

Improved High-Temperature Thermoelectric Properties of Dual Doped $\text{Ca}_3\text{Co}_4\text{O}_9$ for Recycling Waste Heat into Electricity

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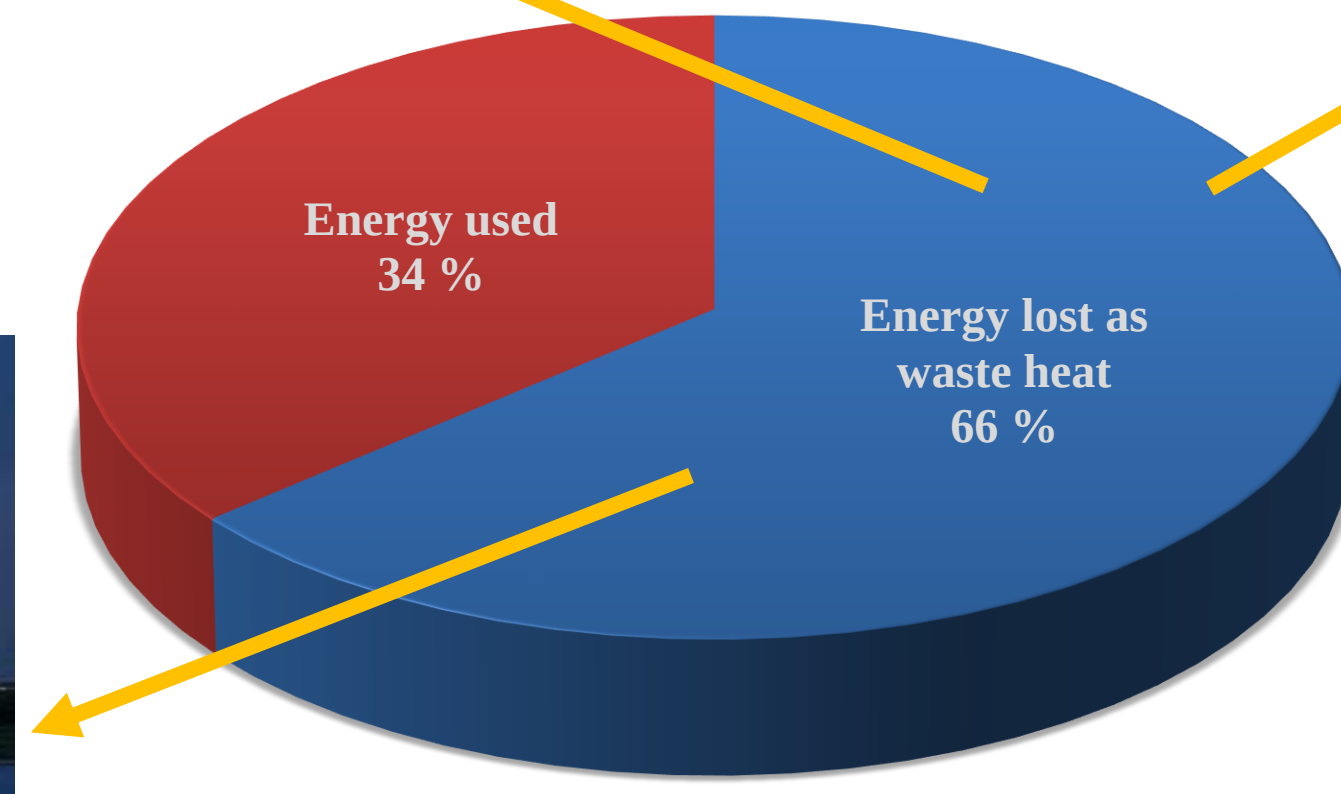
Natural gas



Thermal power plant

Address

1. **SDG-7 (Affordable & clean energy)**
2. **SDG-13 (Climate action)**



Waste Heat
Recovery ???

