Chapter 4

Defect Dynamics in the Resistive Switching Characteristics of $Y_{0.95}Sr_{0.05}MnO_3$ Films

Induced by Electronic Excitations

Chapter IV is dedicated to the studies on resistive switching (RS) behavior of pulsed laser deposition (PLD) grown $Y_{0.95}Sr_{0.05}MnO_3$ (YSMO) manganite films on single crystalline SNTO substrate. YSMO films were irradiated using 200MeV Ag+15 swift heavy ions (SHI) with different fluences using 15UD Tandem Accelerator. In order to study the structural properties, $\theta$–2$\theta$ X–ray diffraction (XRD) measurement was performed. To study the surface morphology of the pristine and irradiated films, atomic force microscopy (AFM) measurement was performed. To understand the RS behavior of presently studied YSMO/SNTO pristine and irradiated films, current–voltage (I–V) hysteretic data were recorded under the sweeping bias voltage cycles: 0V → +10V → 0V → −10V → 0V across YSMO/SNTO junction at room temperature.
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4.1 Introduction

Memristor is one of the next level generation applications as non-volatile memory with ultralow power consumption and high writing–reading speed [1–4]. This material is also useful for memory devices based spintronic technology having high operation speed, high scalability and multi-bit storage potential [5, 6]. The Resistive switching (RS) characteristics is one of the prime tools to verify the potential ability of any device for non-volatile memory application. These characteristics are widely studied for almost in all the oxides starting from the simple transition metal oxide to complex perovskite oxides including manganites [7]. In addition, RS behavior has been found to be completely distinguishable in the context of its behavior and causes [8–15]. It has been studied for Ti/Pr$_{0.7}$Ca$_{0.3}$MnO$_3$ [8], Al/Pr$_{0.7}$Ca$_{0.3}$MnO$_3$ [9], La$_{0.7}$Ca$_{0.3}$MnO$_3$ [10], Ti/La$_{0.7}$Ca$_{0.3}$MnO$_3$/Pt [11], n-Si/La$_{0.7}$Ca$_{1/3}$MnO$_3$/M (M=Ti+Cu) [12], CeO$_2$/La$_{0.7}$(Sr$_{0.1}$Ca$_{0.9}$)$_{0.3}$MnO$_3$ [13], Pr$_{0.7}$Ca$_{0.3}$MnO$_3$ [14], La$_{0.5}$Ca$_{0.5}$MnO$_3$/Nb: SrTiO$_3$ [15] and many more.

In general, the negative differential resistance (NDR) behavior has been observed to accompany with RS behavior in manganites [16–18]. The RS behaviour has been observed in many materials. However, the observation of both the NDR and RS behaviours in the same thin film device of manganite require in-depth understanding. Few attempts have been made to understand their combination in a single device for which theories, mechanisms and models have been reported [16–18].

YMnO$_3$ is one of an interesting perovskite widely studied in its polycrystalline bulk [19], nanostructure [20], thin film [21], device [22], heterostructure [23], etc. for various potential applications. The RS property has also been studied for YMnO$_3$ manganite based thin film devices [24–26]. Bogusz et al [24] investigated the bipolar resistive switching properties of pulse laser depositions (PLD) grown YMnO$_3$ manganite layer on Nb: SrTiO$_3$ (SNTO) (0.5 wt % Nb doping) substrate. They have discussed the RS in YMnO$_3$/SNTO p-njunction on the basis of charge carrier density trapped/detrapped across the interface between YMnO$_3$ and SNTO. Wei et al [25] have studied the RS mechanism in PLD grown YMnO$_3$/SNTO ferroelectric devices. The RS behavior with

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low power consumption has been observed in YMnO₃/SNTO device and has been explained by electric field induced modifications in width of depletion region at the interface. The device exhibited a large R_{HRS}/R_{LRS} ratio, high endurance, long retention time. Bogusz et al [26] have studied RS behavior in YMnO₃ based polycrystalline films in the context of formation and rupture of conductive filaments. They also discussed in detail by considering the efficient role of domain wall and point defects in controlling the RS behavior.

