Experiment Brief

eaSI EDS + EELS

Title

Complete multielement composition analysis with simultaneously collected EDS and EELS

Gatan Instrument Used

eaSI™ is an exclusive technology from Gatan that delivers the most **efficient** and **effective** workflow for advanced STEM experiments. eaSI leverages **EDAX EDS Powered by Gatan** (the EDAX Elite T Super detector to maximize collection efficiency and optimize light element performance with complete **DigitalMicrograph**® software integration) and the **GIF Continuum**® system (exceptional sensitivity and collection efficiency for high-quality EELS).

Background

3D NAND memory's complex architecture requires detailed characterization to confirm the structure and identify failure methods. Elemental mapping, quantification, and chemical state determination are all necessary to form a complete analysis. With eaSI technology, energy dispersive x-ray spectroscopy (EDS) and electron energy loss spectroscopy (EELS) spectra can be combined and synchronized during STEM imaging to provide complementary information. Collecting high energy resolution EELS provides the unique ability to determine chemical state via fine structure analysis. Still, the required energy resolution may limit the energy range and detectable elemental edges. In these cases, simultaneously collected EDS completes the analysis by including spectral information from elements outside the working EELS energy range.

Materials and Methods

3D NAND memory was prepared via FIB and analyzed in a JEOL F200 microscope at 200 keV. EDS data was collected with an EDAX Elite T Super detector, which features a 70 mm^2 SSD chip and windowless sensor design. EELS data were collected simultaneously using a GIF Continuum K3® + Stela system. A 0.6 eV/channel EELS dispersion was used to obtain sufficient energy resolution for fine structure analysis. DualEELS™ was used to extend the energy range of the spectra so the Si L (99 eV) could be simultaneously detected with the N K (402 eV), Ti $L_{3,2}$ (456, 462 eV), and O K (532 eV) edges. However, this dispersion did not allow for collecting the Al K (1560 eV) and W $M_{5,4}$ (1809 and 1872 eV) edges. Combining with EDS, it was possible to collect the Al Kα (1.48 keV) and W Lα (8.39 keV) peaks to fill in the missing information from the EELS data. The elemental distribution can be mapped in DigitalMicrograph using information from combined EDS + EELS.

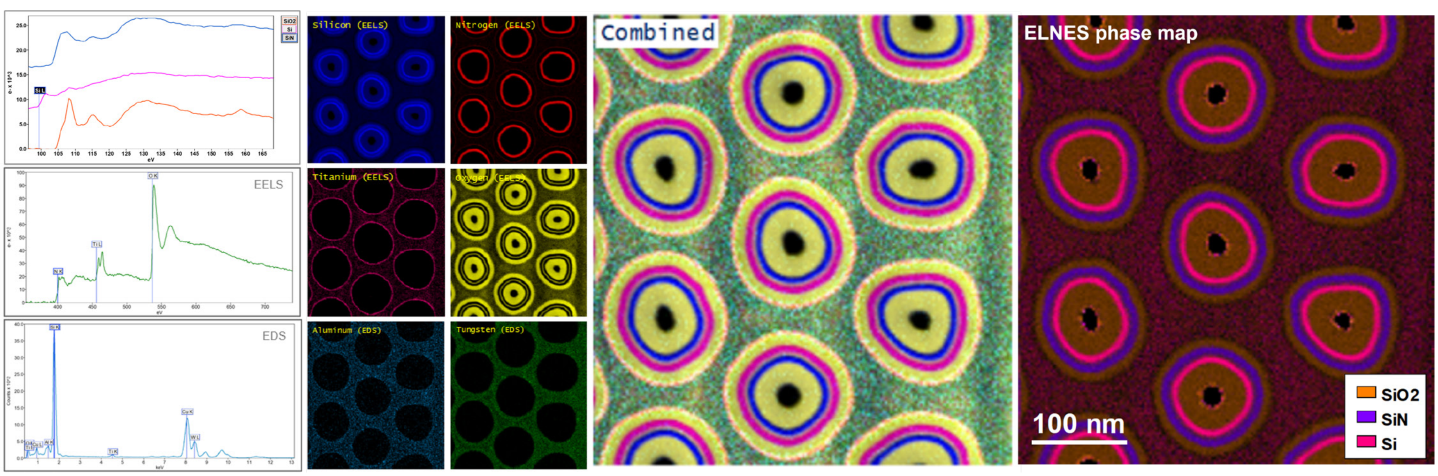

Figure 1. Left) EDS and EELS spectra of key elements from the 3D NAND structure. Middle Left) EDS and EELS elemental maps show the complex elemental distribution. Al and W were collected via EDS for a complete analysis. Middle Right) Elemental map using combined EDS and EELS data. Right) Si phase map created by using the Si $L_{2,3}$ ELNES plotted on the left.

Summary

Combining EDS and EELS data from a 3D NAND sample using eaSI technology allowed both elemental mapping and fine structure analysis. Due to the limited energy range of the EELS dispersion, EDS was used to collect information from Al and W. The EDS and EELS data were analyzed and mapped simultaneously using DigitalMicrograph software. Although the specimen could be studied with EELS or EDS individually, the combined techniques provide a powerful and easy-to-use workflow for complete chemical analysis.

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