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Fig. 1.11. GMR materials are made from alternating layers of magnetic and non magnetic metals that are nanometers in thickness [29].

Fig. 1.12. Phase diagram of $La_{1-x}Ca_xMnO_3$, constructed from measurements of macroscopic quantities such as the resistivity and magnetic susceptibility, FM: Ferromagnetic Metal, FI: Ferromagnetic Insulator, AF: Antiferromagnetic, CAF: Canted AF, and CO: Charge/Orbital Ordered. FI and/or CAF could be spatially inhomogeneous states with FM and AF coexistence [32].

Fig. 1.13. Lower panel Lattice parameters and cell volume as a function of temperature for the $La_{0.5}Ca_{0.5}MnO_3$ sample, measured on cooling. Lines through the points are guides to the eye. The shaded area represents the width of the magnetization hysteresis loop. Upper panel Magnetization (H = 1 T) and electric resistivity (H = 0 T) vs T for $La_{0.5}Ca_{0.5}MnO_3$ measured on cooling [35].

Fig. 1.14. Variation of lattice parameters of bulk and nanocrystalline half doped $La_{0.5}Ca_{0.5}MnO_3$ manganites with measuring temperature [37].

Fig. 1.15. Variation of Unit Cell Volume and Orthorhombic starin of bulk and nanocrystalline half doped $La_{0.5}Ca_{0.5}MnO_3$ manganites with measuring temperature [39].

Fig. 1.16. Temperature variation of magnetization for bulk and nanocrystalline half doped $La_{0.5}Ca_{0.5}MnO_3$ manganites [39].

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Fig. 1.20. Magnetic Phase diagram for $Nd_{1-x}Sr_xMnO_3$ crystal ($0.30 \leq x \leq 0.80$) [47].

Fig. 1.21. Crystallographic Phase diagram for $Nd_{1-x}Sr_xMnO_3$ crystal ($0.50 \leq x \leq 0.80$) [47].

Fig.1.22. The temperature dependence of magnetization (top), resistivity (middle) and lattice parameters (bottom) observed for bulk $Nd_{0.5}Sr_{0.5}MnO_3$. In $Nd_{0.5}Sr_{0.5}MnO_3$ the critical temperature of the charge/orbital ordering transition coincides with the antiferromagnetic Neel temperature ($T_{CO}=T\approx160$ K) [49].

Fig. 1.23. Temperature dependence of field cooled and zero field cooled susceptibility for (a) S30 (30 nm) and (b) S55 (55 nm). The measurements have been performed in the presence of 100 Oe magnetic field. Insets: a(i) and b(i). Temperature dependence of inverse zero field cooled susceptibility in high temperature region for S30 (30 nm) and S55 (55 nm), respectively. The temperature region above 300 K has been fitted according to the Curie–Weiss function, $\chi \approx C/T-\theta p$. a(ii) and b(ii). The minima at temperature dependence of $d\chi/dT$ indicated by arrow represent the paramagnetic to ferromagnetic transition [51].

Fig. 1.24. Variation of lattice parameters of NSMO1150 (bulk) and NSMO750 (nano) samples with temperature obtained from refinement of neutron diffraction data [53].

Fig. 1.25. Temperature variation of zero field cooled (ZFC) and field cooled (FC) magnetization of NSMO1150 (bulk), NSMO850 (nano) and NSMO750 (nano) samples measured at 500 Oe magnetic field [55].

Fig. 1.26. Plot of $1/\chi$ vs. T for bulk and nano NSMO samples. The straight line represents the fitted curve under Curie–Weiss law.The insets (a) and (b) display the distribution of blocking temperatures (T_B) of NSMO750 and NSMO850 samples, respectively [55].

Fig. 1.27. Hysteresis behavior (M–H loop) of NSMO750 (nano) sample measured at 60K. Inset (a) shows the M–H loop at 100K for NSMO850 (nano) sample and Arrott plot utilizing the same. Inset (b) shows the Arrott plot for NSMO750 sample at 60K. Inset (c) shows the M–H loops at 15K and 200K for NSMO1150 (bulk) sample [57].

Fig. 1.28. Magnetic phase diagram for the $Sm_{1-x}Ca_xMnO_3$, solid circle, solid square, and solid triangles represent for T_C, T_{CO}, and T_N, respectively for different compositions. The two hatched zones represent the intermediate regions, and the CMR domain is shown by arrows in the upper part [59].

Fig. 1.29. The temperature dependencies of magnetization (top), resistivity (middle) and lattice parameters (bottom) observed for bulk $Sm_{0.5}Ca_{0.5}MnO_3$ sample, ($T_{CO} \approx 270$ K and $T_N \approx 170$ K) [61].

