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Publication date: 2019

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Grazing incidence X-ray ptychography for \textit{in situ} studies of thin sub-monolayer films of nanoparticles

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\textbf{Introduction}

X-ray ptychography [1] is a scanning coherent diffraction imaging (lensless) technique that provides unlimited fields-of-view for the sample reconstruction and enables reconstruction of the generally unknown illumination function [2]. In ptychography a phase-retrieval algorithm plays the role of an image-forming lens by recovering the unknown phase numerically, using iterative algorithms [3]. Here, we present ptychographic imaging under grazing incidence as a technique suitable for investigation of surface properties of thin films. The grazing incidence configuration is of special interest for the study of sparse monolayers of nanoparticles that yield weak scattering signal in a conventional transmission configuration. The proposed method has a potential for \textit{in situ} studies of particle-substrate interactions in a gaseous environment, under elevated temperatures and will allow describing time-evolution of an inhomogeneous sample structure.

\textbf{Grazing Incidence Ptychography}

In grazing incidence configuration, coherent X-ray scattering from substrate-supported nanostructures is measured below the critical angle of the sample substrate.

\begin{equation}
\begin{align*}
\vec{k}_i & = \text{incident wavevector} \\
\vec{k}_s & = \text{scattered wavevector} \\
\vartheta_i & = \text{angle of incidence} \\
\vartheta_r & = \text{angle of reflection}
\end{align*}
\end{equation}

The shallow incident angle provides a high interaction cross-section with the sample because of the large footprint and the total external reflection of the incident beam from the substrate.

\textbf{Experimental results}

The experiment was performed at the cSAXS beamline of the Swiss Light Source (SLS) facility in Switzerland. Figure 4 shows part of a Siemens star phantom that corresponded to the imaged area used for ptychographic reconstruction along with an amplitude of the reconstructed Siemens star and reconstructed illumination function [5]. (under a grazing incidence angle of 0.27 degrees, both corrected with respect to the aspect ratio of the reconstruction pixel size).

\textbf{Reactor chamber for \textit{in situ} measurements}

Future work

Future improvements to the method will include grazing incidence ptychographic tomography for achieving isotropic resolution in object reconstruction. This requires better alignment of the measured projections, higher precision in the sample motion, and a new design of the reactor chamber for \textit{in situ} studies.

\textbf{Acknowledgments}

This study was supported by the Marie Sklodowska-Curie Innovative Training Network MUMMERING (Multiscale, Multimodal, Multidimensional imaging for Engineers, Tunis, funded through the EU research programme Horizon 2020) and by the Ministry of Higher Education and Science (DANSCATT grant, 7055-00078). The authors would like to acknowledge the support by the staff of the NanoMAX beamline at the MAX IV Laboratory, O. Carbone, A. Björnling, and A. R. Fernandes and of the cSAXS beamline at the Swiss Light Source, A. Diaz. The authors thank O. Hansen, C. D. Damsgaard, and B. Chang from DTU Nanolab who provided test structures for the experiment.

\textbf{References}