Charge Operations of Nitrided Nanocrystalline Silicon Dot Memory Devices

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Abstract

Nitrided nanocrystalline silicon (nc-Si) dots were proposed to be a candidate of memory nodes for nonvolatile applications to make good use of advantages of quantum and defect systems [1]. This novel material featured in the precise control of silicon nitrides both in thickness and in location. Therefore, degradation due to nitrogen accumulation on the Si/SiO_2 interface was trivial and could not impact overall device operations. Nitrided nc-Si dots, provided dual memory nodes: nc-Si dots and silicon nitrides in terms of quantum confinement states and defect traps, respectively. The observed write/storage/erase processes could be combined processes from them. Well understanding on such combined operation mechanisms is meaningful for practical applications.

In this work, a capacitor memory device with a SiO_2 (41 nm)/silicon nitrides (1 nm)/nc-Si dots (7 nm)/SiO_2 (1 nm) structure on a <100> orientated p-type silicon substrate (8 ~ 10 Ω·cm) has been chosen to study displacement current-voltage (*I-V*) across the sandwiched nitrided nc-Si dots for the sake of simplicities in both structures and analysis. Since the displacement current, associating with time-varying voltage, is responsive to confined charges, it allows exploring charge or potential variations in the memory nodes [2], i.e. the charge retention behavior and the transport mechanism between defects and dots as well as dots and a channel. The stored charges in such memory nodes were experimentally identified in not only nc-Si dots but also defect-states of silicon-nitride films by *I-V* spectrum, corresponding to electron delocalized and localized states, respectively. Temperature dependences of the *I-V* characteristics demonstrated an evolution of stored charges in such combined system and clarified the storage mechanisms. A long-term retention mechanism based on novel storage-systems was elucidated.

References

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