TRAPPING MECHANISM OF CHARGE TRAP CAPACITOR WITH Al_2O_3/HIGH-k/Al_2O_3 MULTILAYER

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Key Words: Charge trap capacitor, High-k, trapping mechanism, $HfZrO_2$, ZrO_2.

Charge trap flash memories with Al_2O_3/High-k/Al_2O_3 multilayer have been considered to reduce leakage current and improve electrical properties under low operation voltage for further device scaling down capability [1, 2]. In case of charge trap capacitor with SiO_2/SiN/Al_2O_3 multilayer, the several mechanism have been proposed to recognize where injected electron is trapped. For example, the injected electrons are piled up in a center of SiN-charge trap layer (SiN-CTL) or interface between SiO_2 tunneling layer (TL) and SiN-CTL or other interface between SiN-CTL and Al_2O_3-blocking layer (AlO-BL) [3]. However, the trapping mechanism of the High-k-charge trap layer (High-k-CTL) is still not clear. In this paper, we focus on the trapping mechanism of High-k-CTLs, such as an amorphous $(Ta/Nb)O_x$ (TNO-CTL), a crystallized ZrO_2 (ZrO-CTL) and a ferroelectric $HfZrO_x$ (HZO-CTL), from the data of flatband voltage (V_{fb}) characteristics under program mode.

Pt-gated charge trap capacitors with Al_2O_3/(Ta/NbO_x)/Al_2O_3 (ATNA), Al_2O_3/ZrO_2/Al_2O_3 (AZA), and Al_2O_3/$HfZrO_x$/Al_2O_3 (AHZA) were prepared by atomic layer deposition and annealing processes. The thicknesses of the TNO, ZrO and HZO-CTLs were varied from 5 to 20 nm while Al_2O_3-tunneling layer (AlO-TL) and AlO-BL were kept to be 8 nm thickness.

We observed the different V_{fb} shift behavior among ATNA, AZA and AHZA under program mode. The V_{fb} shift of AZA is much larger than those of ATNA and AZA. We study the trapping mechanism of three capacitors from thickness dependence of the TNO, ZrO and HZO-CTLs on V_{fb} shift. The schematic illustrations of these trapping mechanism of ATNA, AZA and AHZA were shown in Fig. 1. In the ATNA case, the V_{fb} shift satisfy a linear equation as a function of the thickness of TNO-CTL, indicating that the injected electrons are dominantly located at the TNO-CTL/AlO-BL interface. On the other hand, the V_{fb} shift of the AZA satisfy a quadratic equation, indicating that the location of electron is at both AlO-TL/ZrO-CTL and ZrO-CTL/AlO-BL interfaces, and in bulk ZrO-CTL. Finally, the injected electrons are piled up at both AlO-TL/HZO-CTL and HZO-CTL/AlO-BL interfaces in the AHZA. These trapping mechanisms result in the different V_{fb} shift behavior among ATNA, AZA and AHZA under program mode.

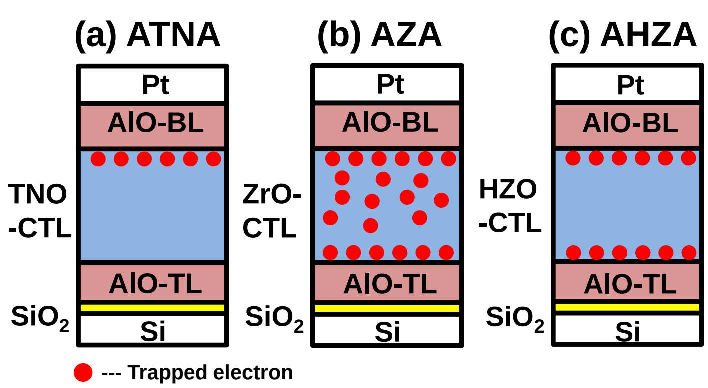

Figure 1 Systematics of trapping mechanism of (a) ATNA, (b) AZA, and (c) AHZA under program mode

Part of this research is supported by CREST, JST.

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