Fig. 1.30. (a) ZFC and FC magnetizations measured at H =1 kOe for the 70 nm SCMO nanoparticles. The inset to (a) shows the enlarged view of the high temperature region. (b) Hysteresis loops of magnetization at 4 K after ZFC and FC under 10 kOe for the 70 nm SCMO nanoparticles. The inset to (b) shows the enlarged view of low field region [63].

Fig. 1.31. M-H hysteresis loops at 4 K after FC under 10 kOe for the nanosized SCMO with different particle sizes. The inset shows the enlarged view of low field region [65].

Fig. 1.32. Zero Field Cooling (ZFC) dc magnetic susceptibility plot of nano (S550), nano (S750) (lower inset) and bulk (SB) (upper inset) $Sm_{0.5}Ca_{0.5}MnO_3$ samples [65].

bottom curve (stars) shows Shirley background. The continuous line overlapping the observed XPS data (solid circles) shows the resulting curve fit [98].

Fig. 3.3. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk and nanocrystalline $La_{0.5}Ca_{0.5}MnO_3$, samples obtained after Rietveld analysis of the XRD data using orthorhombic space group *Pnma*. The vertical tick marks between the observed and difference plot show the Bragg peak positions [103].

Fig. 3.4. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk and nanocrystalline $Nd_{0.5}Ca_{0.5}MnO_3$ samples obtained after Rietveld analysis of the XRD data using orthorhombic space group *Pnma*. The vertical tick marks between the observed and difference plot show the Bragg peak positions [104].

Fig. 3.5. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk and nanocrystalline $Pr_{0.5}Ca_{0.5}MnO_3$ samples obtained after Rietveld analysis of the XRD data using orthorhombic space group *Pnma*. The vertical tick marks between the observed and difference plot show the Bragg peak positions [105].

Fig. 3.6. Evolution of the unit cell volume for bulk and nanocrystalline $La_{0.5}Ca_{0.5}MnO_3$, $Nd_{0.5}Ca_{0.5}MnO_3$ and $Pr_{0.5}Ca_{0.5}MnO_3$ samples calcined at various temperatures [108].

Fig. 3.7. Evolution of strongest XRD profile for bulk and nanocrystalline $La_{0.5}Ca_{0.5}MnO_3$, $Nd_{0.5}Ca_{0.5}MnO_3$ and $Pr_{0.5}Ca_{0.5}MnO_3$ samples calcined at various temperatures. The samples calcined at 600, 700, 800, 900, 1000, 1100, 1200, 1300 and 1400 ^oC are denoted as C6, C7, C8, C9, C10, C11, C12, C13 and C14 respectively [109].

Fig. 3.8. Evolution of lattice parameters for bulk and nanocrystalline samples calcined at various temperatures (a) $La_{0.5}Ca_{0.5}MnO_3$ (b) $Nd_{0.5}Ca_{0.5}MnO_3$ and (c) $Pr_{0.5}Ca_{0.5}MnO_3$ [111].

Fig. 3.9. Variation of orthorhombic strain $OS_{\perp}$ (perpendicular strain along the b- axis) and $OS_{\parallel}$ (strain in ac– plane) for bulk and nanocrystalline samples calcined at various temperatures (a) $La_{0.5}Ca_{0.5}MnO_3$ (b) $Nd_{0.5}Ca_{0.5}MnO_3$ and (c) $Pr_{0.5}Ca_{0.5}MnO_3$ [113].

Fig. 3.10. Variation of Mn-O Bond lengths for (a) $La_{0.5}Ca_{0.5}MnO_3$ (b) $Nd_{0.5}Ca_{0.5}MnO_3$ and (c) $Pr_{0.5}Ca_{0.5}MnO_3$ samples calcined at various temperatures [114].

Fig. 3.11. Magnetization (M) vs temperature (T) curve measured at 0.05 T and 1 T magnetic fields for (a) bulk $La_{0.5}Ca_{0.5}MnO_3$ sample (lower panel) and nano $La_{0.5}Ca_{0.5}MnO_3$ sample calcined at 800 ^{O}C (upper panel). Inset to figure (a) shows first order derivative of magnetization (M) with respect to temperature (T) for bulk $La_{0.5}Ca_{0.5}MnO_3$ sample. Inset to figure (b) shows ac-susceptibility vs temperature for nanocrystalline $La_{0.5}Ca_{0.5}MnO_3$ sample calcined at 800 ^{o}C [116].

Fig. 3.12. Magnetization (M) versus applied magnetic field (H) plot for bulk and nanocrystalline (calcined at 800 ^{O}C) $La_{0.5}Ca_{0.5}MnO_3$ samples measured at 5 K (main panel) and at room temperature (RT) (inset). Ferromagnetic hysteresis loop is clearly seen for nano sample at 5 K. Inset shows the paramagnetic state for both the samples at 300 K (RT) [119].

