ABSTRACT

The synthesis of low resistivity contact materials and development of low power memory structures are essential for further scaling of the complementary metal-oxide-semiconductor devices and electronic systems. Nickel based films have been found to be attractive for applications as a contact material in silicided source-drain junctions. On the other hand, metallic nanocrystals are attractive for the low power non-volatile memory devices. The present research study is concerned with the synthesis and characterization of nickel based thin films and nanocrystals for Schottky contacts, flash memory capacitors and resistive switching memory devices.

Ternary cobalt-nickel silicide thin films for Schottky contacts were deposited by sputtering using an equi-atomic cobalt-nickel alloy target. Grazing incidence XRD spectra have shown the formation of ternary silicide phases. Cross sectional TEM micrographs have revealed a fairly uniform diffusion of metals into Si with the formation of fully silicided film. A minimum value of resistivity of ~ 8.4 μΩ-cm has been obtained for an optimized deposition and annealing conditions. Temperature dependent current-voltage (I-V) measurements were used to characterize the performance of Schottky diodes. The room temperature barrier height and ideality factor have been found to be 0.65 eV and 1.6, respectively for the optimized sample. Structural and electrical characteristics of Ni nanocrystals embedded in high-*k* oxides matrices have been studied. HRTEM micrographs have revealed the formation of tiny Ni nanocrystals. A stable hysteresis memory window of ~2.1 Volt at a sweeping gate voltage of ±15 Volt has been observed in the optimized annealed samples for the tri-layer structure. On the other hand, the maximum charge injection capability (ΔV_{FB} ~ 7.8 V; @±15 V) into nanocrystals has been observed for the optimized tetra-layer devices. Unipolar nonvolatile resistive switching memory characteristics of pulsed laser ablated nickel oxide films have been studied. XRD and electron diffraction spectra of the oxide films have revealed the polycrystalline nature of deposited NiO films. On application of an optimized voltage bias and compliance, Pt/NiO/Pt structures have exhibited unipolar resistive switching having a very low SET and RESET voltages with a maximum resistance ratio of 1000. Ni

nanocrystal embedded titanium dioxide films have been deposited to demonstrate non-volatile resistive switching memory devices. Tiny isolated Ni nanocrystals with an average size of 4 nm have been observed for the 1000 °C, 5 minutes annealed samples. Optimized Ni nanocrystal embedded devices have exhibited bipolar, nonvolatile and bistable resistive switching states with a low SET and RESET voltage of 0.8 V and -0.2 V, respectively. Nanocrystals embedded samples have resulted in a high resistance ratio ($>10^3$), good stability and retention properties. The role of thin Ni nanocrystal layer on the improved memory switching stability has been discussed.

Key words: Ternary cobalt-nickel silicide, nonvolatile memory, Schottky diode, nickel nanocrystals, nanocrystal flash memory, high-k oxide, resistive switching memory, nickel oxide, titanium di-oxide RRAM, nanocrystal embedded switching.