Solution

Thermoelectric (TE)
Renewable Energy Technology

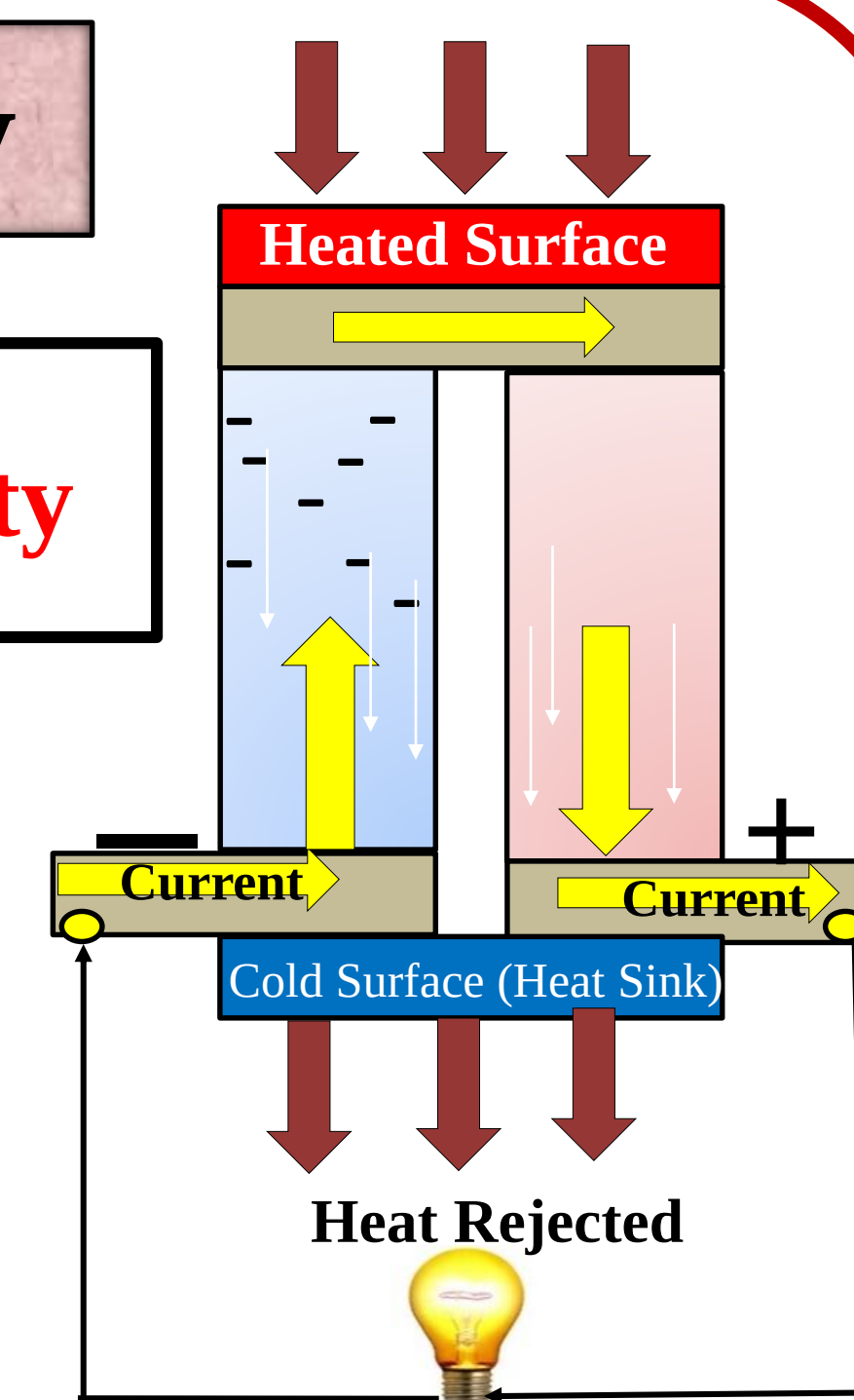
Thermoelectricity

Waste Heat → Electricity

Seebeck Effect **T. J. Seebeck (1821)**

Peltier Effect **J. C. Peltier (1834)**

Power Generation
Refrigeration



$\text{Ca}_3\text{Co}_4\text{O}_9$ Crystal Structure

- ❖ Alloys [**BiTe**, **PbTe** & **PbSe**]
- ❖ Half-Heusler [**MNiSn** (*n*-type) & **MCoSb** (*p*-type)]
- ❖ Skutterudites [**CoSb₃** & **LaFe₃CoSb₁₂**]

