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Coherent X-ray microscopy of real materials at 10nm resolution

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Coherent X-ray microscopy replaces image-forming optics by mathematical algorithms to "reconstruct" the micrograph from the distribution of scattered light. In case of X-rays, its popularity is largely based on its ability to alleviate limitations of resolution and efficiency of available optics. Various methodologies have been developed, and high resolving power could be demonstrated. Yet, stringent constraints on sample preparation and data quality had to be addressed before the technique could advance from proof of principle studies to application. About a decade after the first demonstration using X-rays [J.W. Miao et al., Nature 400 (1999) 342] coherent diffractive imaging (CDI) seems to have matured into a microscopy technique that proves useful in real-life scientific investigations. The major coherent diffractive imaging methods will be reviewed, i.e., its original implementation using plane waves, the so-called Fresnel CDI that exploits curvature in the illuminating wavefront, and ptychographic CDI, which is a scanning microscopy method using multiple exposures. Being fully compatible with spectroscopic contrast channels makes quantitative structural, chemical, and magnetic information accessible, and the penetration power of X-rays can be exploited by tomographic or ab initio reconstruction methods in order to yield three-dimensional reconstructions with high resolution, high specificity, and high dose efficiency. These recent advances have turned coherent X-ray microscopy into a reliable and robust method that is attractive for scientists independent on how (un-)familiar they are with X-ray microscopy. Applications from the materials and life sciences will be discussed.