Evaluation of random telegraph noise in Hf-based MONOS nonvolatile memory with HfO_2 and HfON tunneling layer

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1. Introduction

Previously, we have investigated Hf-based metal/oxide/nitride/oxide/silicon (MONOS) non-volatile memory (NVM) with HfON tunneling layer (TL) to decrease the equivalent oxide thickness (EOT) and improve the memory characteristics compared to that of MONOs with HfO_2 TL [1]. However, the MONOS with HfON TL shows higher density of interface states (D_{it}) than that of MONOS with HfO_2 TL [1].

In this research, the random telegraph noise (RTN) characteristics were evaluated to investigate the interface characteristics of Hf-based MONOS NVM with HfO_2 and HfON TL according to the channel length (L) and width (W).

2. Experimental procedure

The Hf-based MONOS stack structures were in situ formed on p-Si(100) substrate. The Hf-based MONOS NVM was fabricated by the typical gate last process [1]. The HfON TL (3 nm) was formed by the Ar/O_2 plasma oxidation of deposited 2 nm-thick HfN followed by in situ deposition of $HfN_{0.5}$ (Gate; 10 nm)/HfO_2 (Blocking layer; 8 nm)/$HfN_{1.1}$ (Charge trapping layer; 3 nm) by electron cyclotron resonance (ECR) plasma sputtering at room temperature [1]. The 3 nm-thick of HfO_2 TL was deposited utilizing the same condition of HfO_2 BL. The post metallization annealing (PMA1) was carried out at 600°C/1 min in N_2. After the contact hole formation and Al evaporation, PMA2 was carried out at 300°C/10 min in N_2/4.9%H_2. The L and W were 10 and 15 - 90 μm, resepctively. The fabricated Hf-based MONOS NVM were evaluated by I_D-V_G and RTN measurements.

3. Results and Discussion

Figure 1(a) shows the noise spectral density (S_{ID}) of the MONOS NVM with HfO_2 and HfON TL. Both devices show 1/*f* dependence according to the frequency. The S_{ID} of MONOS with HfO_2 TL shows 3.5 x 10^{-18} A^2/Hz at frequency of 10 kHz for the L/W of 10/90 μm. Meanwhile, HfON TL shows low S_{ID} of 8.4 x 10^{-19} A^2/Hz compared to that of MONOS with HfON TL [1]. This is because, the MONOS with HfON TL shows high S_{ID} due to the high D_{it} [1]. Figure 1(b) shows the S_{ID}s as a function of W. Both S_{ID} of MONOS NVM with HfO_2 and HfON TL are increased by decreasing the W. It was reported that by decreasing the L and W, the S_{ID} is increased [2]. At the W of 15 μm, S_{ID} of MONOS with HfO_2 TL is increased to 3.7 x 10^{-18} A^2/Hz. Meanwhile, S_{ID} of MONOS with HfON TL is increased to 1.5 x 10^{-17} A^2/Hz.

4. Conclusion

We investigated RTN characteristics of Hf-based MONOS NVM with HfO_2 and HfON TL. Although, the introduce of HfON TL showed high S_{ID}, the increase ratio with W of S_{ID} is decreased compared to the MONOS with HfO_2 TL which is suitable for device scaling.

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References

[1] J. Pyo *et al.*, IEEE Trans. Semicondc. Manuf., **34**, p. 1-5 (2021).
[2] M. P. Lu *et al.*, Appl. Phys. Lett., **88**, 6, 063511 (2006).

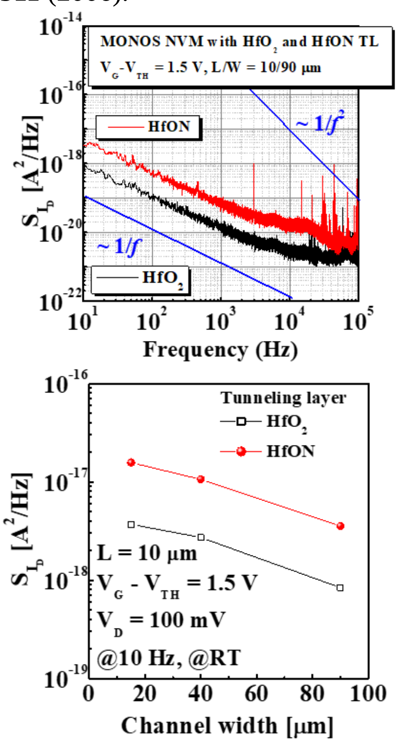

Figure 1. S_{ID}, dependence on (a) frequency and (b) channel width for MONOS NVM with HfO_2 and HfON TL.