Fig. 3.13. Magnetization (M) versus applied magnetic field (H) plot for nanocrystalline $Nd_{0.5}Ca_{0.5}MnO_3$ (left panel) and $Pr_{0.5}Ca_{0.5}MnO_3$ (right panel) at 5 K. Ferromagnetic hysteresis loop is clearly seen for both the samples [119].

Fig. 3.14. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for nanocrystalline $La_{0.5}Ca_{0.5}MnO_3$,

samples (prepared by Sol-Gel method and calcined at 700 ^{o}C) obtained after Rietveld analysis of the XRD data using orthorhombic space group Pnma. The vertical tick marks between the observed and difference plot show the Bragg peak positions. Upper panel at room temperature and lower panel at 15 K [121].

Fig. 3.15. Variation of unit cell volume (left upper panel) and lattice parameters (left lower panel) for $La_{0.5}Ca_{0.5}MnO_3$ samples prepared by sol-gel method and calcined at various temperatures. The middle panel shows the evolution of strongest peak of Mn_3O_4 impurity (around $2\theta \approx 36.17$) for samples calcined at various temperatures. The samples calcined at 700, 800, 900, 1000, 1100 1300 ^{o}C are denoted as C7, C8, C9, C10, C11 and C13 respectively [124].

Fig. 4.1. Scanning electron microscopic (SEM) images of (a) bulk (C13) and (c) nano (C9) $Nd_{0.5}Sr_{0.5}MnO_3$ samples. Energy dispersive Spectrum (EDS) of samples (b) C13 and (d) C9. Inset to Fig. 4.1(d) shows the TEM image of C9 samaple [133].

Fig. 4.2. X-ray photoelectron spectra (solid circles) of Mn $2p_{3/2}$ core level for bulk (C13) and nano (C6) $Nd_{0.5}Sr_{0.5}MnO_3$. The solid triangles and solid squares show the core level peak fits for the Mn^{4+} and Mn^{3+} ions, respectively. The bottom curve (stars) shows Shirley background. The continuous line overlapping the observed XPS data (solid circles) shows the resulting curve fit [135].

Fig. 4.3. Magnetization vs temperature (M-T) plots for the samples (a) C13, (b) C9, (c) C6 measured at the magnetic field of 0.05 T. Zoomed portion of the M-T plot at lower temperatures (a,b,c) [137].

Fig. 4.4. The inverse susceptibility (χ^{-1}) vs Temperature (T) plots of the samples (a) C13, (b) C9, (c) C6 and first derivative of magnetization (dM/dT) vs temperature (T)) of the samples (d) C13, (e) C9, (f) C6 $Nd_{0.5}Sr_{0.5}MnO_3$ ceramic [139].

Fig. 4.5. The Magnetization (M) vs applied magnetic field (H) plot for bulk and nanocrystalline $Nd_{0.5}Sr_{0.5}MnO_3$ at 5 K (main panel) and at 150 K (inset). Hysteresis indicative of ferromagnetism is clearly seen at 5 K. Inset also shows the ferromagnetic behaviour for both the samples [142].

Fig. 4.6. Powder XRD patterns of $Nd_{0.5}Sr_{0.5}MnO_3$ ceramics prepared at various calcination temperatures 600 ^oC, 700 ^oC, 800 ^oC, 900 ^oC, 1000 ^oC, 1100 ^oC, 1200 ^oC and 1300 ^oC. The strong superstructure peaks are marked by asterisks [144].

Fig. 4.7. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk(C13) $Nd_{0.5}Sr_{0.5}MnO_3$ at 300K obtained by using *Imma*. The vertical tick marks above difference plot show the Bragg peak positions [146].

Fig. 4.8. Evolution of selected XRD profiles with temperature (13 K to 300 K) for bulk (C13) $Nd_{0.5}Sr_{0.5}MnO_3$ sample. The miller indices on top corresponding indexing using orthorhombic structure [147].

Fig. 4.9. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk(C13) $Nd_{0.5}Sr_{0.5}MnO_3$ at 13K obtained by using coexisting *Imma*+$P2_1/m$ space groups. The vertical tick marks above difference plot show the Bragg peak positions [150].

Fig. 4.10. Temperature variation of lattice parameters and unit cell volume for bulk (C13) $Nd_{0.5}Sr_{0.5}MnO_3$ obtained by Rietveld structure refinement [151].

Fig. 4.11. Evolution of orthorhombic (101/020), (202/040) and (400/004/242) XRD profiles for $Nd_{0.5}Sr_{0.5}MnO_3$ samples prepared at various calcination temperatures [153].

