Simulated Quantum Electron Microscope Images

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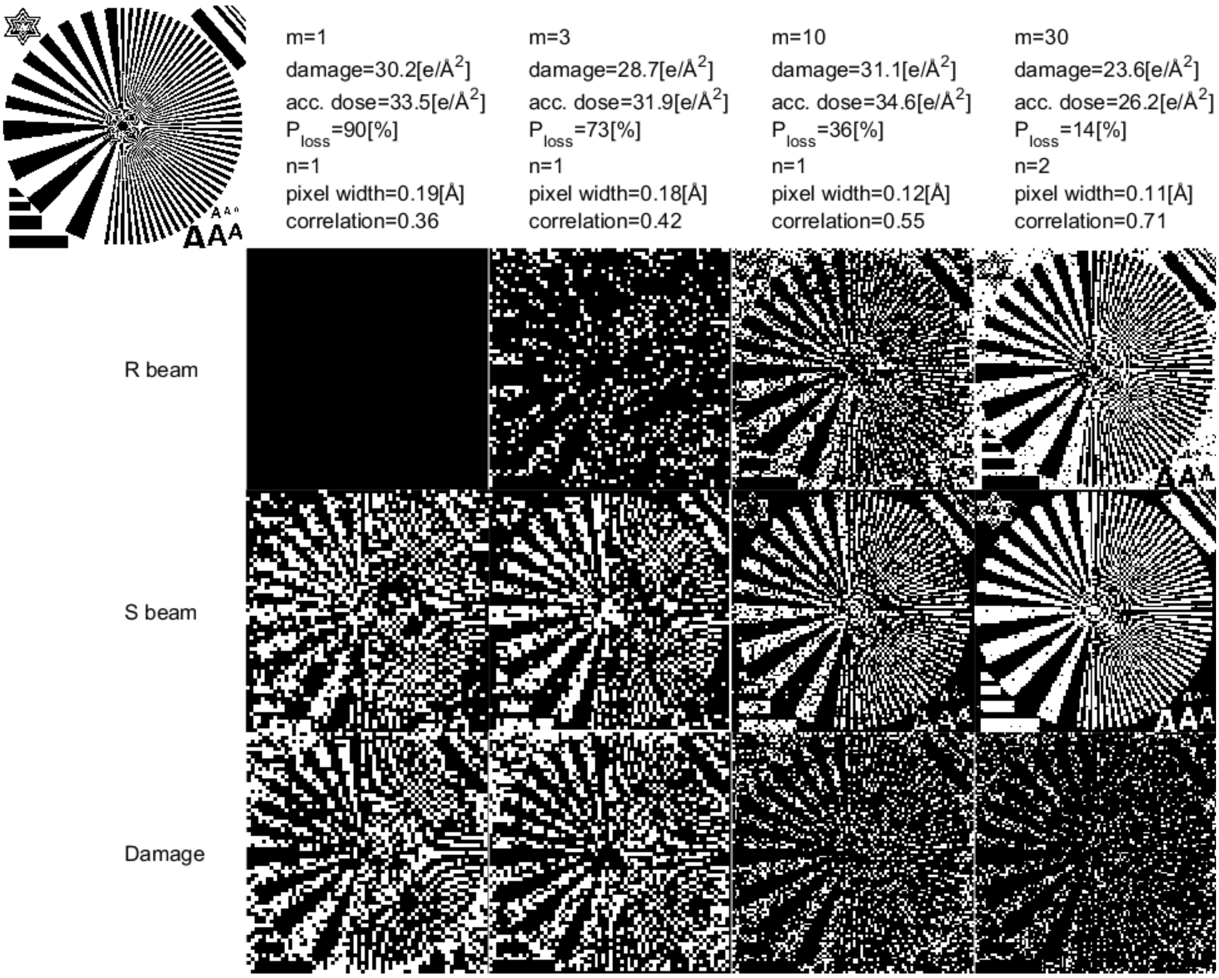
The concept of interaction-free measurements as proposed by Elitzur and Vaidman [3] for photons, should also work with electrons [2]. When built into a transmission microscope [3], this may lead to imaging modes with reduced damage. In the analysis of the image contrast that interaction-free microscopy can create, our tentative conclusion is that we may obtain good contour images of very high contrast specimen [4]. However, for specimen with weak phase- and weak amplitude contrast it is difficult to get an advantage in the interaction-free mode over regular STEM. A multi-pass phase contrast method may be of more value for those specimen [5]. To find out what to expect from the interaction-free, or better "interaction-lean" , mode of operation we perform image simulations. As a start we take a typical resolution sample with radial lines that increase in width from the center towards the outside of the "object". The radial lines are characterized by a transmission alpha, which means that there is a probability (1-alpha) that an electron passing through the sample will lose energy and thus cause damage. In other simulations we also apply a phase shift to the wave. In the simulation, we fire a Poisson-distributed random number of electrons into each pixel. As per the principle of interaction-free measurements, only a fraction of the electron wave passes through the sample, the rest stays in the reference beam. After a certain number of cycles, the intensity in the reference beam, respectively the sample beam, is detected. The figure below shows a typical example of the output of a simulated measurement for alpha=10%, where for each pixel there is signal in the reference beam, the specimen beam and the inelastic, or damage channel. From left to right, we decrease the amplitude in the sample beam and increase the number of cycles. m=1 is effectively a normal bright field (S-beam) and dark field (Damage) image. Because a larger number of cycles allows for a higher resolution at equal damage, we decrease the pixel size in the simulation. However, we keep the applied dose through the sample and thus the damage approximately constant for all the images. The figure clearly shows the advantage of interaction free measurement for such a simple high contrast object.



Simulated images for increasing number of cycles through the sample.

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