The SHI irradiation is an efficient tool to create and control the defects and oxygen vacancies in the oxide lattice for tuning various physical properties [27, 28]. As per best of our knowledge, there exist only few RS studies in the literature for SHI effects on various functional oxides [29–31]. This RS behavior observed in different functional oxides have been understood on the basis of trapping/detrapping mechanisms and role of formation and rupture of conducting filaments in the oxide lattice. It is also observed that SHI irradiation could create and control the defect formation as well as, by setting-up the irradiation parameters; it could also govern the defect distribution in the material. All these can easily modify the RS behavior of all oxide films.

Recently, some reports describe that divalent cation Ca²⁺, when substituted at Y³⁺ ionic site in YMnO₃ can enhance the hole concentration in manganite (Y₀.₉₅Ca₀.₀₅MnO₃), therefore, it can be used as p-type semiconductor for forming p-n junction in the form of thin film devices [32–35]. Dhruv et al [32–35] have recently studied, the current – voltage characteristics, dielectric, capacitance and electroresistance (ER) behavior of Y₀.₉₅Ca₀.₀₅MnO₃/Si thin film devices.

The present study reports the RS characteristics of both pristine and swift heavy ion irradiated Y₀.₉₅Sr₀.₀₅MnO₃ (YSMO) manganite having a very high hole concentration (p-type) of thickness 100nm thin layer grown on (100) single crystalline SNTO substrate (n-type material).

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4.2 Experimental Details

Polycrystalline bulk sample of $\text{Y}_{0.95}\text{Sr}_{0.05}\text{MnO}_3$ (YSMO) manganite was synthesized using $\text{Y}_2\text{O}_3$, $\text{MnO}_2$ and $\text{SrCO}_3$ of 99.9% purity (sigma Aldrich) by conventional solid state reaction (SSR) route. These starting oxide and carbonate materials, in proper stoichiometry, were calcined at 950°C for 24hrs twice with intermediate grindings. Well calcined powder was palletized (20mm in diameter) after proper grinding followed by sintering at 1100°C for 48hr. Well sintered pellet of YSMO manganite was characterized by XRD measurements with high resolution Bruker D-8 powder diffractometer with Cu Kα radiation ($\lambda = 1.54$ Å) operating at 40kV/30mA at room temperature to confirm its single phasic nature. YSMO manganite pellet (20mm diameter) was used as a target in pulsed laser deposition (PLD) technique to grow YSMO films having ~ 100nm thicknesses on single crystalline high quality (100) Nb:$\text{SrTiO}_3$ (SNTO) substrates with 248nm wavelength having ~ 1.80 J/cm$^2$ energy of KrF Excimer laser at 10Hz repetition rate under 100 mTorr oxygen partial pressure.

