AN 450
Electron Energy Loss Spectroscopy (EELS) Characterization of an Ultrathin Multilayer Film

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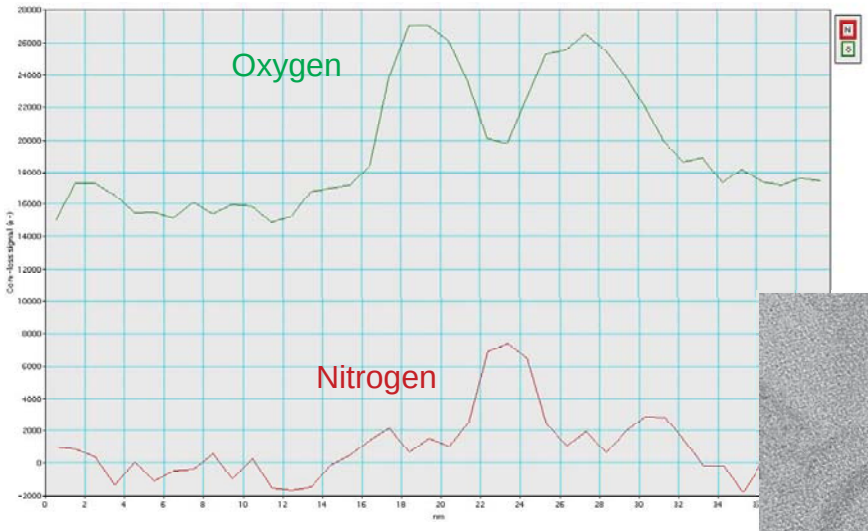
Introduction

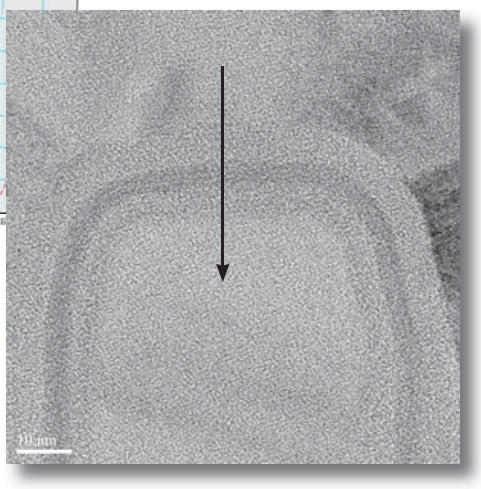
The characterization of thin layer stacks can be complicated by many factors. While depth profiles can provide excellent data from thin layers that are uniform over large areas, they are not well suited for nanometer- or even micrometer-scale domains. Scanning Transmission Electron Microscopy (STEM) is a well-known technique for providing high resolution images with spatial resolution as good as 0.2nm. This makes the technique an excellent choice for measuring thickness, roughness, uniformity, integrity and other important characteristics. Energy Dispersive X-ray Spectroscopy (EDS) can be coupled with STEM to provide elemental identification with 2-3nm spatial resolution. However, for some applications, EDS may not provide adequate spatial resolution nor provide sufficient sensitivity to carbon, nitrogen, oxygen and other light elements. Electron Energy Loss Spectroscopy (EELS) is also a STEM-based analytical technique and is an excellent compliment to EDS. EELS typically can provide somewhat better spatial resolution (~1nm) and significantly better sensitivity to the light elements compared to EDS. EDS is the superior technique for heavier elements.

Discussion

In the example below, a commercial Flash memory device was cross sectioned parallel to the word line and imaged by STEM. The poly1 floating gate, oxide/nitride/oxide (ONO) multilayer dielectric stack, and the poly2 gate electrode were imaged. The floating gate width is ~55nm. The ONO stack was further investigated using EELS to determine its structure. The data shows the normalized intensities of oxygen and nitrogen along the vertical line scan indicated on the STEM image. The EELS data shows that the ONO stack had approximate dimensions of 5nm : 4nm : 5nm.



EELS line scan across thin ONO layer stack



TEM image of ONO stack indicating where EELS line scan was acquired.

