Trapping reduction of SiO_2/GaN MOS structure by high pressure water vapor annealing

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Gallium nitride, which is the next generation semiconductor for high temperature and power applications, has been widely investigated for the last ten years. In order to improve the reliability issues for commercialization, several optimization efforts have been devoted to GaN devices from controlling material properties to device structure engineering [1]. In our research, high pressure water vapor annealing (HPWVA) treatment was applied, aimed at improving the bulk and interface property of GaN/SiO_2 MOS capacitor.

The MOS capacitors were fabricated, a freestanding GaN substrate with highly Si-doped epi-layer was cleaned. After that, a SiO_2 dielectric layer (50nm) was deposited using plasma enhanced chemical vapor deposition, followed by HPWVA under the condition of 400℃ and 0.5 MPa for 30 min. The sample without HPWVA treating for reference was also prepared. Circular aluminum electrodes were deposited by electron beam evaporation through the shadow mask.

A combination of C-V and I-V measurements were conducted for evaluating the effect of HPWVA on the reliability of GaN/SiO_2 MOS devices. From I-V measurements, the constant-current stressed (10nA) time dependent dielectric breakdown (TDDB) data is shown in Figure, for reference sample, the voltage went through a fast increase and a subsequent abnormal decrease, followed by a small decrease just before breakdown. The same sequence is found for HPWVA sample. According to previous investigators' theory [2], the voltage rise and decrease could be related to the electron trapping in bulk SiO_2 and hole trapping near the interface between GaN and SiO_2. It's obvious that electron trapping effect is smaller for HPWVA sample. Besides, the electron flow endurance or the lifetime under same current stress is found to be larger for HPWVA sample. For more details, a mathematical kinetic model was applied, indicating that both density and cross-section of the traps can be reduced by HPWVA treatment.

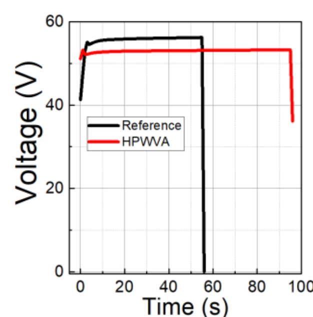

Figure1 Constant current TDDB data.

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[2] Ih-Chin Chen, S.E. Holland, Chenming Hu IEEE Trans. Electron Devices, Vol. ed-32, NO. 2, (1985)

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