Following parameters were set to grow YSMO films: substrate temperature: ~ 700°C; oxygen partial pressure: ~ 100mTorr; target to substrate distance: ~ 5.5cm and repetition rate: 10Hz. The films were irradiated at different ion fluencies ($1 \times 10^{11}$ ions/cm$^2$, $1 \times 10^{12}$ ions/cm$^2$ and $1 \times 10^{13}$ ions/cm$^2$) with 200MeV $\text{Ag}^{+15}$ ions at room temperature using 15 UD tandem Pelletron accelerators at Inter University Accelerator Centre (IUAC) New Delhi. These samples hereafter are referred as YSMO-PRI, YSMO-11, YSMO-12 and YSMO-13 respectively for pristine, samples irradiated with the fluencies of $1 \times 10^{11}$ ions/cm$^2$, $1 \times 10^{12}$ ions/cm$^2$ and $1 \times 10^{13}$ ions/cm$^2$. To achieve uniform irradiation on the film surface, the ion beam was magnetically scanned over a 1 x 1 cm$^2$ area covering the complete film surface. The structural quality of all the films was determined by performing the XRD measurements at room temperature using Cu Kα radiation. The surface morphology and its modification for YSMO films were studied by performing atomic force microscopy (AFM) measurement. The transport properties were investigated by taking the Hysteresis I–V measurements (under the sweep voltage...
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Figure 4.1 (b) shows the XRD pattern of both the pristine and SHI irradiated PLD grown YSMO manganite films on single crystalline SNTO (100) substrates. From the XRD patterns, it is clear that all the films show single phase having orientations in \((h00)\) direction parallel to substrate orientations. The intensity as well as peak position \((2\theta)\) of all the films gets changed with ion fluence of 200 MeV Ag\(^{+15}\) ions irradiation. Further, observed lattice mismatch between films and substrate is shown as an enlarged view of most intense XRD peak at right of figure 4.1 (c). The small separation between the two peaks indicates the presence of lattice mismatch \((\delta)\) between the film and the substrate. The lattice mismatch can be calculated using the formula: \(\delta (\%) = [(d_{\text{substrate}} - d_{\text{film}}) / d_{\text{substrate}}] \times 100\) and for presently studied YSMO/SNTO films, \(\delta\) is found to be \(\sim +1.53\%\) for YSMO-PRI film while it gets enhanced to \(\sim +1.72\%\) in YSMO-11 and \(+1.85\%\) for YSMO-12 with increase in ion fluence. For YSMO-13 film, \(\delta\) is found to be \(\sim +1.09\%\).

The positive sign in above values indicates that tensile strain is present for all the pristine and irradiated films [37]. With increase in ion fluence, i.e. YSMO-11, YSMO-12, the defect density increases which lead to structural modifications and, hence, crystal structure get improved. In the case of higher ion fluence, i.e. YSMO-13, the structure becomes more disordered due to local annealing process and recrystallization, and as a result, strain gets suppressed in this irradiated film. In addition, two peaks at \(\sim 23.11^\circ\) and \(47.21^\circ\) are observed along with \((100)\) and \((200)\) respectively in the XRD patterns of figure 4.1 (c), confirming the single crystalline growth of 100nm YSMO/SNTO films onto the single crystalline \((100)\) SNTO substrate.

4.4 Microstructural Properties

To understand the effect of SHI irradiation using 200 MeV Ag\(^{+15}\), on surface morphology of YSMO manganite layers, AFM images were captured for all the pristine and irradiated films at room temperature.
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Figure 4.2: AFM images (2D images) with Z axis scale bar (top), average rms roughness analysis (2nd raw), surface (granular) profile with randomly selected grains (3rd raw) and 3D images (bottom) with enlarge view of pristine and irradiated YSMO/SNTO thin films.

Figure 4.2 shows the AFM images of pristine and all irradiated films with the same scale bar of 200nm ($1 \times 1 \mu$m) for better comparison point of view. It can be seen from figure 4.2 that, pristine film possesses homogeneous circular shaped granular islands which gets modified into hillock like defects onto surface after irradiation with ion fluences of $1 \times 10^{11}$, $1 \times 10^{12}$ and $1 \times 10^{13}$ ions/cm$^2$. In addition, Z axis scale bar is shown in the top of figure 4.2, which depicts that maximum height of the grain in the AFM images are found to be 6.09nm (YSMO-PRI), 6.75nm (YSMO-11), 18.84nm (YSMO-12) and 16.73nm (YSMO-13). The effect of SHI irradiation on film’s surface...
has been understood using an average rms surface roughness analysis (2\textsuperscript{nd} raw) and surface profile (3\textsuperscript{rd} raw). It is evident from the surface and morphology analysis of figure 4.2 that an average grain size decreases from ~ 66.11nm (YSMO-PRI) to 40nm (YSMO-12) while rms surface roughness increases from 5.1nm (YSMO-PRI) to 10.2 nm (YSMO-12). This can be understood by irradiation effect: surface morphology gets modified due to electronic energy transfer and the deposition of large kinetic energy by irradiated ions instantaneously on the films’ surface. For higher ion fluence i.e. YSMO-13, an average grain size increases ~ 78nm while rms surface roughness decreases ~ 2.4nm, because of local annealing process, as a result of maximum energy transfer into the surface of the film and, hence, an average grain size gets enhanced. Irradiated films possesses defects due to SHI irradiation effect, as shown in 3D AFM images (enlarge view). Surface morphology has been discussed in the context of (i) formation of defects (YSMO-11), (ii) defect density enhancement (YSMO-12) and (iii) local annealing process (YSMO-13) under SHI irradiation effect.

