

Radiation Damage in Electron Microscopy and Low Dose Approaches

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Sub-ångström resolution has been demonstrated in transmission electron microscopy (TEM) and scanning TEM (STEM) imaging experiments thanks to the recent development of spherical and chromatic corrected equipment and/or to the development of methodologies capable to overcome the limitations related to the electron optical aberrations. Moreover, a special attention has to be paid to the eventual damage induced by the electron irradiation that can alter the structure of the specimen. Radiation damage has a dramatic sudden effect on soft matter or biologic specimens but can also affect in a subtle way the study of inorganic specimens, preventing an accurate quantification of their properties. The use of new TEM/STEM aberration corrected equipment and field emission cathodes enable to deliver a high-density of current on the specimen making radiation damage an issue of growing importance also for inorganic material and even for metals. Radiation damage is the basic handicap to atomic resolution of single particle in biology or to the development of atomic resolution methods for electron tomography. This issue has to be tackled, as often happened in electron microscopy, by both technological and methodological improvement. The relatively recent development of direct conversion detectors for TEM cameras is an example of effective technological advance, which is producing a revolution not only in cryo-EM, to improve the information contained in a TEM image acquired at low dose. The imaging of a single nanometric radiation-sensitive low-atomic-number particle at atomic resolution is an experimental challenge that, to be handled, needs as first a way to locate a suitable particle in an inhomogeneous TEM specimen. The second step is to fine tune the electron optic to acquire an image with reliable and measurable features. These steps have to be performed without destroying, or damaging, the particle with the dose of electrons necessary to achieve, at least, a faint clue of where the particle is and to tune properly the electron optical conditions. Here we discuss the role of the radiation damage on TEM/STEM experiments on single particle and propose specimen-based solutions by using different methodologies like electron coherent diffraction imaging and inline holography.