$$ZT = S^2T/\rho k \quad ZT \geq 1$$

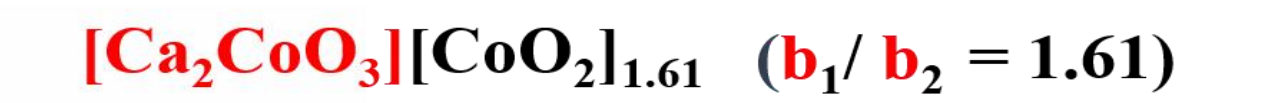
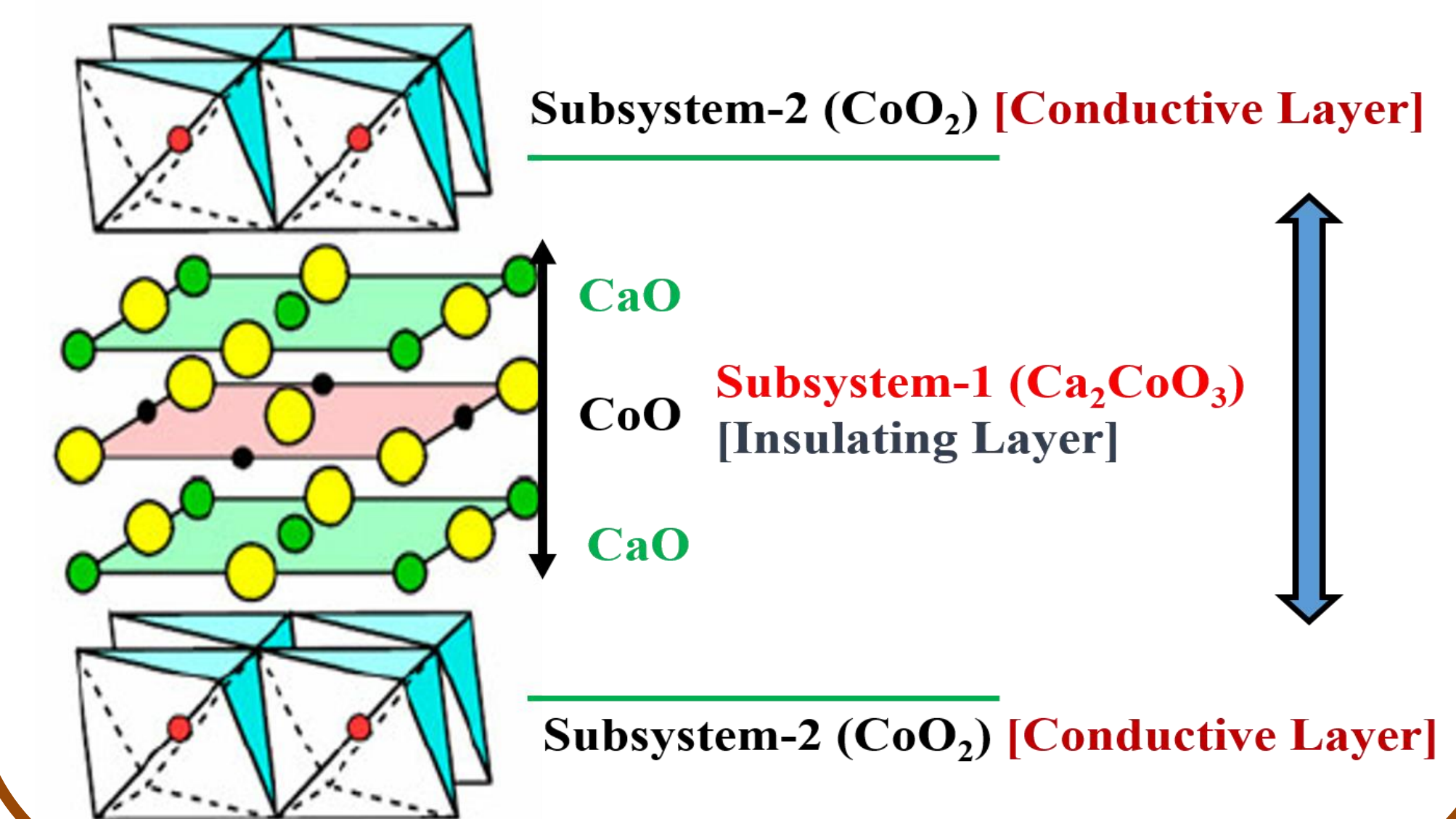
Issues:

