Comparison of non-volatile memory characteristics for Hf-based MONOS diode with HfO_2 and HfON tunneling layer

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1. Introduction

We have investigated Hf-based MONOS non-volatile memories (NVM) to improve the memory characteristics. The 6 V/2 ms operation was confirmed for the Hf-based MONOS NVM with HfO_2 tunneling layer (TL) [1]. However, SiO_2 interfacial layer (IL) between the TL and Si substrate would be formed which increases the equivalent oxide thickness (EOT) and degrades memory characteristics [2].

In this experiment, we utilized HfON as the TL of MONOS diodes to decrease the EOT and improve the memory characteristics [2].

2. Experimental procedure

After 100 nm SiO_2 growth and active area formation on p-Si(100) substreate, the HfO_2 or HfON TL (3 nm) was formed followed by in-situ deposition of $HfN_{0.5}$ (Gate; G, 10 nm)/HfO_2 (Blocking layer; BL, 8 nm)/$HfN_{1.1}$ (Charge trapping layer; CTL, 3 nm) by ECR plasma sputtering at room temperature [1-3]. The HfON TL was formed by the Ar/O_2 plasma oxidation of 2 nm-thick HfN [3]. Then, post-deposition annealing was carried out at 600°C/1 min in N_2. After the Al electrode was evaporated and patterned to form a contact electrode, the $HfN_{0.5}$ metal layer was etched by DHF. Then, Al back electrode was evaporated. The electrode size was 100 × 100 μm^2. The fabricated samples were characterized by C-V measurements.

3. Results and Discussion

Figure 1 showed the flat-band voltage shift depends on the pulse width and voltage characteristics of MONOS NVM diodes. The measured EOT of HfO_2 and HfON TL MONOS NVM diodes was 7.2 and 4.9 nm and the memory window (MW) was obtained as 2.9 and 3.5 V at the program/erase (P/E) condition of ±8 V/100 ms, respectively. The HfON TL operated below the HfO_2 TL P/E condition of 6 V/2 ms [1]. The HfON TL obtained 0.8 V of MW even for low P/E conditions, such as ±5 V/100 µs. This is because the SiO_2 generation at the interface was suppressed [2]. Therefore, the EOT and P/E condition of HfON TL MONOS NVM diode was improved than HfO_2 TL.

4. Conclusion

In this paper, the effect of HfON TL of MONOS NVM diode was investigated to improve the memory characteristics. Because of the decreased EOT and suppression of the SiO_2 IL formation, the HfON TL operated at the ±5 V/100 µs of P/E condition which is faster than HfO_2 TL.

Acknowledgement

The authors would lik to thank Mr. M. Suzuki of Tokyo Institute of Technology, the late Prof. Emeritus T. Ohmi, Prof. T. Goto, Prof. R. Kuroda and Prof. T. Suwa of Tohoku Univeristy, Dr. M. Shimida and Mr. M. Hirohara of JSW-AFTY for their support and helpful discussion on this research. This work was partially supported by JSPS KAKENHI Grant Number 19H00758 and Toshiba Electronic Devices & Storage Corporation.

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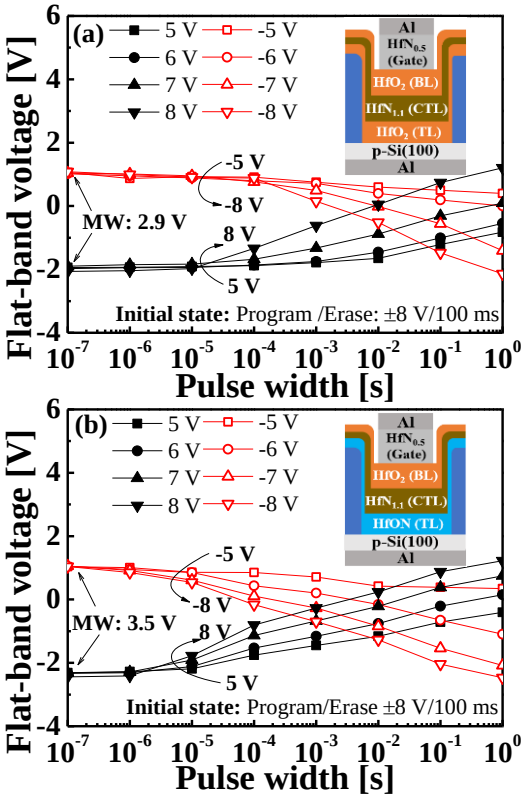

Figure 1. Dependence of the pulse width and voltage characteristics of (a) HfO_2 and (b) HfON TL MONOS diode.