# Clean Energy

## Thermoelectric and magnetic properties of Bi, Cu double-substituted $La_{1-x}Sr_xCoO_3$ at room temperature


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## Abstract

This work is focused on the study of Thermoelectric (TE) properties of oxides system for the room to high temperature regime application. The La-cobaltite system with specific doping of Bi and Sr have been studied to optimize thermal and electrical conductivity. The detail analysis for structural, magnetic, elemental, electrical and thermal analysis have been performed for other relevant details.

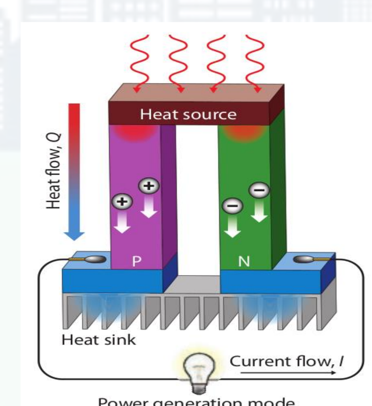

## Introduction

The research on renewable energy is on the rise because these alternative energy sources could be holding the key for controlling the climate change and provide fulfillment of energy required for various purposes. Every year though any urban province, billions of KWh of unused waste heat are dumped into environment and If that energy will put to use, it will reduce large amount of greenhouse CO2 emission. In addition, it will also reduce the energy cost for industrial and household purposes significantly. It makes a lot of sense to tap into the enormous potential of this form of power production and generating electricity from waste heat at relatively moderate temperature range for universal applicability.

**Seebeck effect**
**(Discovered by: Thomas Johann Seebeck, in 1821)**

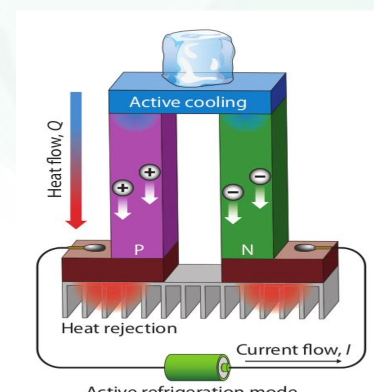
An electric current would flow continuously in a closed circuit made up of two dissimilar metals, if the junctions of the metals were maintained at different temperatures.

