

Ar/N₂-plasma nitridation process for LaB_xN_y tunnel layer formation on pentacene-based floating-gate memory utilizing N-doped LaB₆ metal and high-k LaB_xN_y insulator

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1. Introduction

The nitrogen-doped (N-doped) lanthanum hexaboride (LaB₆) has widely used as the contact electrode with a low resistivity, low work function, and oxidation immunity [1].

Previously, we have reported pentacene-based floating-gate (FG) Au/pentacene/N-doped LaB₆(Metal: M)/ LaB_xN_y (Insulator: I)/ N-doped LaB₆(M)/LaB_xN_y(I)/n⁺-Si(100) (Semiconductor: S) MIMIS diode with 5-nm thick LaB_xN_y tunnel layer (TL) formed by Ar/N₂-plasma sputtering [2].

In this study, we have investigated the Ar/N₂-plasma nitridation on N-doped LaB₆ FG for the LaB_xN_y TL formation.

2. Experimental procedure

Pentacene-based FG MIMIS diode was fabricated on n⁺-Si(100) substrate as a control gate (CG). N-doped LaB₆ (FG)/LaB_xN_y (Block layer: BL) stacked layer with a thickness of 20/10 nm was in-situ deposited. LaB_xN_y BL was deposited with Ar/N₂ gas flow ratio of 4/2.8 sccm at the gas pressure of 0.19 Pa. In the case of the N-doped LaB₆ FG layer, the Ar plasma sputtering was carried out with Ar gas flow rate of 10 sccm at sputtering gas pressure of 0.35 Pa. Then, the Ar/N₂-plasma nitridation was carried out at 30 W for 60 min for the LaB_xN_y TL formation. During the Ar/N₂-plasma nitridation, the shutter was closed to suppress the deposition of LaB_xN_y. Next, the post deposition annealing (PDA) process was carried out at 200°C/1 min in N₂ (1 SLM). Then, a 10 nm-thick pentacene channel layer and a 3 nm-thick α-rubrene passivation layer were formed by thermal evaporation with deposition rate of 0.3 nm/min 5 nm/min, respectively. Finally, Au and Al of top and bottom contact electrode were formed by thermal evaporation. The electrode size for MIMIS diode is φ 100 μm. C-V characteristics and program/erase (P/E) characteristics were evaluated.

3. Results and Discussion

Figure 1(a) shows frequency dispersion of C-V characteristics for the pentacene-based FG MIMIS diode. The smaller equivalent oxide thickness (EOT) of 1.7 nm was obtained compared to the pentacene-

based FG MIMIS diode with 5-nm LaB_xN_y TL formed by Ar/N₂-plasma sputtering, which indicated EOT of 3.1 nm [2]. Figure 1(b) shows the P/E characteristics. The memory window (MW) of 0.87 V was obtained under low P/E pulse of ±2.9 V/10 ms.

4. Conclusions

We investigated pentacene-based FG MIMIS diode by utilizing the Ar/N₂-plasma nitridation for LaB_xN_y TL formation. MW of 0.87 V was obtained under input pulse of ±2.9 V/10 ms with EOT of 1.9 nm.

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References

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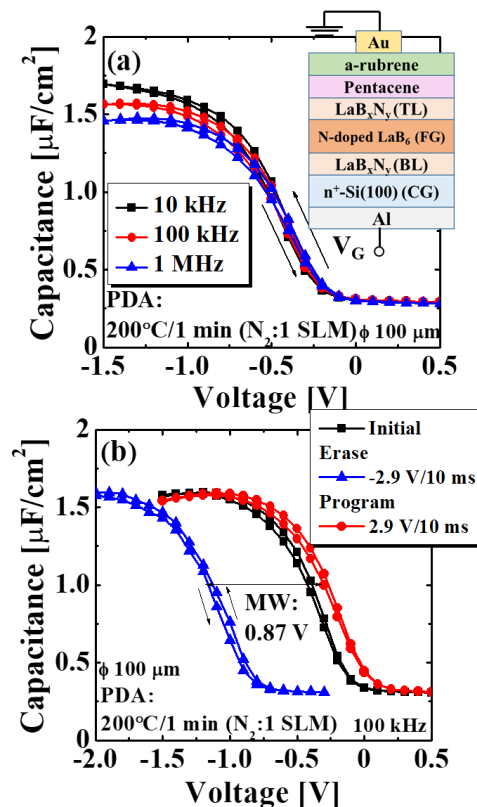


Figure 1. (a) C-V characteristics and (b) P/E for the pentacene-based FG MIMIS diode.