Anomalous Nernst Effect and Joule Magnetostriction in ferromagnetic $La_{0.5}Sr_{0.5}CoO_3$ synthesized by microwave irradiation

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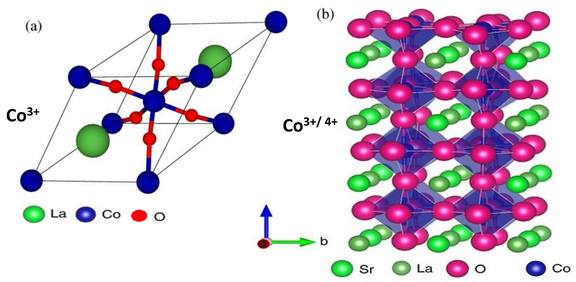
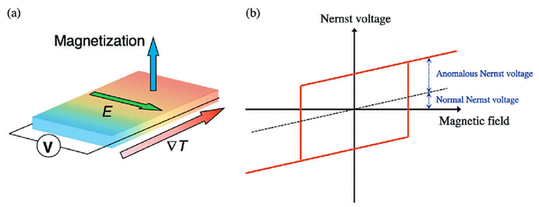
Introduction



- $LaCoO_3$ is a paramagnetic insulator at low temperature.
- Co^{3+} undergoes a gradual transition from low spin (S= 0, LS) to Intermediate spin (S =1, IS) with increasing temperature in the range T = 50 K- 100 K.
- Ferromagnetism in $LaCoO_3$ is induced by Sr^{2+} substitution at La^{3+} site.
- $La_{0.5}Sr_{0.5}CoO_3$ is a ferromagnetic metal with $T_C \sim 250$ K.
- **Motivation :** No previous study on the synthesis of $La_{0.5}Sr_{0.5}CoO_3$ by microwave method and investigations of the anomalous Nernst effect and magnetostriction

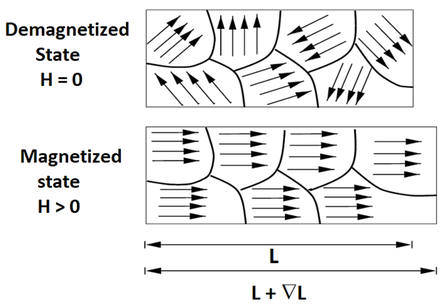
Anomalous Nernst Effect



$S_{xy} = E_y / \nabla_x T : E_y \propto H$ *in paramagnet*

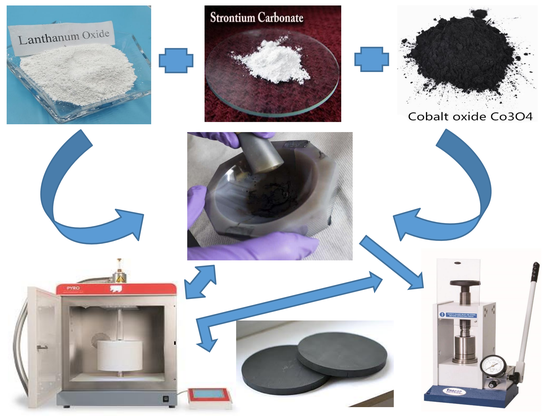
$E_y \propto M$ *in ferromagnet*

Magnetostriction



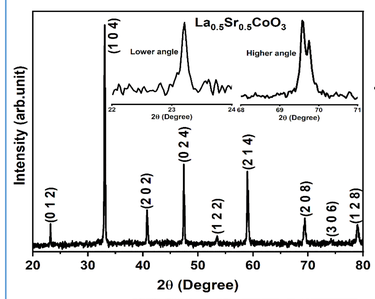
- Magnetostriction : A change in the physical dimension of a sample when it is magnetized.
- Spin-Orbit is the general cause of MST at high fields. However, orbital moment is usually quenched for Co^{3+} and Co^{4+} ions in cubic crystalline electric field due to surrounding oxygen ions.

Sample synthesis



1200°C/1600W/20 mint.

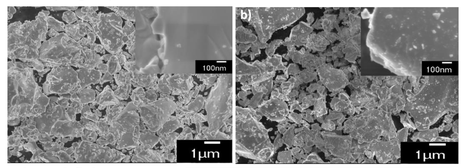
Results



XRD

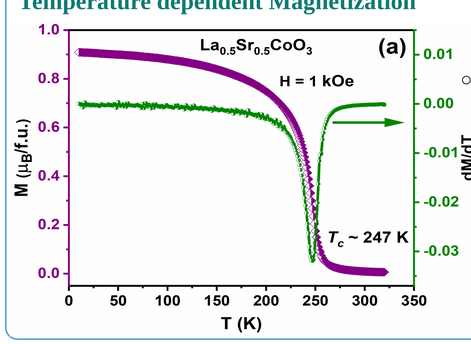
- **Rhombohedral (a = b** = 5.416(2), **c** = 13.266(5) Å and volume **V** = 337 Å^3) with space group of $R\bar{3}c$.

FE-SEM

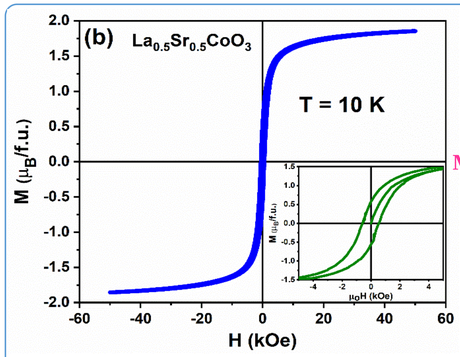


- An irregular shaped flaky natured particles with a sizes of largest is about 3 microns and the smallest is ~ 100 nm.