4.5 Charge Transport Properties

To understand the charge transport mechanism across YSMO–SNTO interface at room temperature (300K) for presently studied pristine and irradiated films, the current – voltage (I–V) hysteresis were recorded using standard dc two probe techniques. Figure 4.3 shows the I–V hysteresis of pristine YSMO film, applied sweep voltage in a sequence of 0V \(\rightarrow\) +10V \(\rightarrow\) 0V \(\rightarrow\)-10V \(\rightarrow\) 0V, as indicated by the arrows. It is clearly seen that present film exhibits bipolar resistive switching (BRS) behavior along with negative differential resistance (NDR) effect in reverse bias mode. Presently, RS behavior follows counter eightwise variation in current with voltage, i.e. devices gets switched from low resistance state (LRS; cycle 1) to high resistance state (HRS; cycle 2) \cite{38}. Also, it is observed that large reverse current (I\textsubscript{R}) exists as compared to forward current (I\textsubscript{F}) which indicates backward diode like behavior across YSNO–SNTO interface \cite{39, 40}. This kind of behavior can be understood by (i) electric field induced modifications in the depletion region (barrier height and thickness), (ii) charge carrier trapping–detrapping processes across the interface due to pre-existing defects in pristine film and (iii)
migration/movement of oxygen vacancies in YSMO layer, which is also very important to consider at present case. As shown in figure 4.3, during cycle 1 (0V → +10V) with increase in applied sweep voltage across YSMO-SNTO interface, current starts to increase exponentially and during cycle 2 (+10V → 0V), current starts to decrease exponentially with decrease in applied voltage.

Figure 4.3: The current–voltage curves of pristine film YSMO/SNTO at room temperature.

In forward bias mode during (cycle 1 and cycle 2), I–V curves exhibit small hysteresis along with two differentiable resistive states or transition from LRS to HRS. This can be understood by schematic diagram as shown in figure 4.4 (a). External electric field [i.e. applied positive bias voltage (cycle 1)] the electrons of SNTO towards YSMO, where electrons get the energy and cross over the depletion layer resulting in the conduction across the interface and current increase with voltage for cycle 2. This suggests the sweeping voltage induced formation of conducting filamentary paths in the pristine film lattice. During cycle 2, current recorded is found to be less as compared to cycle 1. This can be understood in terms of rupture of existing filamentary paths which results in the reduction in the movement of free charge carriers across the junction. It is also worth to consider that, while charge carriers have crossed over the interface during

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cycle 1, few electrons (charge carriers) got trapped at the interface (which is heavily disordered as compared to the film lattice due to presence of the strain in the pristine film XRD analysis) [41]. During cycle 2, these trapped charge carriers can not contribute back to the conduction and hence, current is found to be less during cycle 2.

Figure 4.4: Schematic energy band diagram of YSMO/SNTO device in (a) forward bias mode, and (b) reverse bias mode.