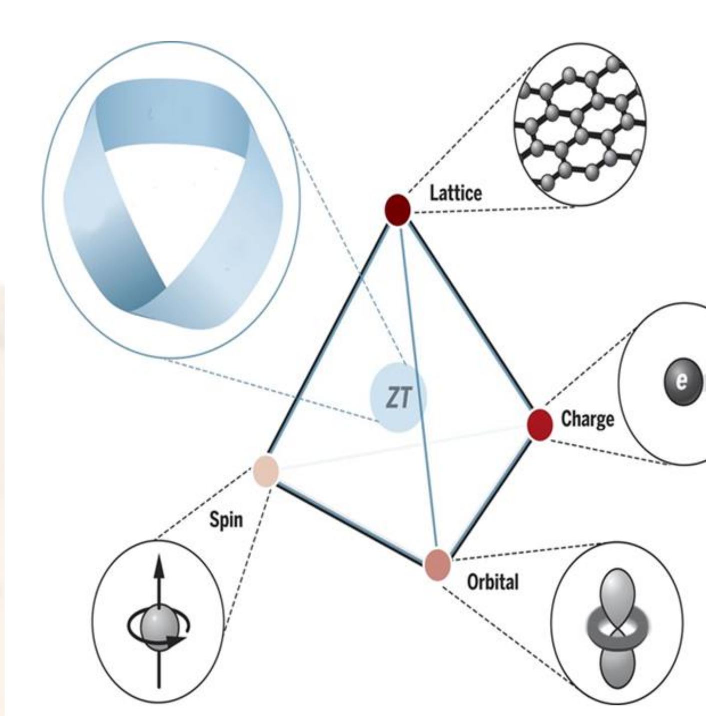
$$S = \frac{\Delta V}{\Delta T}$$

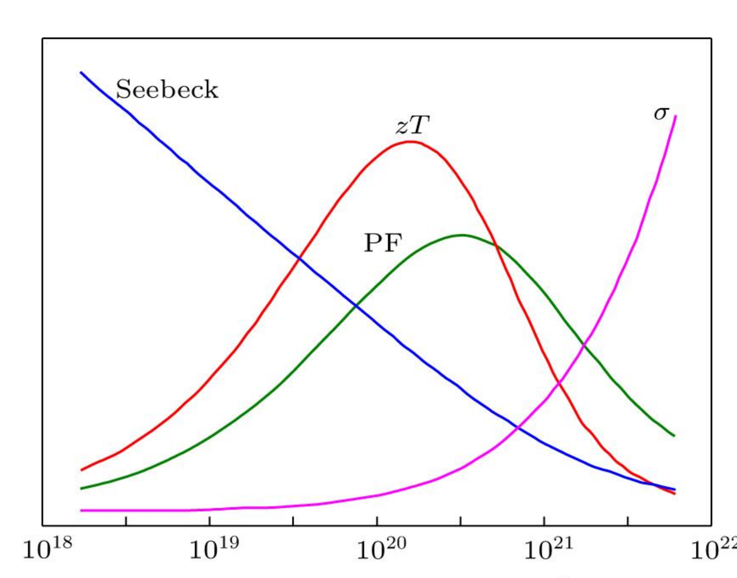



The performance of thermoelectric material is characterized by the dimension less figure of merit called as *ZT* parameter which can be defined as

$$ZT = \frac{S^2\sigma T}{\kappa_e + \kappa_{ph}}$$




## Materials and Methods

- The polycrystalline samples of $La_{0.95-x}Bi_xSr_{0.05}Co_{0.5}Cu_{0.5}O_3$, $0.00 \le x \le 0.06$, in steps of 0.02 have been prepared through Solid State Reaction rout.
- The x-ray diffraction (XRD), scanning electron microscopy (SEM) and he electron dispersive analysis of X-ray (EDAX) measurements were performed for phase identification, microstructural and elemental and stoichiometric analysis for the prepared samples respectively.
- The Physical property measuring system (PPMS) is used for measuring specific heat capacity $C_p$ and Debye temperature of the samples and the thermal response of the sample is analyzed by DXF-900.
- The M-H and M-T measurements were carried out using SQUID magnetometer (Quantum Design MPMS XL7).
- The I-V and Seebeck measurement has been done on Advance Riko- ZEM-3 instrument to extract ZT coefficient as a TE response for all samples.

## Conclusions

- The ZFC-FC and (M-H) plots shows the spin glass behavior at low (≈10K) and paramagnetic nature of the system at room temperature.
- With increasing the Bi-substitution for $x = 0.04$ & $0.06$, the thermal conductivity ($\kappa$) decreases, while the Seebeck voltage (S) increases.
- The decrease of $\kappa$ and increase of S, is desirable for good thermoelectric properties.
- The power factor (PF) and ZT values were extracted from the derived parameters and the results (ZT≈0.016, PF≈80µW/mK2) shows the co-doping system of $La_{0.95-x}Bi_xSr_{0.05}Co_{0.5}Cu_{0.5}O_3$ have potential for efficient thermoelectric performance.

