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In situ Materials Science with X-ray Ptychography

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With the ability to control the structure of multiphase materials for applications on the nano- and mesoscale, methods for imaging these materials are becoming increasingly important. Especially techniques able to image sub-micron structures of functional materials in operando are in high demand, as these problems often fall outside the range of electron microscopy due to requirements of complex sample environments or less invasive sample preparation procedures.

Ptychography is a technique for lensless imaging, implemented for X-rays over the last few years and still in rapid development[1, 2]. Relying on an iterative reconstruction algorithm to form real space images from a series of coherent small-angle scattering patterns, thus solving the "phase problem", it yields quantitative images of both the absorption and phase shift induced by the object. The penetrating power of X-rays allows ptychography to work also in customized sample environments, such as high temperatures and specific gas atmospheres. Using tomography methods, ptychography can also provide three-dimensional images[3].

We discuss the potential of this new imaging technique for solving problems in materials science, especially related to structure investigations of highly inhomogenous materials with structures on length scales approaching 10 nm. Examples will be drawn from our recent work on hydration of isolated silk fibres, where we have used three dimensional quantitative imaging by X-ray ptychography to show that silk fibres swell anisotropically through absorption of water in the protein matrix when the surrounding atmosphere changes from low to high relative humidity, while the pore structure is left unchanged[4].

References
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