Interface Structure of Tunnel Oxynitride for Flash Memory Studied by Hard X-ray Photoelectron Spectroscopy

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Silicon Oxynitride (SiON) have drawn great attention as candidate dielectric due to the benefit of small charge-trapping amount[1], which is known to be limiting factor of program/erase cycling endurance of floating-gate type FLASH memory. The effect of nitrogen incorporation, however, shows process-condition dependence rather than nitrogen-amount dependence. Chemical state of nitrogen atoms in SiON film is likely playing critical role in the dielectric characteristics.

In this study, chemical depth profile of nitrogen atoms, in two kinds of 7nm SiON films with significant difference in charge trapping behavior, was studied by angle-resolved photoelectron spectroscopy (AR-PES), at BL15XU in SPring-8. The excitation energy was chosen as 3keV± 0.3eV based on the balance of the detectable depth and photoionization cross section.

Fig.1 shows N1s spectra consisted of N1-N4 components. The results implied a significant difference that N1 was detectable only in NO-annealed film. Angle dependence of N1-N4 indicated that N1 exist in and N2 exist closer to the interface, N3 and N4 are distributing within the SiON films. Referring to recent reports[2], we assigned N1 to Si_3N_4 in SiO_2/Si interface, and N2 to [N-Si_3] within the near interface region. With AR-PES, we found that the interface structure of NO-annealed film is a mixture of SiO_2 and Si_3N_4 cluster, while that of N_2O-annealed film is the same as the SiO_2 film. Since NO-annealed film contains a significantly higher number of electrically active electron traps existing mainly in the interface than the N_2O-annled film, we thus demonstrate that the interfacial electron trap generation relate to Si_3N_4 cluster at the interface.

[1] F. Jong et al. IEEE EDL. 18, 343(1997). [2] S. Toyoda et al. Appl. Phys. Lett. 83, 5449(2004).

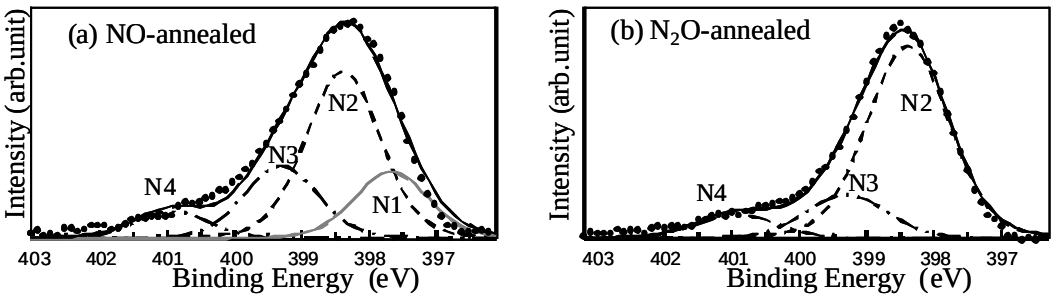

Fig.1 N1s photoelectron spectra obtained from SiON films in the normal emission.