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Characterization of ONO structure using Electron Energy Loss Spectrum for Si L edge chemical shifts

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Introduction

Silicon-oxide-nitride-oxide multilayers(ONO stacks) attracted considerable interest for the charge storages structures in nonvolatile memory devices. The electrical performance of ONO-based devices is largely determined by the elemental profiles of both oxygen and nitrogen across the ONO stacks[1, 2]. The thickness and composition of SiOxNy that is produced at SiO2/SiN interfaces are also affect the device performance[3]. In this study, the thickness of SiOxNy layer is determined using electron energy loss spectrum for Si L edge chemical shifts by the first deviation of maximum for Si L edge spectrum.

Experimental procedure and results

Fig. 1 shows the schematic diagram of spatially- resolved EELS. A post-column energy filter(Gatan) was used. The GIF was specially aligned to keep positional information perpendicular to the energy loss axis in the spectrum plane. The vertical axis of the spatially resolved EELS image corresponds to the sample position, and the horizontal axis corresponds to the energy loss. The slit is used to select the rectangular area of the sample. Fig. 2 (a) and (b) display the TEM image for ONO stack test structure and the spatially-resolved EELS image obtained from ONO stack test structure in Fig. 2(a), respectively. The accelerating voltage is 300kV. The energy dispersion is 0.05eV/ch.

The extracted line spectra for Si L edge from EELS image(Fig. 2 (b)) is shown in Fig. 3. The backgrounds are subtracted using the power law model. The change in the energy loss near edge structure(ELNES) for SiN, SiOxNy and SiO2 can be clearly observed[4, 5]. Moreover, with increasing the Nitrogen concentration, the edge onset in Si L edge shifts to lower energy loss value. In this study, thickness of SiOxNy which is produced at SiO2/SiN interfaces was determined by the first deviation of maximum for Si L edge spectrum. Fig. 4 (a) and (b) display the TEM image and plot of the fist deviation of maximum for Si L edge spectrum, respectively. Intermediate phase SiOxNy between SiO2 and SiN can be clearly seen at SiO2/SiN interface. The thickness of the intermediate phase of SiOxNy was 3nm at the left interface and 2nm at right interface. The information of the intermediate phase at SiO2/SiN interface makes it possible to analyze the device reliability and its performance. The spatially resolved EELS is effective tool for detailed chemical analysis of ONO structure.

Acknowledgements

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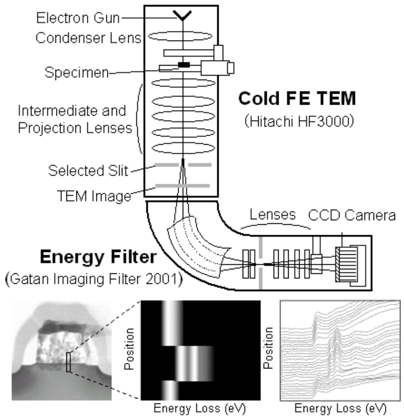

Fig. 1 The schematic diagram of spatially-resolvedEELS. A post-column energy filter(Gatan) was used.

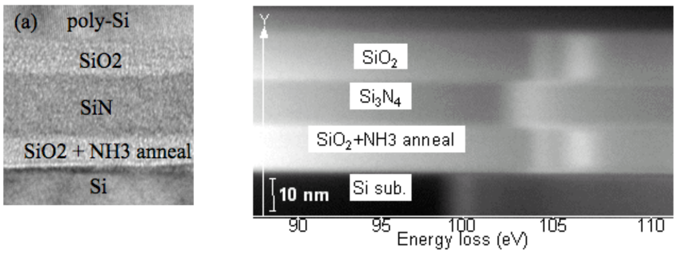

Fig. 2 (a) TEM image for ONO stack test structure. (b) Spatially-resolved EELS image obtained from ONO stack test structure in Fig. 2(a).

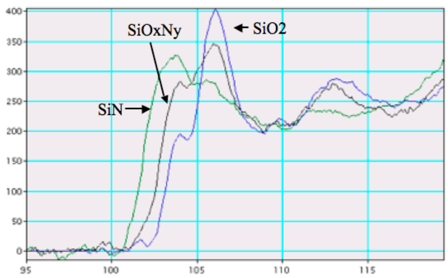

Fig. 3 Extracted line spectra for Si L edge from EELS image. The change in the energy loss near edge structure(ELNES) for SiN, SiOxNy and SiO2 can be clearly observed. The edge onset in Si L edge shifts to lower energy loss value with increasing the Nitrogen concentration.

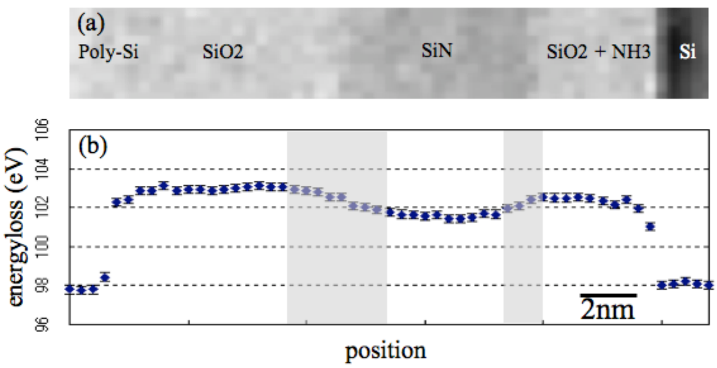

Fig. 4 (a) TEM image obtained from ONO structure. (b) Plot of the fist deviation of maximum for Si L edge spectrum. Intermediate phase SiOxNy between SiO2 and SiN can be clearly seen at SiO2/SiN interface.