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Role of Nanostructured Defects through Swift Heavy Ion Irradiation for Resistive Switching of Manganite Thin Film Devices: A Short Review

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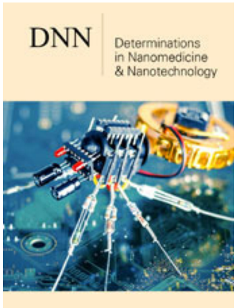

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Abstract

Recently, memory devices based on resistive switching (RS) have attracted enormous attention of researchers due to their fast switching speed, cost effective fabrication, great endurance and retention behaviors, small power consumption, simple structure and Complementary Metal Oxide Semiconductor (CMOS) compatibility. Amid various materials, manganite's are known to possess both the elemental RS types, i.e. unipolar and bipolar switching. Formation of defects, induced by Swift Heavy Ion (SHI) irradiation, can influence the resistive state (i.e. RS) of the manganite devices through nanostructuring. In short, nanostructuring for manganite thin films through SHI irradiation offers the improvement in their RS behaviors.

Keywords: Nanostructuring; Resistive switching; SHI irradiation

Introduction

Non-volatile nature of memory devices makes them promising candidates for Resistive Random Access Memory (RRAM) applications. Resistive Switching (RS) based memory devices are of great interest in recent times. Among various manganese oxide materials with Resistive Switching (RS) effect, the perovskite $YMnO_3$ (YMO) has been verified to be versatile, demonstrating both unipolar [1,2] and bipolar switching [3-5]. Ion irradiation can be used as a tool to modify the materials property. There exist few reports available on modifications in RS character by ion irradiation in manganite materials [6-9]. This short review reports the work carried out on RS properties of SHI irradiated doped manganite YMO thin film devices and studied their RS modifications based on nanostructuring process.

Manganite Based Thin Film Devices

The manganite based thin film of Sr-doped YMO with thickness ~300nm was studied by few researchers. Hirpara et al. [6] have reported the dynamic role of defects in $Y_{0.95}Sr_{0.05}MnO_3$ (YSMO) on SNTO substrate. The preparation of these devices was carried out by Pulsed Laser Deposition (PLD) technique. These thin films were irradiated by 200MeV Ag^{15+} ions to create defect structure in the devices. Hysteretic current-voltage measurements were performed in the study to understand resistive switching behavior. They have used different theoretical models to understand possible charge conduction mechanisms. They stated the role of oxygen vacancies, field induced modification of interface and charge carriers trapping/detrapping are the possible responsible mechanisms. Time scale stability has been shown to be improved by irradiation. Rathod et al. [7] have reported the resistive switching of ion irradiated YSMO thin films with the film thickness ~ 100nm with spectroscopic correlations. They confirmed the presence of oxygen vacancies with Rutherford Backscattering Spectrometry (RBS) and Near Edge X-ray Absorption Fine Structure (NEXAFS). They showed that with ion irradiation, the RS behavior improves to optimal ion fluence and then found to get reduce. In both of these studies, authors have discussed the effect of SHI irradiation fluence (i.e. ion fluence) on micro strain state as well as morphological modifications in the context of nanostructuring effects.

Another recent study on YSMO devices with the film thickness ~ 100nm has shown that trapping and detrapping can be responsible for RS behavior across the interface of YSMO device and SNTO substrate [8]. Gadani et al. [8] shown that the YSMO devices are affected by nanostructured defects (morphological study) induced by ion irradiation. Room temperature

RS of the pristine and irradiated devices has been discussed on the basis of structural strain state between film and substrate, oxygen vacancies and nanostructured defect density. They have studied trapping/detrapping process by LRS-HRS transformation, NDR, backward diode behavior, current compliance. In this study, endurance and retention measurements were performed to understand stability and reliability of the RS devices and their dependence on the nanostructuring processes, i.e. creation of nanostructured morphologies on the surface of the films. Recently, Gadani et al. [9] have studied same device system for dielectric measurements. They found that ion irradiation also modifies the electrical behavior. They have discussed these variations in dielectric behavior in the context of lattice mismatch between film and substrate. They showed that universal dielectric response is the possible mechanism to understand dielectric nature of these RS devices. Above reports suggest that all these YSMO thin film devices can be considered as strong RS application candidates.

Conclusion

The reports discussed in this short review are based on YSMO manganite based thin film devices for RS studies as well as dielectric behavior. Interesting results on RS studies for these devices can be considered for their applications in RRAM devices. Dielectric studies also suggest the possibility of these devices for their applications in energy storage devices.

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