Multi-Dimensional Data Acquisition and Analysis
in the Scanning TEM – Three Dimensional Data And Beyond

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Spectrum-Imaging is a powerful approach in data acquisition for materials characterisation whereby a spectrum is recorded at each pixel position in an image to form a ‘3-D data-cube’. As a technique it is a powerful means for rapid materials characterisation at the nanometre level and is well established, especially in the field of materials science. Rapid increases in computing power, increased ease of use, and the advent of high sensitivity and high throughput detectors have enabled acquisition of higher dimensional data sets within a practical time-scale. Advances in control software and systems integration has allowed simultaneous capture of multiple spectral signals, as well as providing complementary information in spatial correlation to further increase the ability of this powerful tool.

Combined EELS and EDS spectrum-imaging is a formidable approach for solving materials science problems, enabling quantitative concentration for a wide range of elements to be obtained along with chemical state information. Further, diffraction-imaging extends STEM-mode data acquisition to another dimension, opening up new possibilities in advanced materials science characterization at the nanoscale.
FIG. 1 Schematic diagram illustrating STEM multi-signal data capture with digital beam control, as used for spectrum- and diffraction-imaging. The wide range of signals available often contain complementary information for materials characterization.

FIG 2. A diffraction-image example taken from a semiconductor gate device. Using an ADF survey image (left), an energy-filtered diffraction-image was acquired from the region marked in green. A CBED diffraction pattern, extracted from point marked in red, is shown center. Using the interactive 4DViewer tools it is possible to generate an image from any feature or angular range in the diffraction space in real-time. Shown is an RGB composite image computed in this way comprising of a bright field image (red), an ADF image (green, 60-65 mrad), and an HAADF image (blue, 120-130 mrad).