PO1040

High performance resistive switching device fabricated from NbO2-x and HfO2 layers deposited by high power impulse magnetron sputtering

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Owing to the impressive electrically-induced resistive switching characteristics, metal oxide based high density non-volatile memory devices is of interest as a potential replacement for flash memories. Lowering the threshold currents and increasing the ratio of high-to-low resistance state is crucial for the enhanced device performance. The resistance switching characteristics of NbO_{2-x}/HfO_2 layers, deposited on platinum coated Si by reactive high power impulse magnetron sputtering (HiPIMS) of niobium, were investigated for non-volatile memory application. Sub-stoichiometric niobium oxide NbO_{2-x} is favourable than the stoichiometric one (NbO_2) as selector layer to reduce the threshold current and the write/erase power. The stoichiometry and composition of the niobium oxide films were precisely controlled by tuning the duty cycle of HiPIMS voltage pulses. The fine control of oxygen content in the deposited niobium oxide films was obtained by the use of smooth transitions of the reactive HiPIMS discharge between the target covered with compound layer on low duty cycle and the metallic target obtained at high duty cycle of the applied HiPIMS voltage pulses. The enhanced switching performance was exhibited by the devices made from these films, as the switching from high resistance state (HRS) to low resistance state (LRS) occurs at 2.8 V, while HRS is restored by inversing the voltage to -0.96 V. The stable retention behaviour was observed for the period of 5.2×10^6 s with the resistance ratio between HRS and LRS states maintained greater than 930. Different switching features were observed depending on the film composition, which demonstrates the simplicity of HiPIMS process in determining the functional properties of the depositing films. This study also demonstrates that HiPIMS can be used to synthesize graded layer films where the stoichiometry is varied either continuously or abruptly during the deposition.

Keywords
Resistive Switching
HiPIMS
Threshold current reduction