Experiment Brief

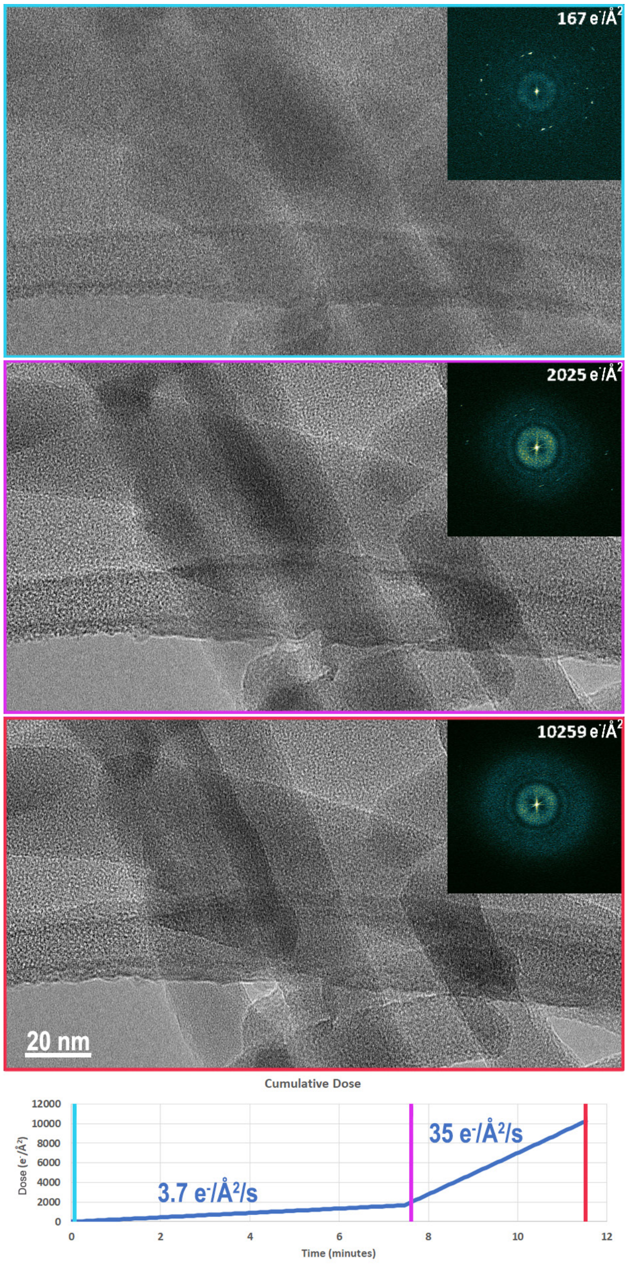
Metro Camera

Title

Monitoring and quantification of beam damage via low-dose continuous imaging

Gatan Instrument Used

The Metro™ camera enables low-dose **imaging** and diffraction at **low kV via real-time electron counting** with a simple user interface.



Background

Zeolites and metal-organic frameworks (MOFs) are nanostructured materials easily damaged by the electron beam, making them difficult to characterize by transmission electron microscope (TEM) imaging. With the advent of sensitive direct detection cameras capable of counting electrons one by one, the dose rate on the sample can be kept low enough to image these materials for extended periods with minimal damage. This creates opportunities to characterize the distribution of defects, supported metals, and other structural features within individual nanostructures.

Materials and Methods

The zeolite structures imaged here are hydroxycancrinite nanorods. The TEM used to capture the data was a JEOL F200 with a cold field emission gun operated at 200 kV. The Metro camera was used to record a >10 min video dataset at 10 fps with an initial dose rate of 3.7 $e^-/Å^2/s$. This resulted in the low degradation of the structure, which could be seen in the FFT, where lattice spots decreased in intensity. Since the degradation was slow, there was ample time to observe the sample's pristine structure and adjust the focus. At 7.5 min into the video, the dose rate was increased to 35 $e^-/Å^2/s$. This caused rapid deterioration of the structure, leaving no visible lattice spacings 2 min later. Frames were drift corrected and summed to produce each 2.5 s frame shown in Figure 1.

Summary

The Metro camera was used to capture this video dataset at a low electron dose rate. Continuous observation of the sample using the *in-situ* video recording capability of the Metro camera enabled monitoring of the damage resulting from the gradually increasing electron dose. The user can therefore easily determine the critical dose or dose rate below which damage is minimized, even for beam-sensitive samples. In this dataset, some reduction in lattice visibility began at less than 200 $e^-/Å^2$, but some fringes were still visible at up to 7500 $e^-/Å^2$. The pristine structure could be observed at the video start since the structural damage was slow at the initial low dose rate.

Figure 1. Three frames from an *in-situ* video dataset with their corresponding FFTs, showing the initially clear visibility of lattice fringes, followed by their destruction as the total electron dose increases. As the cumulative dose plot shows, the dose rate was kept low at first, to enable a longer period of observation, and then increased by an order of magnitude after nearly 8 min.

Credit(s)

Zeolite sample courtesy of Dr. Shery Chang, University of New South Wales.

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