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Title(English)	A New Resistive Switching Based on Breakdown and Anodic Re-Oxidation of Thin SiO2 at the Interface of CeOx Buffer Layer and Silicon Related Bottom Electrodes
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Resistive random access memory (ReRAM) has been focused as one of the candidates for storage class memory (SCM), owing to its nonvolatility with a fast read/write capability. The resistance is commonly determined by the electron conduction through defect-chained filaments in the insulator bridging the two electrodes. Upon the recovery of the end of the filaments by oxygen ions drift (reset process), a high resistance state can be obtained. By bridging again the filaments between the electrodes (set process), low resistance state can be obtained. As the resistance depends on the breakage and recovery of the filament ends, the on/off ratio tends to be less than 100, which is not preferable for SCM. Also, a forming process to create the initial filament by applying high voltage to one of the electrodes need to be removed for large memory cell. In this thesis, we propose an ReRAM using two layers of insulators; one acting as a switching layer and the other as a buffer layer. The proposed switching mechanism is based on local breakdown and local anodic oxidation for set and reset processes, respectively. Based on proper material selection, including those for electrodes, a demonstration of forming-free ReRAM with high on/off ratio over 10^6 is described.

The set process is determined by the contrast in the dielectric constant of the buffer and switching layers. Therefore, the switching layer will be first broken down if the layer has low dielectric constant. To obtain a low resistance at this state, the buffer layer should have a narrow bandgap with large electron and ion conductions. For reset process, the local spot need to be recovered quickly, so that the buffer layer should have high oxygen ionic conductivity. To increase the resistance at this state, the switching layer should have high insulating properties. From material selection, CeO_x and SiO_2 are chosen as buffer and switching layers, respectively.

Firstly, resistive switching of CeO_x insulator has been demonstrated. The switching property was found to be dependent on the bottom electrode (BE). The reason for the difference was determined to be the interfacial layer formation between the CeO_x and the BE. When p^+Si is utilized as BE, the creation of a thin SiO_2 layer at the interface between CeO_x and BE has

been confirmed and a stable resistive change has been obtained. However, due to parallel electron conduction through the SiO_2 layer, a low off-state resistance limits the on/off ratio. The off-state resistance can be increased by creating an SiO_2 by thermal process, reducing the background leakage current. With this process, an on/off ratio over 10^3 was demonstrated.

When $NiSi_2$ electrode is utilized as BE, a forming-free resistive switching with a high on/off ratio over 10^6 was obtained. The properties might be attributed the high insulating property of 1.5-nm-thick SiO_2 between the CeO_x layer and the NiSi-BE, with also low breakdown field due to the incorporation of Ni atoms.

Transient response current at the set and reset processes revealed that the device switching speed of about 200 ns, and endurance characteristic longer than 200 cycles were confirmed. These results indicate that the proposed ReRAM structure and mechanism are suitable for the storage class memory application.