In line Holography and Coherent Diffraction Imaging in Electron Microscopy

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In-line holography, coherent diffraction imaging and related imaging techniques in electron microscopy such as convergent beam electron diffraction (CBED) will be presented, and their pros and cons will be compared. All of these electron imaging techniques can be realised with electrons of different energies, ranging from high-energy electrons (20–300 keV) accessible in commercially available transmission electron microscopes (TEMs) to low-energy electrons (30–300 keV) accessible in specially designed electron microscopes. In-line holography can be realised with both high- and low-energy electrons. In particular, in-line holography with low-energy electrons allows for the imaging of radiation-damage sensitive biological samples such as individual macromolecules or proteins. In addition, low-energy electrons are extremely sensitive to local electric fields: a single-atom charged impurity on a graphene surface creates a bright spot in an in-line hologram, allowing evaluation of the charge strength with precision of a fraction of an elementary charge. Coherent diffraction imaging can also be realised with electrons of different energies (wavelengths) and provides the highest possible resolution (a few Angstroms) in the resulting reconstructions. CBED has been conventionally applied in the study of defects and stains in thick crystals. Recently, CBED has been used in the imaging of 2D crystals such as graphene and van der Waals structures. CBED allows the extraction of quantitative information about the 3D structure and defects from a single CBED image. Moreover, qualitative information about the deformations can be extracted from the CBED patterns even without reconstruction, simply by comparing the interference patterns for different CBED spots. Examples of all three of these electron imaging techniques, the reconstruction procedure used and their potential applications will be presented.