Random telegraph noise in Hf-based MONOS nonvolatile memory with HfO_2 and HfON tunneling layer.

Tokyo Institute of Technology, [O]Jooyoung Pyo, Akio Ihara, and Shun-ichiro Ohmi

E-mail: pyo.j.aa@m.titech.ac.jp, ohmi@ee.e.titech.ac.jp

1. Introduction

Previously, we have investigated Hf-based metal/oxide/nitride/oxide/silicon (MONOS) non-volatile memories (NVM) with HfON tunneling layer (TL) to decrease the equivalent oxide thickness (EOT) and improve the memory characteristics compared to HfO_2 TL [1]. However, HfON TL shows large density of interface states (D_{it}) than HfO_2 TL [1,2].

In this research, the random telegraph noise (RTN) characteristics were utilized to investigate the interface characteristics of Hf-based MONOS NVM with HfO_2 and HfON TL [3].

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 followed by the Ar/O_2 plasma oxidation of deposited 2 nm-thick HfN, and HfON TL 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) 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 was carried out at 600°C/1 min in N_2 as PMA 1. After the contact hole formation and Al evaporation, PMA 2 was carried out at 300°C/10 min in N_2/4.9%H_2. The gate length (L) and width (W) were 10 and 90 μm. The fabricated Hf-based MONOS NVM were evaluated by I_D-V_G and RTN characteristics.

3. Results and Discussion

Figure 1(a) shows the I_D-V_G curves of the MONOS NVM with HfO_2 and HfON TL. The electrical characteristics of HfON TL device were improved compared to HfO_2 TL due to the suppression of interfacial layer gwroth [1]. However, the off-current of HfON TL device was increased due to the interface characteristics degradation than HfO_2 TL [1,2]. Figure 1(b) shows the noise spectral density (S_{ID}) as a function of frequency. HfO_2 TL device shows proportional to $1/f$ noise. Meanwhile, HfON TL device shows large S_{ID} compared to HfO_2 TL. It shows proportional to $1/f$ noise frequency from 630 Hz to 25 kHz. However, it shows a proportional to $1/f^2$ of the Lorentzian trend below frequency of 630 Hz due to the defect at the interfacial layer [3].

4. Conclusion

We investigated RTN characteristics of Hf-based MONOS NVM with HfO_2 and HfON TL. Although, HfON device shows the Lorentzian trend below frequency of 630 Hz, it shows proportional to $1/f$ noise characteristics in other frequency range. Thus, HfON TL will be good candidate for the MONOS NVM as device scaling issues.

Acknowledgements

The authors would lik to thank Dr M. Shimada and Mr. M. Hirohara of JSW-AFTY for their support. This work was partially supported by JSPS KAKENHI Grant Number 19H00758 and Toshiba Electronic Devices & Storage.

References

[1] J. Pyo *et al.*, IEEE Trans. Semicondc. Manuf., **34**, p. 1-5 (2021).

[2] D. Han *et al.*, IEICE Trans. Electron., **E97-C**, p. 413-418 (2014).

[3] R. Thamankar *et al.*, J. Appl. Phys., **119**, 084304 (2016).

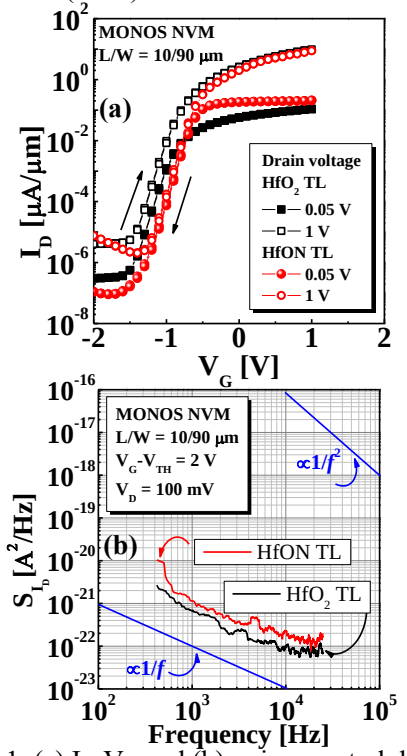

Figure 1. (a) I_D-V_G and (b) noise spectral density in the drain-current of MONOS NVM devices.