- **Toxic**
- **Stability issues**
- **Expensive**

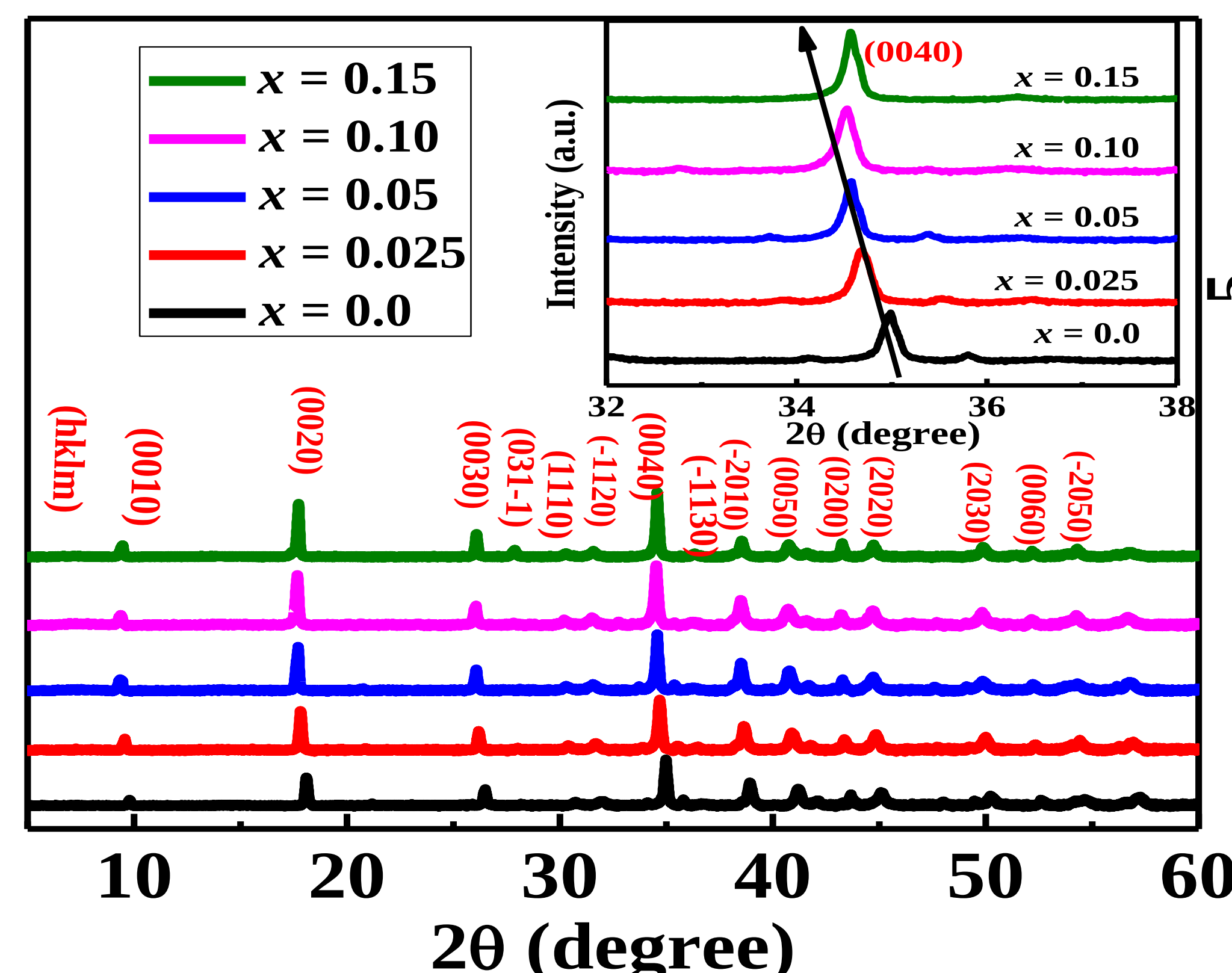