During reverse bias mode, applied negative voltage, across YSMO-SNTO interface, one can expect increased depletion region (as shown in figure 4.4 (b) as compared to forward bias mode [figure 4.4 (a)]. This depletion region can be considered as insulating (comparatively high resistive) region across which charge carriers cannot pass through easily under low applied negative voltage up to ~ 0.9V. After achieving sufficient energy through the negative applied voltage (field), efficient flow of charge carriers across the interface has been taken place which is reflected in the form of sharp increase of current (in cycle 3) which reached to ~1.2mA at ~3V for pristine

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Figure 4.5 shows a schematic of the effect of SHI irradiation on the structural and microstructural aspects of YSMO/SNTO films. As discussed from the XRD and AFM analysis, $1 \times 10^{11}$ ions/cm$^2$ SHI fluence creates defects in YSMO film (YSMO-11) as well as enhances the defects density at the YSMO-SNTO interface and enhances the lattice strain between the film and substrate. Higher dose $1 \times 10^{12}$ ions/cm$^2$ of SHI irradiation further improves its effects on microstructure of YSMO film and YSMO-SNTO interface, as shown in a schematic figure 4.5. Due to local annealing effect, recrystallization takes place at higher fluence of SHI $1 \times 10^{13}$ ions/cm$^2$, therefore, reduces the effect densities in film layer as well as interface region and suppresses the structural strain at interface between YSMO film and SNTO substrate lattice.

Figure 4.6: Hysteretic I–V curves of pristine (a) and irradiated (b), (c) and (d) YSMO/SNTO films at room temperature.
To understand the structural–property correlations in the presently studied YSMO/SNTO films irradiated by higher energetic Ag\(^{2+}\) ions, RS behavior (at 300K), was recorded across junctions understudy. Figure 4.6 shows the hysteretic I–V curves of pristine and irradiated YSMO/SNTO films recorded using current perpendicular to plane (CPP) mode across the interface at room temperature. It is evident that all the pristine and irradiated films exhibit distinct RS behavior, signifying an important and effective role of SHI irradiation in governing the device characteristics. Figure 4.6 (b) shows the RS behavior of YSMO-11 film showing the same counter eightwise nature [as seen in pristine film: figure 4.6 (a)], i.e. transformation of resistance states from LRS to HRS while performing cycle 1 to cycle 2. The current observed for YSMO-11 film is found to be \(\sim 10\) times larger at +10 V than that for pristine film. This can be understood by three possible mechanisms: (i) YSMO-11 film possesses higher strain value (+1.72%) as compared to pristine film (+1.53%) indicating a larger strained region (figure 4.5). In this strained region large number of defects exists containing oxygen vacancies which results in the higher conduction across the junction (ii) irradiation induced creation of defects in the YSMO film which contains large number of oxygen vacancies. These oxygen vacancies transfer Mn\(^{3+}\) ions to Mn\(^{2+}\) in the YSMO lattice and, hence, strengthens the possible zener double exchange (ZDE) mechanism in the lattice, which results in an enhancement in the current during cycle 1 [42]. (iii) According to the microstructural observations, YSMO-11 film possesses smaller grain size as compared to pristine one. This indicates that 1E11 film possesses comparatively larger grain boundary density. These grain boundaries are defective in nature as compared to grain structure [43]. Enhanced boundary density in YSMO-11 and, hence, provides better conduction through the transformation from Mn\(^{3+}\) to Mn\(^{2+}\) (due to our pre-assumption that many oxygen vacancies and non-stoichiometry are present as defects in this material) which supports the zener double exchange (ZDE) mechanism across the irradiated YSMO film lattice (YSMO-11 film) and provides an enhanced current across the junction, as compared to pristine film. It is also important to note here that in pristine film, critical voltage (minimum required voltage after current start to flow across the junction) is found to be \(\sim 4\)V which gets enhanced towards higher voltage \(\sim 2\)V in YSMO-11 film. Reduced
critical voltage (by a factor of 2) in YSMO-11 film can be ascribed to (i) strained region of interface, (ii) more defective nature of the YSMO film and (iii) reduced grain size and an enhanced grain boundary density in YSMO-11 film. Although, SHI irradiation could enhance the charge conduction in the YSMO lattice, it does not affect much the value of HRS/LRS (i.e. RS effect) in the forward bias mode which is found to be $\sim 1.75$ in PRI film which slightly gets reduced to 1.70 in 1E11 film at $+8.0$ V bias voltage.