Temperature dependent Magnetization



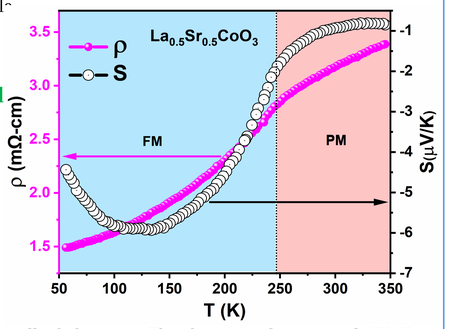
- Ferromagnetic below T_C = 247 K .



Field dependent Magnetization

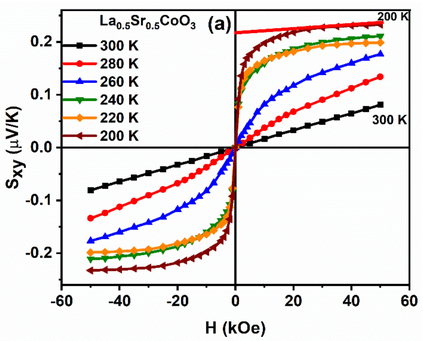
- M shows a tendency to saturate above 40 kOe with $H_c \sim 530$ Oe.
- M_{max} is ~ 1.89 μ_B/f.u. at 50 kOe: Comparable with the solid state prepared sampl~

Resistivity and Thermopower



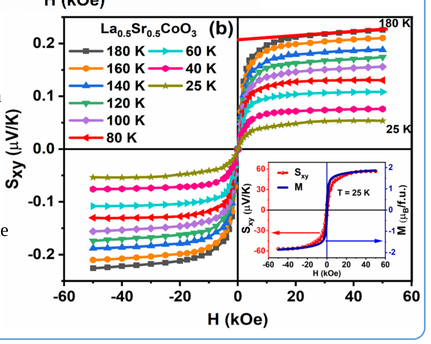
- $\rho(T)$ exhibits metallic behaviour. The change in slope around 250 K is due to decrease in spin-disorder scattering.
- The sign of S indicates that the majority charge carriers are electrons

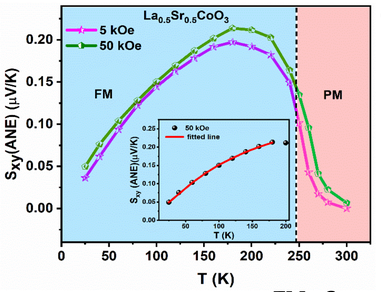
Anomalous Nernst Effect



- The Nernst thermopower (S_{xy}) resembles that magnetization: It increases linearly with H in the paramagnetic state but show non linear behaviour in the ferromagnetic state

- Resemblance in M & S_{xy}: both show a rapid increase in low fields ($H < 4$ kOe) and a tendency to saturate at high fields ($H \geq 40$ kOe).

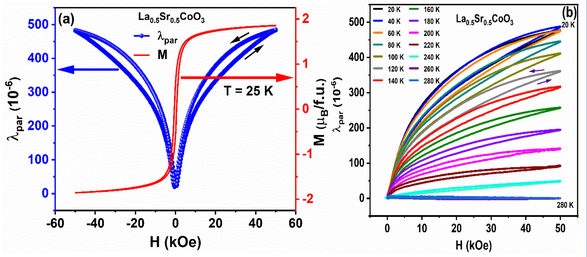




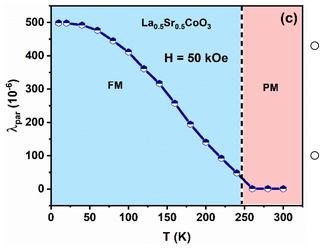
- $S_{xy}(ANE)$ increases as the temperature increases, reaches a max around 180 K ~ 0.21 μV/K (single crystal ~ 0.26 μV/K) for 50 kOe, and decreases rapidly as T_C is approached

Magnetostriction

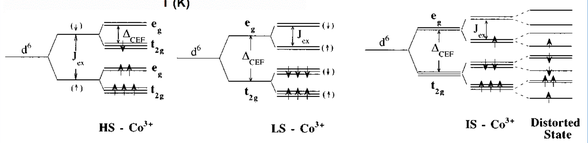
- **FM :** $S_{xy} = S_{xy}(NE) + S_{xy}(ANE)$



$$\lambda_{par} = [L(H) - L(0)]/L(0)$$



- Mismatch in the forward and reverse mag. field sweep: shows an opened unsaturated λ_{par} loop.
- λ_{par} is nearly temperature independent and reaches a max ~ 500 ppm at below 40 K.



Conclusions

- The crystal symmetry obtained here from a relatively very short-time of microwave irradiation is identical to that achieved by long time process of solid state method.
- Field dependence of the S_{xy} exhibits a hysteresis similar to magnetization and the extracted ANE shows a maximum value of ~ 0.21 μV/K at 180 K in an applied magnetic field of 50 kOe.
- The fitted value of n ~ 0.7 below 150 K suggests that the ANE is having more contribution likely from extrinsic skew scattering.
- The positive λ_{par} in the order of 100 x 10^{-6} over a measured temperature range 250 K – 10 K is relatively higher than the value obtained by conventional solid state reaction.

References

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