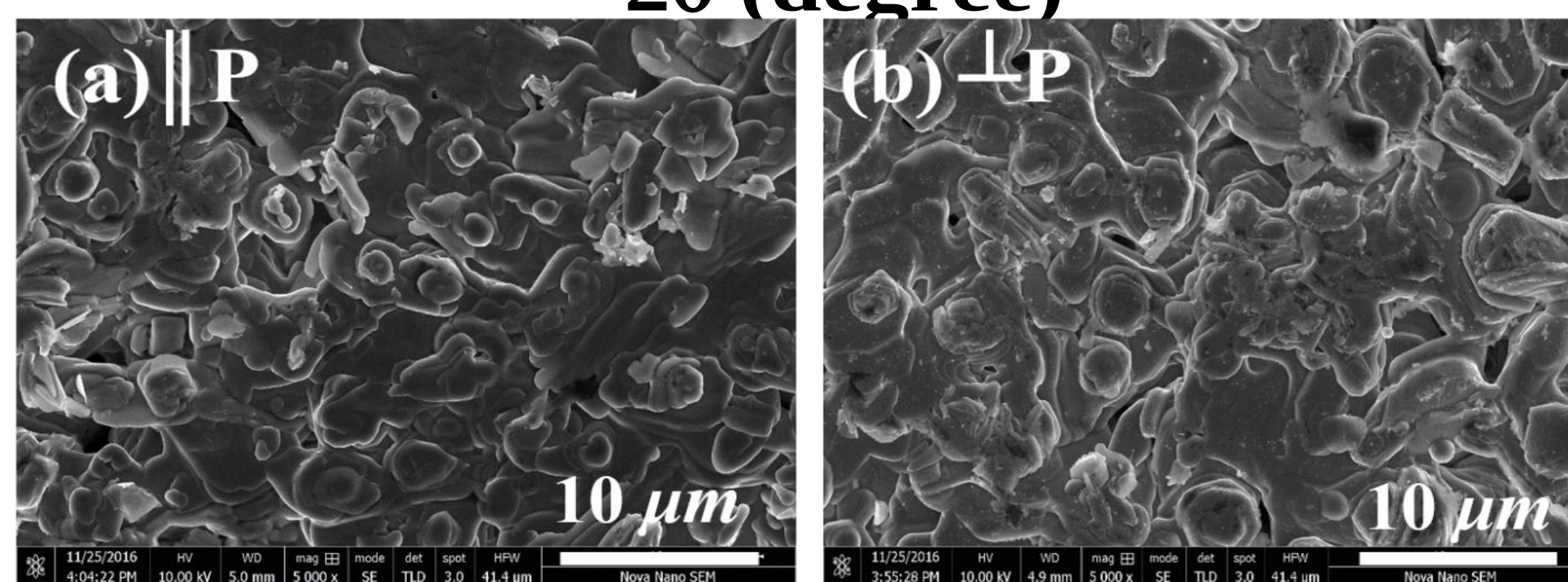
Why Oxides ????????

