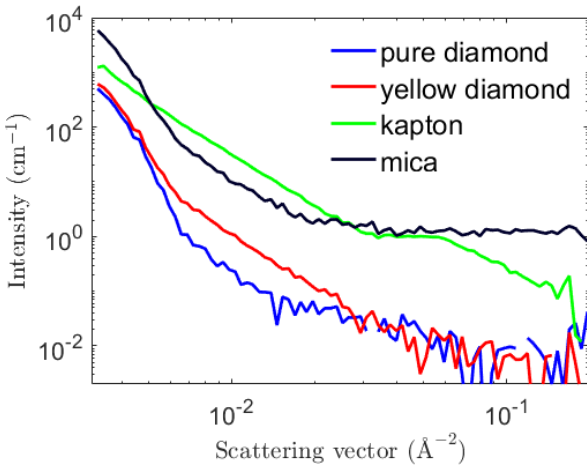


Diamonds for X-ray lenses

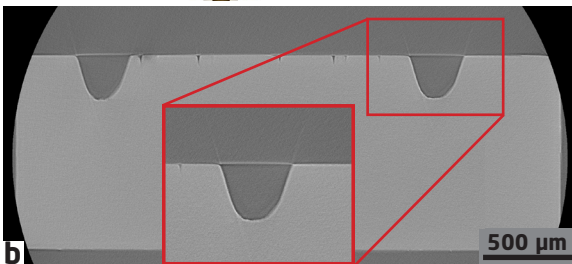
JJ X-ray A/S design, produce, and install hardware for X-ray and neutron sources. They are in the process of developing compound refractive lenses (CRLs) of diamond which has the potential of improving the beam quality on X-ray beamlines and could be a vital component in the next generation of X-ray 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.



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



a



a) 3D image of a lens array produced in a cheap yellow diamond. b) Cross sectional 2D image of CT data seen from the side including a zoom onto a single lens.

Challenge

In order to lower the price of CRLs made from diamond, yellow diamonds containing nitrogen impurities, 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 Institute at University of Copenhagen and the 3D Imaging Centre at DTU. This collaboration was part of the LINX project in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques.

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.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Centre at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/Industry-Portal

DTU 3D Imaging Centre