## Industrial Significance

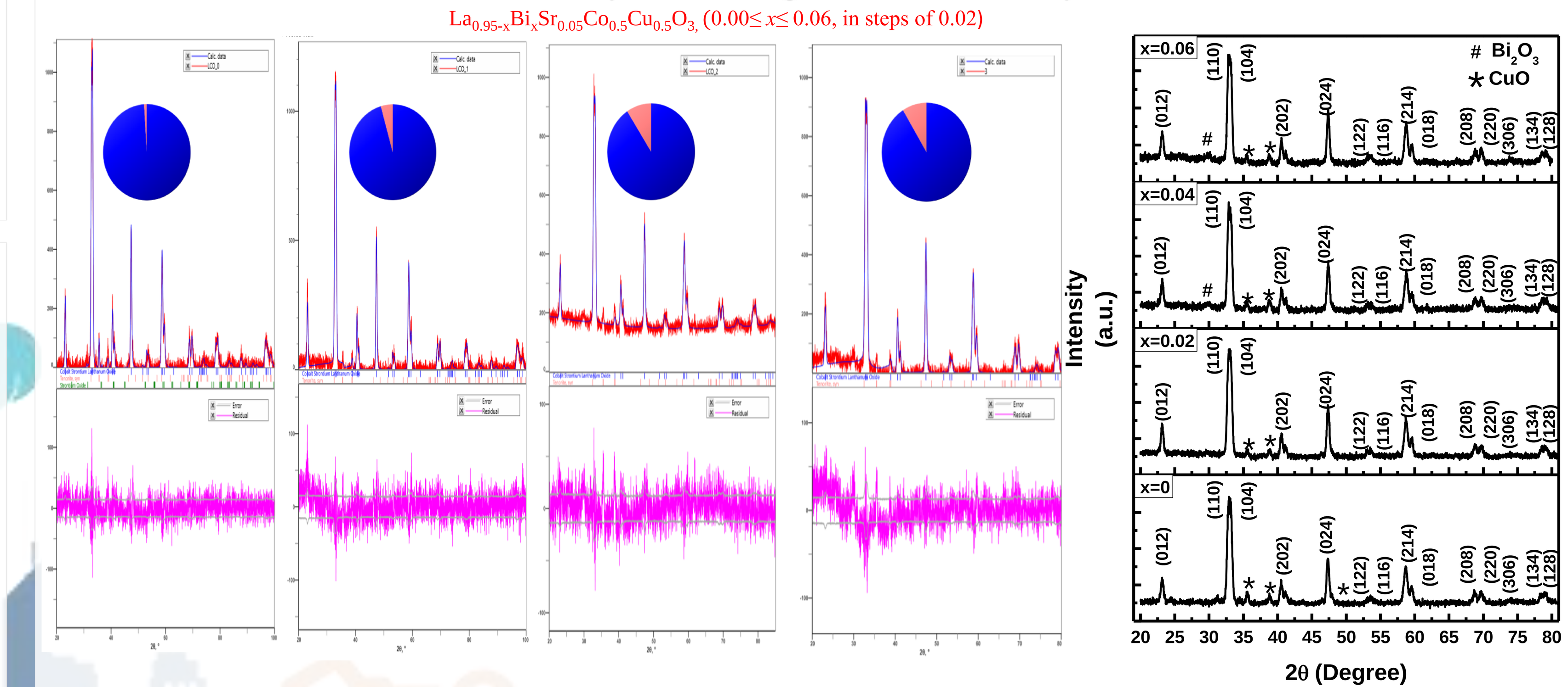
Oxide thermoelectric provides robust and cost effective material technology for production of renewable and clean energy.

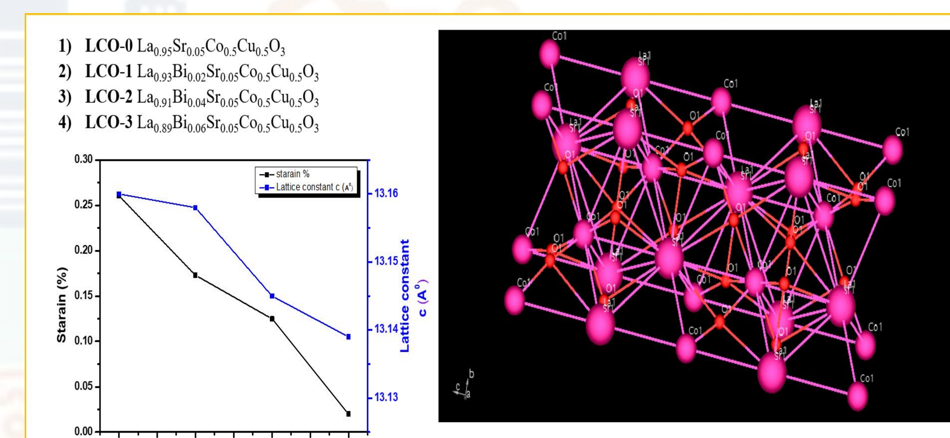
**Technology Readiness Level: Research Level**

## Results

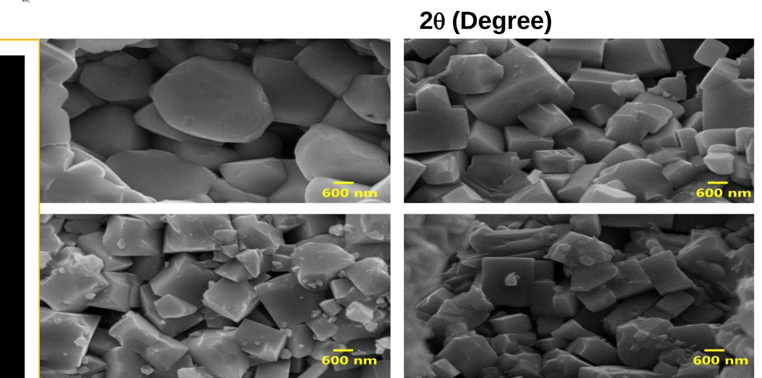
### Structural and morphological Analysis :