- **Thermally stable**
- **Low cost**
- **Non toxic**

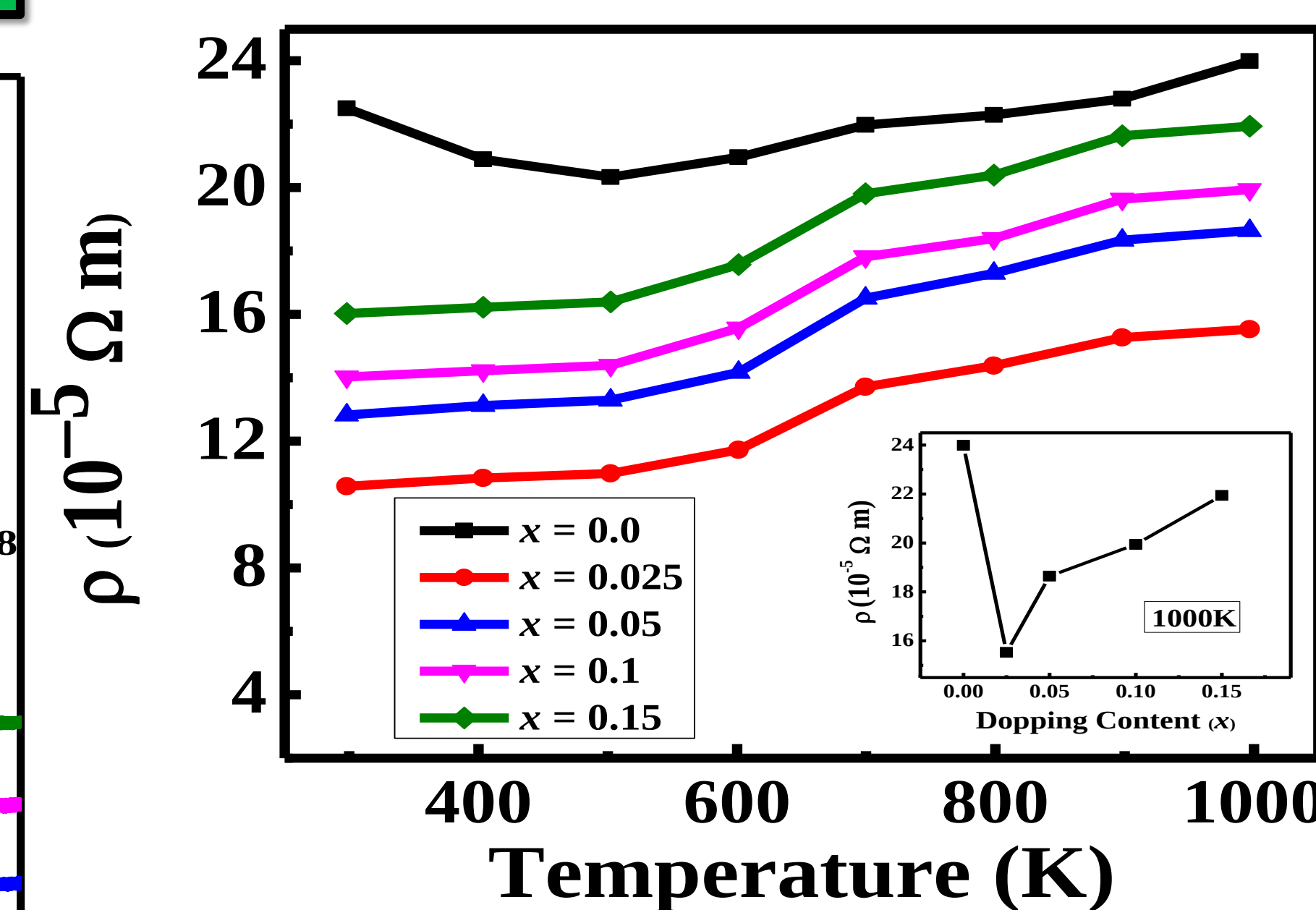
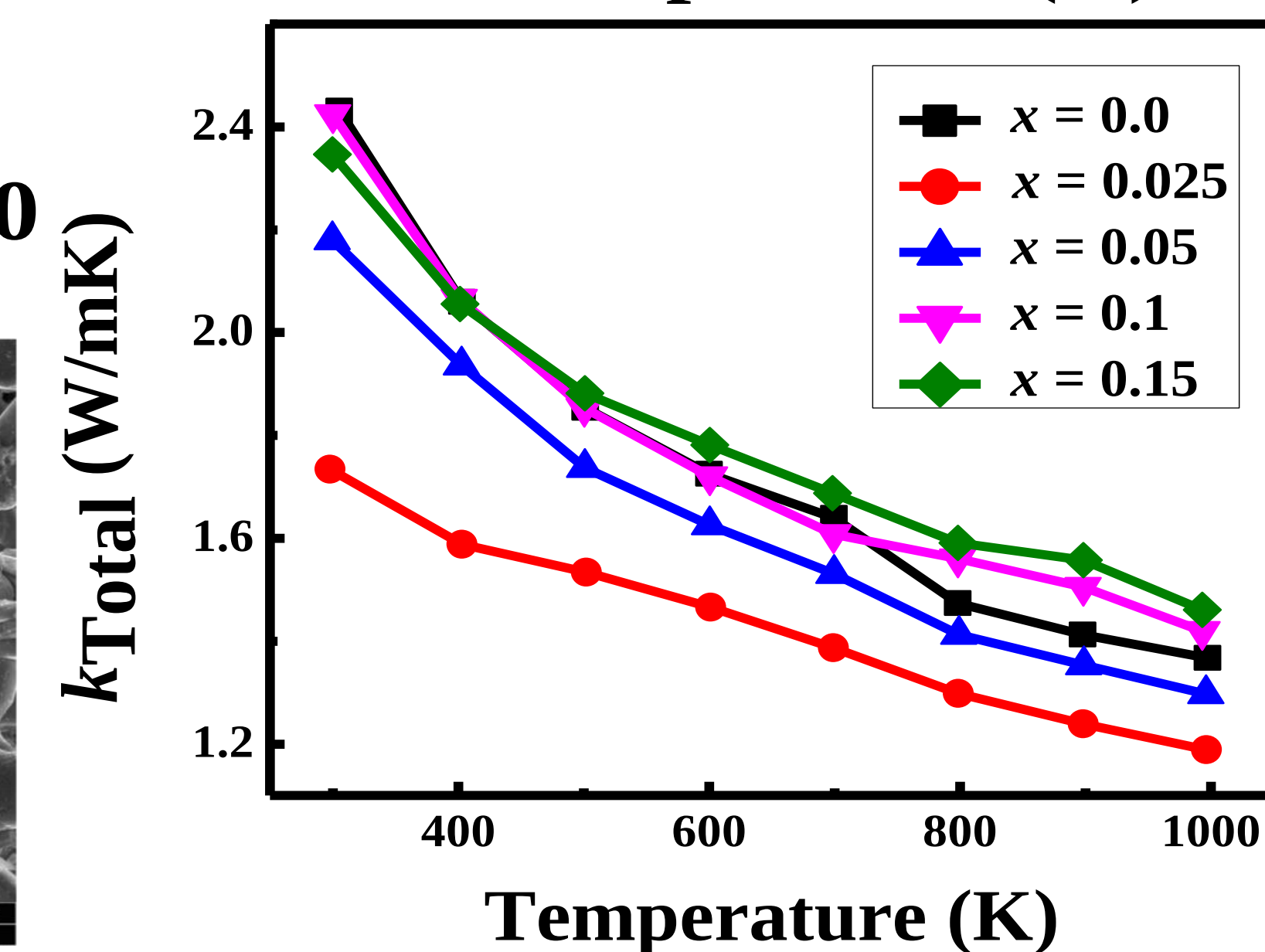