Fig. 4.12. Le-Bail profile fits for XRD patterns of nanocrystalline $Nd_{0.5}Sr_{0.5}MnO_3$ using various structural models (a) C9 sample using orthorhombic (*Imma*) (b) C9 sample using orthorhombic (*Pnma*), (c) C9 sample using monoclinic ($P2_1/m$), (d) C6 sample using monoclinic ($P2_1/m$) (e)) C9 sample using monoclinic (*Pm*) with lattice parameter ($2a_o$, b_o, $3c_o$) and (f) C6 sample using monoclinic (*Pm*) with lattice parameter ($2a_o$, b_o, $3c_o$) [157].

Fig. 4.13. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for nanocrystalline (a) C9 and (b) C6 $Nd_{0.5}Sr_{0.5}MnO_3$ samples obtained after Le-Bail profile matching analysis of the XRD data. The vertical tick marks above the difference plot show the Bragg peak positions [159].

Fig. 4.14. Variation of lattice parameters and unit cell volume for nanocrystalline $Nd_{0.5}Sr_{0.5}MnO_3$ samples prepared at various calcination temperatures [160].

Fig. 5.1. The scanning electron microscope (SEM) images of $Sm_{0.5}Ca_{0.5}MnO_3$ ceramics prepared at calcinations temperautre 700 ^oC and 900 ^oC [164].

Fig. 5.2. Powder XRD patterns of $Sm_{0.5}Ca_{0.5}MnO_3$ ceramics prepared at various calcination temperatures 600 ^oC, 700 ^oC, 800 ^oC, 900 ^oC, 1000 ^oC, 1100 ^oC, 1200 ^oC, 1300 ^oC and 1400 ^oC [166].

Fig. 5.3. Evolution of selected XRD profiles with calcinations temperature for $Sm_{0.5}Ca_{0.5}MnO_3$ samples [168].

Fig. 5.4. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for bulk $Sm_{0.5}Ca_{0.5}MnO_3$, samples obtained after Rietveld analysis of the XRD data using orthorhombic space group

Pnma. The vertical tick marks between the observed and difference plot show the Bragg peak positions [169].

Fig. 5.5. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for nanocrystalline $Sm_{0.5}Ca_{0.5}MnO_3$, samples (calcined at 1100 ^oC) obtained after Rietveld analysis of the XRD data using (a) orthorhombic space group *Pnma* and (b) coexistence of two phase with space group $P2_1/m+Pnma$. The vertical tick marks between the observed and difference plot show the Bragg peak positions [171].

Fig. 5.6. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for nanocrystalline $Sm_{0.5}Ca_{0.5}MnO_3$, samples (calcined at 900 ^oC) obtained after Le-Bail analysis of the XRD data using (a) coexistence of two phase with space group $P2_1/m+Pnma$ (b) modulated crystal structure with monoclinic space group *Pm* with lattice parameters $2a_o$, b_o, $3c_o$. The vertical tick marks between the observed and difference plot show the Bragg peak positions [172].

Fig. 5.7. Experimentally observed (dots), Rietveld calculated (continuous line) and their difference (continuous bottom line) profiles for nanocrystalline $Sm_{0.5}Ca_{0.5}MnO_3$, samples calcined at (700 ^oC) obtained after Le-Bail analysis of the XRD data using (a) modulated crystal structure with monoclinic space group *Pm* with lattice parameters $2a_o$, b_o, $3c_o$ and (b) modulated crystal structure with monoclinic space group *Pm* with lattice parameters $5a_o$, b_o, $2c_o$. The vertical tick marks between the observed and difference plot show the Bragg peak positions [174].

Fig. 5.8. Variation of lattice parameters and unit cell volume with calcinations temperature/particle size for $Sm_{0.5}Ca_{0.5}MnO_3$ obtained by Le-Bail analysis of the structure. Lattice parameters and cell volume of modulated phases were suitably scaled to correspond to the orthorhombic cell parameter bulk sample [176].

Fig. 5.9. Magnetization vs temperature (M-T) plots for the $Sm_{0.5}Ca_{0.5}MnO_3$ samples are C7 (calcined at 700 ^{0}C), C9 (calcined at 900 ^{0}C) and C14 (calcined at 1400 ^{0}C) measured at the magnetic field of 0.05 T [178].

Fig. 5.10. Magnetization vs temperature (M-T) plots for the $Sm_{0.5}Ca_{0.5}MnO_3$ samples are C7 (calcined at 700 ^{0}C), C9 (calcined at 900 ^{0}C) and C14 (calcined at 1400 ^{0}C) measured at the magnetic field of 1 T [179].

Fig. 5.11. The Magnetization (M) vs applied magnetic field (H) plot for bulk and nanocrystalline $Sm_{0.5}Ca_{0.5}MnO_3$ measured at 5 K. Hysteresis indicative of ferromagnetism is clearly seen [181].