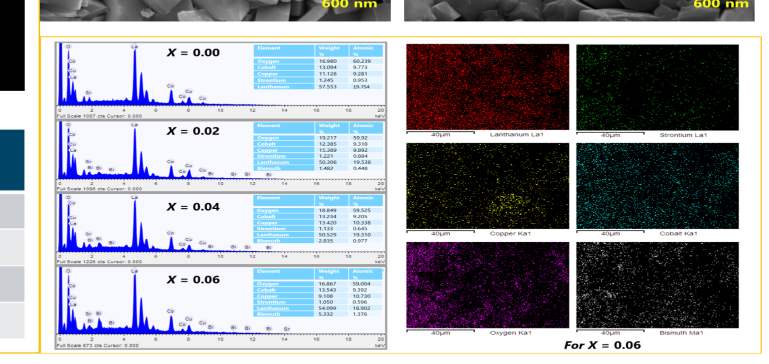
$La_{0.95-x}Bi_xSr_{0.05}Co_{0.5}Cu_{0.5}O_3$ ($0.00 \le x \le 0.06$, in steps of 0.02)



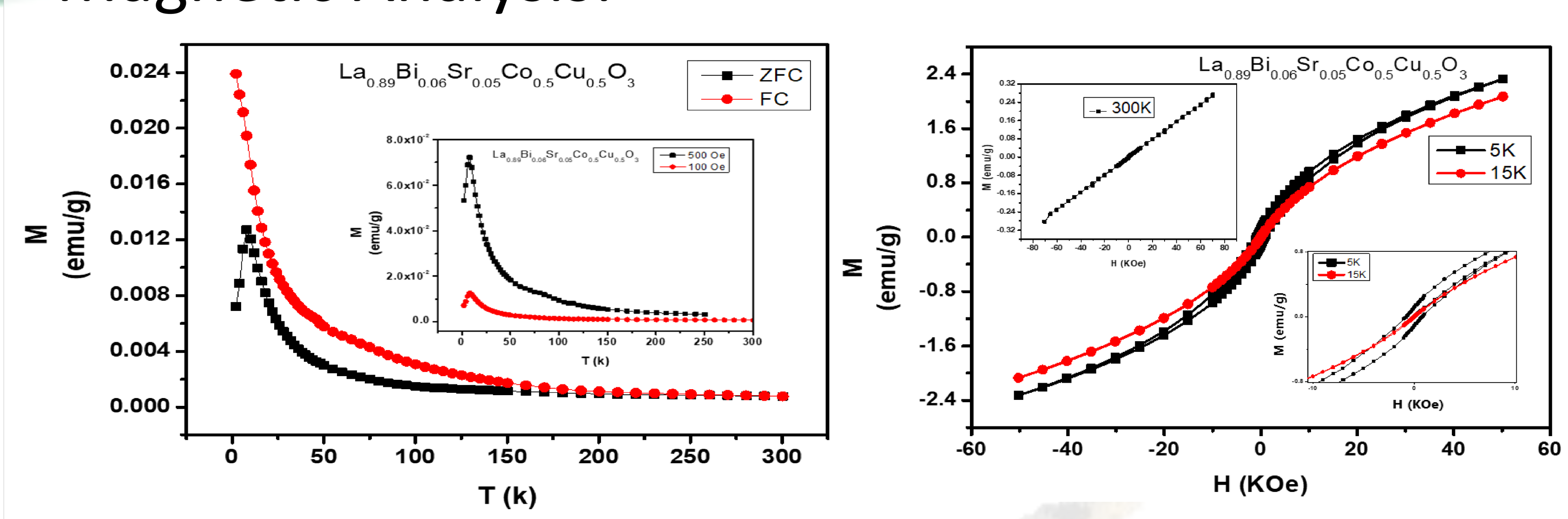



| sample | a (Å) | b (Å) | c (Å) | α, β, γ | Strain (%) | CuO impurity (%) |
|---|---|---|---|---|---|---|
| LCO 0 | 5.4672 | 5.4672 | 13.160 | 90, 90, 120 | 0.2606 | 1 |
| LCO 1 | 5.4643 | 5.4643 | 13.158 | 90, 90, 120 | 0.173 | 4 |
| LCO 2 | 5.457 | 5.457 | 13.145 | 90, 90, 120 | 0.125 | 9 |
| LCO 3 | 5.4549 | 5.4549 | 13.139 | 90, 90, 120 | 0.02 | 9 |