As discussed for the YSMO-PRI film, YSMO-11 also possesses larger depletion region at the YSMO/SNTO junction while performing the reverse bias mode. Since, YSMO-11 film possesses homogeneous distribution of the defects, introduced by irradiation process (homogeneous distribution is expected due to the fact that magnetic scanner was used to provide irradiation on the surface of the films understudy), large number of defects are expected to be present in the depletion region of 1E11 film (as compared to PRI film) as shown in figure 4.5. This result in an effective breakdown of the depletion region during cycle 3 for YSMO-11 film that consequence in the shoot of current $\sim -1.6mA @ -2.4V$. Similar to YSMO-PRI film, YSMO-11 also exhibits NDR behavior for the voltage range between $-2.4V$ to the highest applied $-10V$. Enhanced voltage range (i.e. $-2.4V$ to $-10V$) observed for NDR region in YSMO-11 film as compare to PRI one (i.e. $-3.0V$ to $-10V$) can be ascribed to the fact that after a stronger breakdown process of depletion region in 1E11 film may generate a stronger and sharper interface between YSMO-11 film and SNTO substrate. This possibly sharp interface can provide better tunneling effect across the YSMO/SNTO junction that result in the larger voltage range for NDR behavior. During cycle 4 (as discussed for PRI film) current gets suppressed with decrease in the applied voltage. Also, value of current at $-10V$ for YSMO-11 film is found to be $\sim 0.68mA$ which is slightly higher than that for YSMO-PRI film (i.e. $\sim 0.35mA$), based on a strong role of lattice strain and microstructural aspects of the films. By increasing the irradiation fluence from $1 \times 10^{11}$ ions/cm$^2$ to $1 \times 10^{12}$ ions/cm$^2$, RS behavior has been efficiently modified for, both, forward and reverse bias modes. Figure 4.6 (c) shows the RS behavior of YSMO-12 film recorded at 300K. YSMO-12 film also exhibits counter eight wise RS behavior having following features of switching: (1) YSMO-12 shows the almost symmetry in cycle 1 and cycle 3. (2)
Maximum current recorded for YSMO-12 film is found to be higher than YSMO-PRI and YSMO-11 films which can be understood in terms of increased lattice strain at the YSMO-SNTO interface and reduced grain size of YSMO film (YSMO-12). (3) As a result of an enhanced strain and reduced grain size, 1E12 film exhibits very low value of critical voltage (~ 0.5V) in the forward bias mode as compared to YSMO-PRI and YSMO-11 films, which can also be correlated with the structural and microstructural aspects of the YSMO-12 film. (4) No more reduction in HRS/LRS ratio has been found in the YSMO-12 film, as compared to YSMO-PRI and YSMO-11 films. Ratio gets slightly suppressed from 1.75 (PRI) to 1.70 (YSMO-11) to 1.38 (YSMO-12). (5) Interestingly, YSMO-12 film (possessing large number of defects created due to irradiation) exhibits constant current region from 3.0V to studied voltage limit, i.e.10V. This phenomenon is known as current compliance effect for the observed large current range. Observed current compliance effect can be useful for any device to protect from hard dielectric break down process. Similar current compliance effect can be observed for reverse bias mode between -1.3V to -10V. The existence of observed current compliance effect in the presently studied YSMO-12 film can be understood as: Since, higher fluence of 1E12 ions/cm$^2$ can create large number of oxygen vacancies in the lattice of YSMO (by reducing grain size and by enhancing more disordered grain boundary density) as well as at the YSMO-SNTO interface (by introducing more strain at the YSMO/SNTO junction and, hence, more oxygen deficiency and non-stoichiometry in this region). All these oxygen vacancies of YSMO films (interface strained region which is large in reverse bias mode) get attracted toward interface region, especially around YSMO boundary of the interface. All these positive charged oxygen vacancies trap the free charge carriers and, hence, block the further conduction across the junction. This process known as current compliance ($I_{CC}$) which gives rise to constant current values even further increase in applied positive as well as negative voltages in forward and reverse bias modes, respectively. (6) In this 1E12 film, due to an existence of current compliance process through the blocking of the interface/depletion region for further possible conduction, no NDR behavior could be possible. (7) During cycle 4, similar observation can be understood as discussed for PRI and 1E11 films.
Figure 4.6 (d) shows the RS behavior of 1E13 film irradiated with higher fluence of $1 \times 10^{13}$ ions/cm$^2$. 1E13 film also exhibits a distinct behavior as compared to all other pristine and irradiated films. Other than backward diode like behavior exhibited by 1E13 film, almost symmetric hysteresis I–V character can be seen. Overall, cycle 1 shows that the maximum drawn current, across the interface, is found to be reduced from $\sim 12$mA (1E12) to $\sim 4$µA (1E13) which can be ascribed to the reduction in charge conduction due to (i) suppressed lattice strain between the YSMO film and SNTO substrate, (ii) reduced defects/oxygen vacancies at the strained interface region and (iii) enhanced grain size and, hence, reduced grain boundary density. As a result, YSMO-13 film shows a critical voltage at $\sim 5.0$V which is highest among all other three films understudy. Interestingly, YSMO-13 film exhibits $\sim 2.47$ ratio of HRS/LRS which is highest amongst all pristine and irradiated YSMO/SNTO films, which is a useful feature for practical device applications. Due to reduced strain value, improved grain size, suppressed grain boundary density and decrease in oxygen vacancies, no breakdown of depletion region or current compliance behavior has been observed for YSMO-13 film. Although, due to the improved strain state, a sharp interface can be expected during reverse bias mode which results in the better tunneling process across the junction and, hence, larger current across interface for reverse bias mode as compared to forward one. This is known as backward diode like behavior.
4.6 Conclusion

