TCAD Simulation on the Impact of Source and Drain Contact Positions in Thin Film Ferroelectric Transistors

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Introduction

Among the possible mechanisms, the depolarization field was regarded as the main factor to degrade the retention performance of the ferroelectric thin-film transistor (FeTFT). For the FeTFT, the physical details near the source/ drain electrode edge are sophisticated but important. In this work, we employed the 2D finite volume method (FVM) to simulate the distribution of physical fields in N-type FeTFT with a bottom contact bottom gate architecture. With the aid of FVM, the electrical details near the edge of drain contact and its impact were analyzed quantitatively in this article.

Results and Discussion

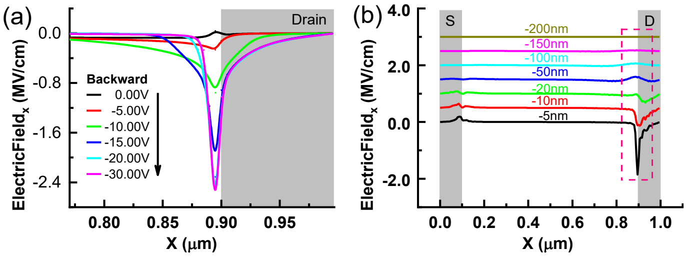

Figure 1 (a, b) The lateral components of electric field at the Ferro-Semi interface in the vicinity of drain electrode in backward scan. While sweeping the gate bias (V_g) to -30V, the electric field is enhanced dramatically. The peak of the electric field in this region reaches 3.45 MV/cm. Figure 1 (b) shows that this electric field penetrates about 20 nm into the ferroelectric layer for both near the source and drain edge while V_g at -30V.

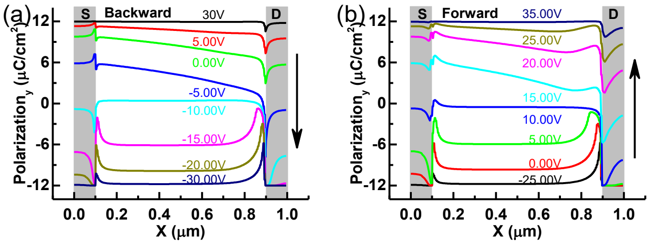

Figure 2 (a), (b) The vertical component of ferroelectric polarization at Ferro-Semi interface under various V_g. While V_g increases to -30V, the vertical component ferroelectric polarization near the drain electrode is much weaker than that in the center of the channel. While sweeping V_g in forward scan, the curves in Figure 2(b) present that the lowest point of vertical component of polarization is about 150 nm away from the drain edge while turning on. For the curve of V_g at 15V in Figure 2(b),

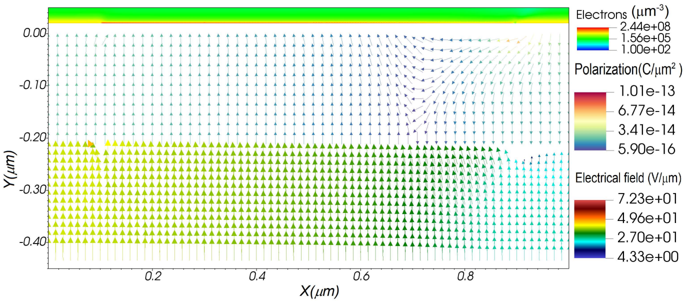

Figure 3 The colour maps for Holes, polarization field and electric field and for V_g at 13V in forward scan. The electric field near the drain is much large than other part in the channel.

Conclusion

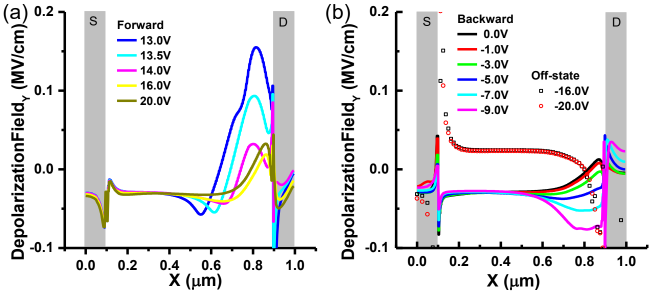

Figure 4 The depolarization field at Ferro-Semi interface in different standby states operated from the forward scan(a) and backward scan (b). Tthe intensity of depolarization field near the edge of the drain electrode reaches 0.15 MV/cm for V_g stopped at 13.0V in the forward scan, which is stronger than that in the middle of the channel, and is also stronger than that in the same region for the off-states (open shapes in (b)). Hence, the off-state exhibits a better retention performance than the on-state.

The polarization in the vicinity of the drain electrode is pinned along channel length direction by the junction field in off-state. So, the leakage gate current in off-state should be reduced. The vertical depolarization filed in the same region while operating the device in the forward scan to on-state is enhanced. Thus, the off-state of BCBG FeTFT should present better retention performance compared with the on-state.

Acknowledgments

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