Si Substrate Orientation Dependence of Ferroelectric HfO_2 Properties Deposited by RF Magnetron Sputtering

Tokyo Institute of Technology[1], ○Min Gee Kim[1], Shun-ichiro Ohmi[1]

E-mail: kim.m.ak@m.titech.ac.jp, ohmi@ee.e.titech.ac.jp.

Ferroelectric HfO_2 is receiving great attention for one-transistor type ferroelectric random access memory. Although it was reported that undoped HfO_2 exhibits orthorhombic phase [1,2], which is ferroelectric phase of HfO_2, direct deposition with orthorhombic phase on Si substrates is necessary to be investigated. The crystallinity of HfO_2 should depend on the Si orientation. In this research, the growth of orthorhombic HfO_2 on Si(100) and Si(111) substrates and electrical characteristics were investigated.

After p-Si(100) and p-Si(111) substrates were cleaned by SPM (H_2SO_4:H_2O_2=4:1) and DHF (HF:H_2O=1:100) solutions, the 24 nm-thick HfO_2 film was directly deposited by RF magnetron sputtering at room temperature. The flow ratio was Ar/O_2 = 2/1 sccm with gas pressure of 0.4 Pa. Then, post deposition annealing (PDA) was carried out at 600°C for 30 s to crystallize the film. Finally, Al as top and bottom electrodes were deposited by thermal evaporation. The fabricated diodes were measured by C-V and J-V.

Figure 1 shows C-V and J-V characteristics of the diodes. Smaller capacitance in the Al/HfO_2/p-Si(111) diode indicates that thicker interfacial layer was formed than that of Al/HfO_2/Si(100), as shown in Fig. 1(a). The leakage current was almost same for both diodes as shown in Fig. 1(b). Although the effective electric field applied for the HfO_2 film on p-Si(111) substrate was smaller, the memory window of 0.45 V was obtained in the Al/HfO_2/p-Si(111) diode, while it was 0.39 V in case of Al/HfO_2/p-Si(100) diode at the same operating voltage. This results suggested that crystallinity was improved in case of the HfO_2 deposited on the Si(111) substrate.

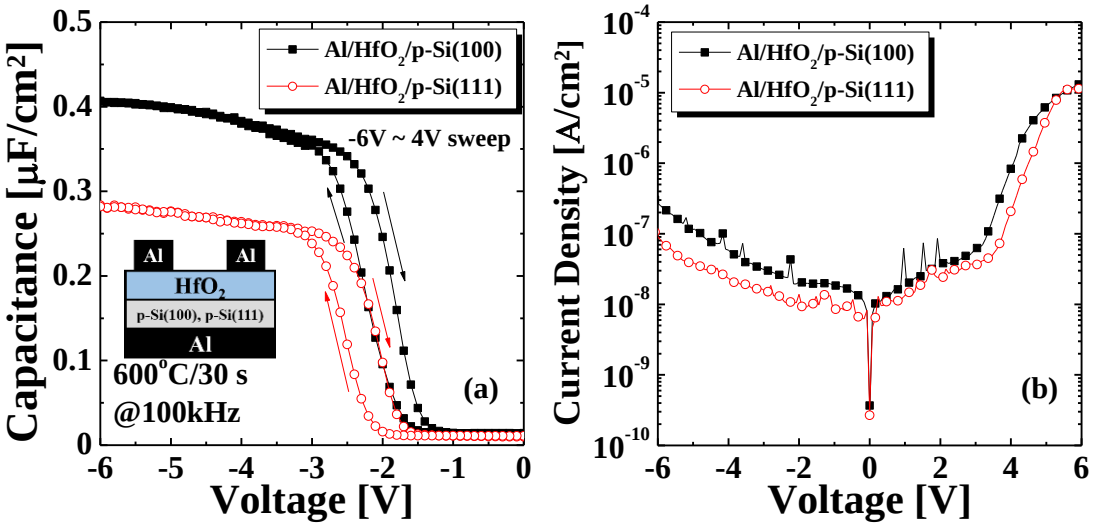

Fig. 1. (a) C-V and (b) J-V characteristics of the Al/HfO_2/p-Si(100) and Al/HfO_2/p-Si(111) diodes.

Acknowledgements

The authors would like to thank H. Inoue of Tokyo Institute of Technology, J. J. Liao of Xiangtan University for their support and useful discussion. This research is based on the Cooperative Research Project of Research Center for Biomedical Engineering, Ministry of Education, Culture, Sports, Science and Technology.

References

[1] R. Jiang et al., Sci. Rep., **7**, 9354 (2017).
[2] T. Nishimura, et al., Jpn. J. Appl. Phys, **55**, 08PB01 (2016).