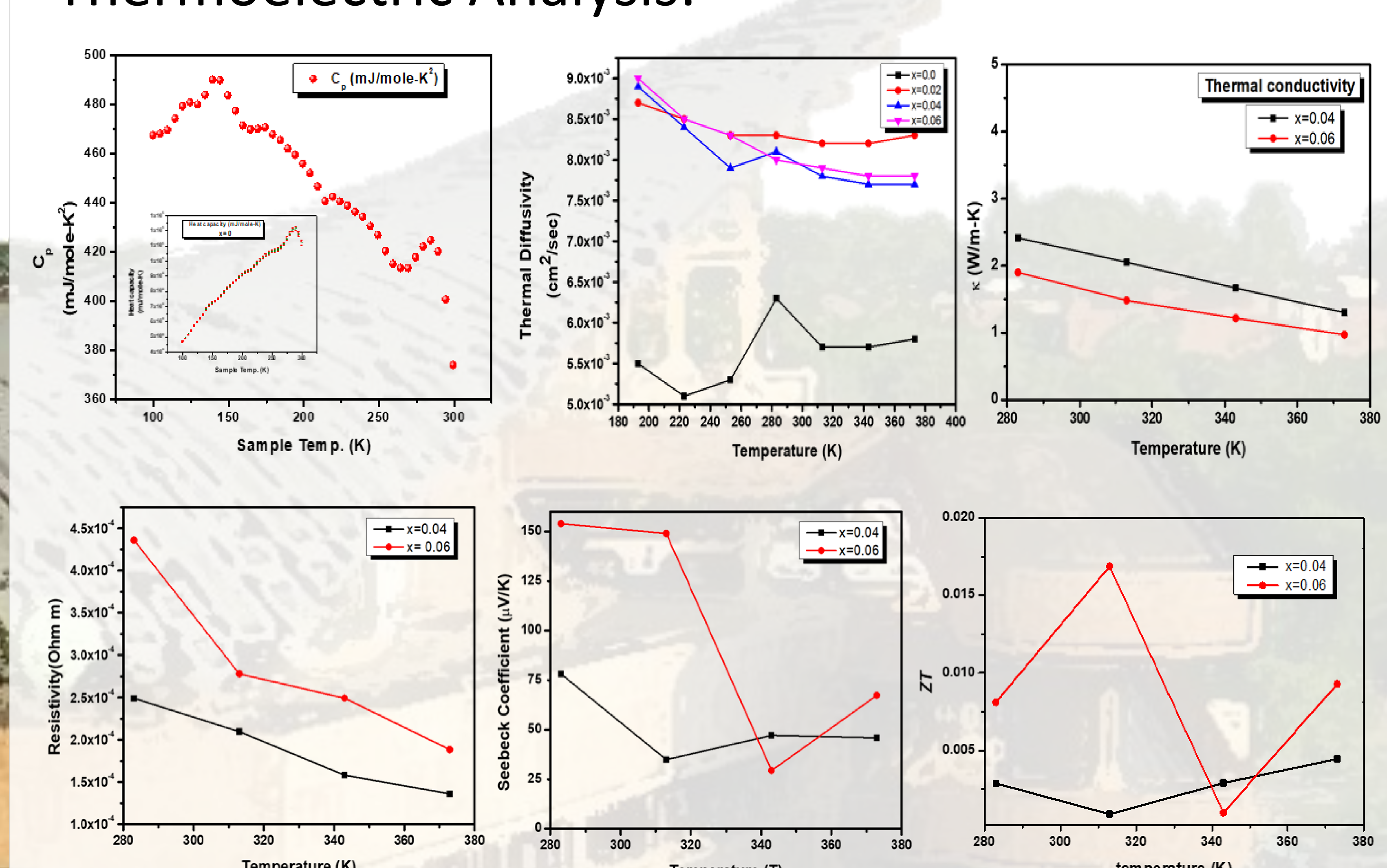




### Magnetic Analysis:




### Thermoelectric Analysis:





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