Effect of Hydrogen Ion Beam Treatment on Si Nanocrystal/SiO_2 Superlattice Memory Devices

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This study presents a novel route for synthesizing silicon-rich oxide (SRO)/SiO_2 superlattice-based memory devices with an improved memory window and retention properties. The SiO_2 and SRO superlattices are deposited by reactive sputtering. Specifically, the hydrogen ion beam is used to irradiate the SRO layer immediately after its deposition in the vacuum chamber. The use of the hydrogen ion beam was determined to increase oxygen content and the density of the Si nanocrystals. The memory window increased from 16 to 25.6 V, and the leakage current decreased significantly by two orders, to under ±20 V, for the hydrogen ion beam-prepared devices. An increase in the memory window and a reduction in the leakage current of samples through HIBAS were achieved because of the increase in the O/Si ratio. This study investigates the mechanism into how hydrogen ion beam treatment alters SRO films and influences memory properties.

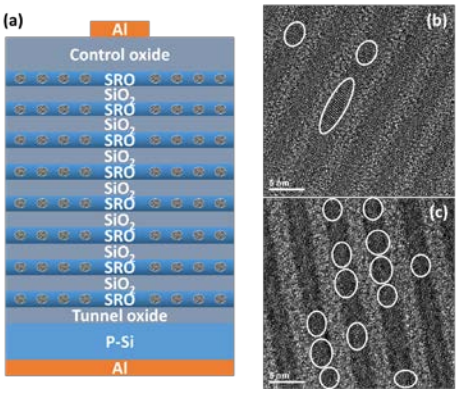

Figure 1 (a) Structure of the Si NC/SiO_2 SL memory device. HR-TEM images of Si NC/SiO_2 SL in (b) sample A and (c) sample B.

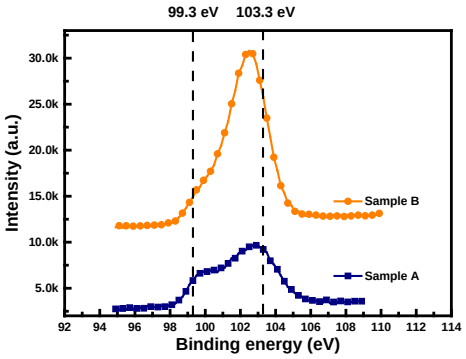

Figure 2 XPS spectra of the Si 2p core-level for Si NC/SiO_2 SL in samples A and B.

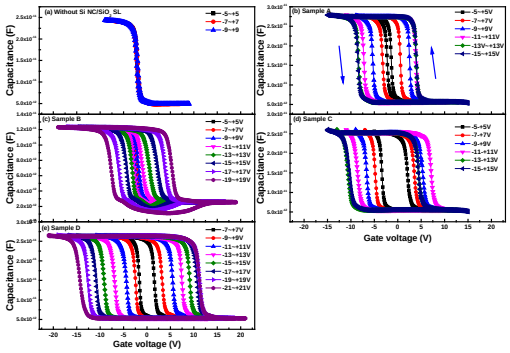

Figure 3 C–V hysteresis characteristics under various Vg from ±5 to ±21 V.

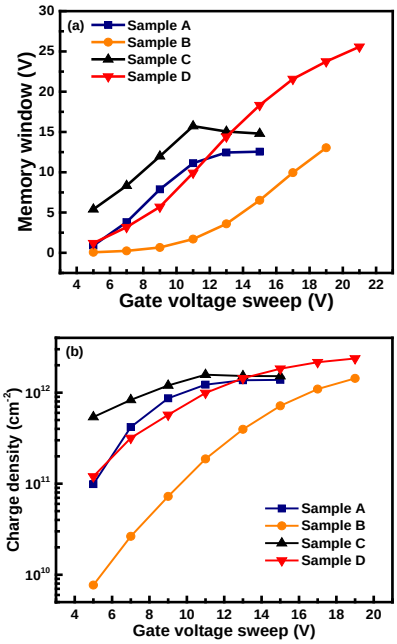

Figure 4 (a) Memory window and (b) charge density as a function of Vg for samples A–D.

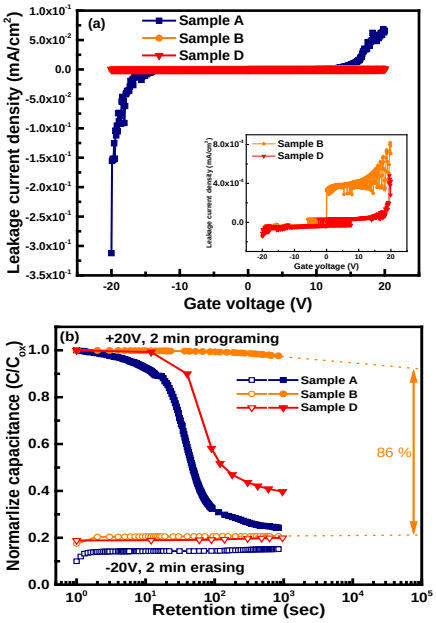

Figure 5 (a) Current density versus gate voltage and (b) Capacitance retention of samples A, B, and D.

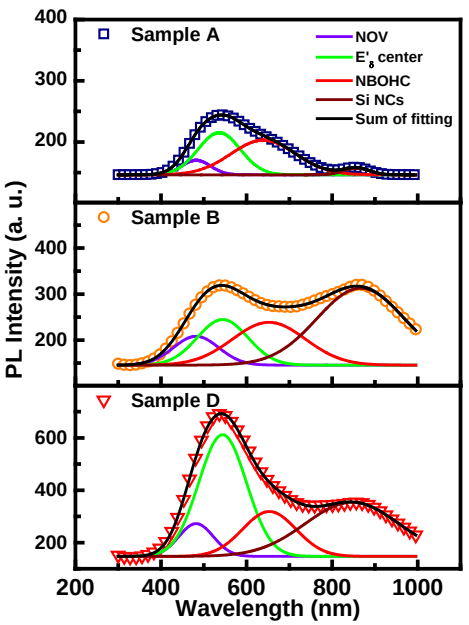

Figure 6 PL spectrum of samples A, B, and D.