In conclusion, we have successfully fabricated YSMO manganite films having ~
100 nm thickness on n–type semiconducting SNTO substrate by using PLD technique
and irradiated by SHI Ag\(^{15+}\) irradiation with different ion fluences i.e. $1 \times 10^{11}$ to $1 \times 10^{13}$
ions/cm\(^2\). From the XRD patterns, it is confirmed that pristine and irradiated films are
single phase. The lattice mismatch between the film and the substrate gets modified under
the SHI irradiation through the creation of defects in the YSMO lattice as well as local
annealing effect. While, the pristine film possesses homogenous island type grain growth,
the irradiated films exhibit hillock like structures due to defects created by the SHI
Irradiation. The forward bias mode of pristine film has been discussed in the context of
RS behavior with charge trapping–detrapping processes across the interface. Reverse bias
mode shows the role of depletion region and NDR behavior for the pristine film. Upon
irradiation the YSMO/SNTO film with $1 \times 10^{11}$ and $1 \times 10^{12}$ ions/cm\(^2\), modifications in
RS for both, forward and reverse bias modes, have been discussed in the context of the
role of defect density, structural strain at the interface, oxygen vacancies and modified
depletion region of the films. Presence of current compliance effect and absence of NDR
behavior have been ascribed to the large defect density in YSMO/SNTO film irradiated
with $1 \times 10^{12}$ ions/cm\(^2\) fluence. At higher fluencies the ion irradiated film shows an
improved RS behavior with no NDR, no current compliance effect and effective
backward diode character which has been ascribed to an enhanced lattice strain and
improved surface morphology.
References


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