Y_2O_3 ドープ HfO_2 を用いた強誘電体トンネル接合の実証

Ferroelectric tunnel junctions with ultrathin Y_2O_3-doped HfO_2

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1. Introduction

The ferroelectric tunnel junction (FTJ) is considered to be a promising nonvolatile resistive memory in terms of fast operation speed, low power consumption, and non-destructive reading process. Ferroelectric doped HfO_2 since reported, has drawn great interests not only in the ferroelectric devices community but also in the Si ULSI application[1]. In this work, the resistive switching resulting from the tunneling electroresistance effect in ferroelectric ultrathin Y-doped HfO_2 film is demonstrated.

2. Results and Discussion

The ferroelectric layer in MIM structure of FTJs should be with only a few nm thicknesses, taking advantage of prominent tunneling effect across the barrier. The tunneling probability dependent on the polarization state contributes to the resistive switching effect in FTJs[2]. Especially, in asymmetric metal electrode structure (**Fig. 1**), a screening length difference between metal electrodes gives rise to a different depolarization effect for opposite polarization states. It can modify the effective tunneling barrier height and lead to the polarization direction-dependent tunneling current.

3-nm-thick Y-doped HfO_2 was prepared on bottom TiN, and Ag was deposited as the top electrode. The ferroelectricity was confirmed by piezo-response force microscopy (PFM). Besides, it was also confirmed by the ferroelectric polarization switching current in the double pulse measurement[3]. The voltage was swept from +1.2 to -1.2 V in a round trip. As demonstrated in **Fig. 2**, it was turned ON to the low resistance at around -1.0 V and back to the high resistance at ~0.5 V, giving an ON/OFF ratio up to 100. The threshold switching voltage is in good agreement with the coercive field deduced from the phase switching in PFM, indicating the ferroelectric-induced resistive switching in Y-doped HfO_2 film. Moreover, no compliance current or forming process was needed in the resistive switching. The area-dependent current from different sizes of electrodes further distinguishes it from the filament type conduction. Furthermore, consistent resistive switching was observed at lower temperature measurement, indicating the direct tunneling process in the current transport mechanism.

3. Conclusion

Ferroelectric tunnel junctions with ultrathin Y-doped HfO_2 was demonstrated with an ON/OFF ratio up to 100. The ferroelectric-related resistive switching was confirmed, differentiating it from filament type of conduction in oxide resistive memory. Compared to traditional perovskite FTJs, HfO_2-based FTJ assures promising future in terms of robust manufacturability.

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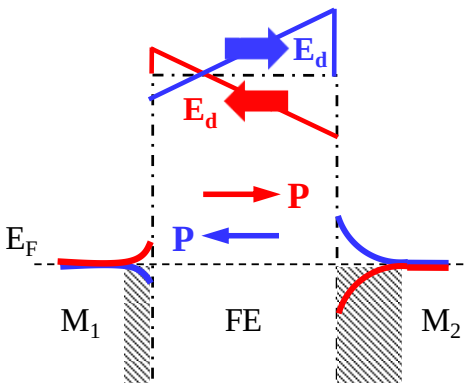

Fig. 1 The operation mechanism of FTJ in asymmetric electrode structure. The dashed line is the original position of conduction band at V=0 with no polarization in the film. The shaded area at interfaces represent the screening charges appearing on the metal side.

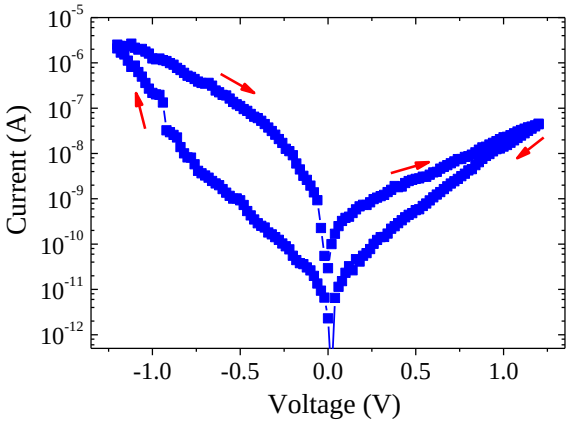

Fig. 2 Ferroelectricity induced resistive memory effect in ultrathin Y-doped HfO_2 FTJ. Arrows indicate voltage sweeping direction. Reproducible measurements show an ON/OFF ratio up to 100. The ON and OFF current show non-linear characteristic and both could be fitted with direct tunneling process.