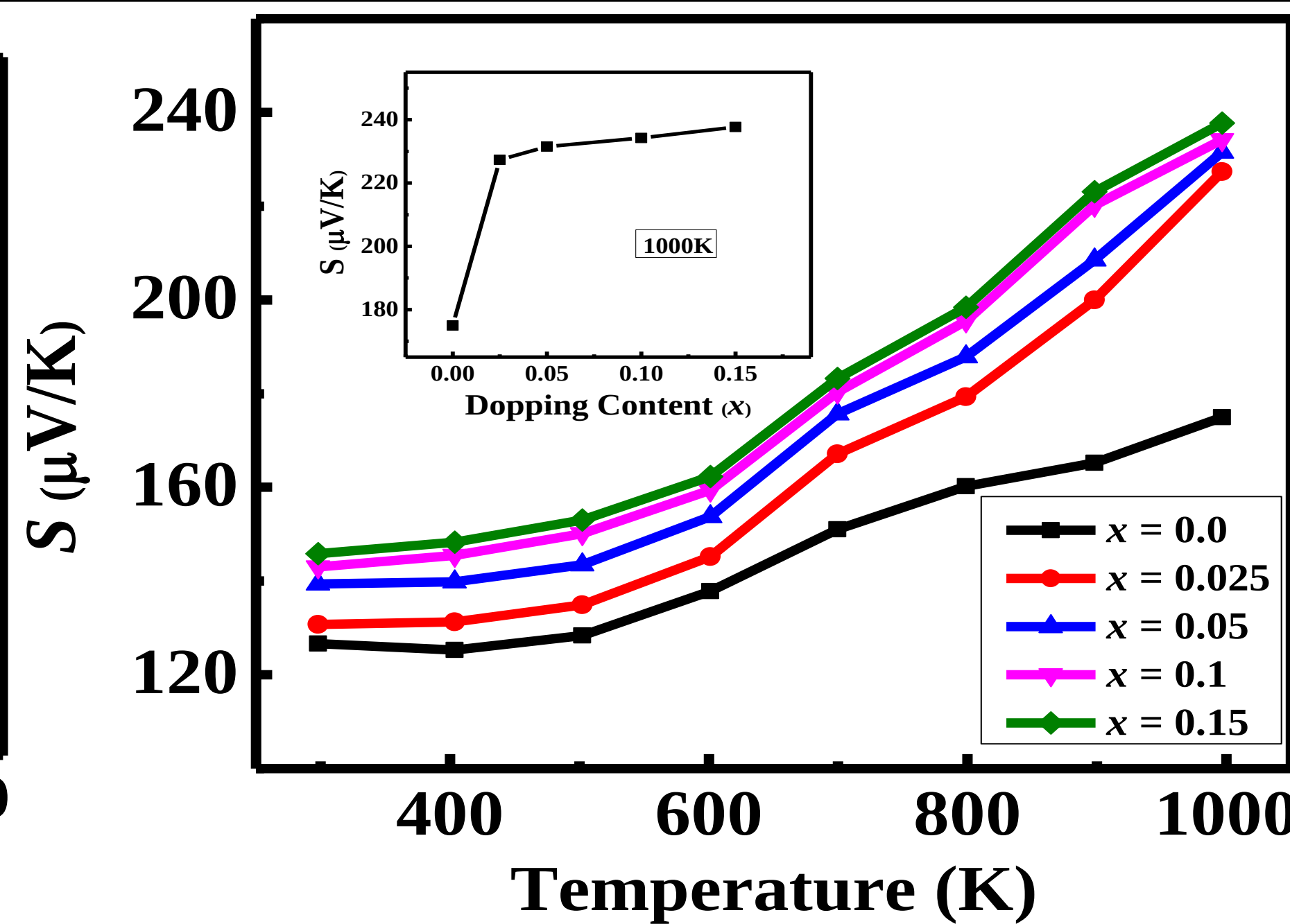
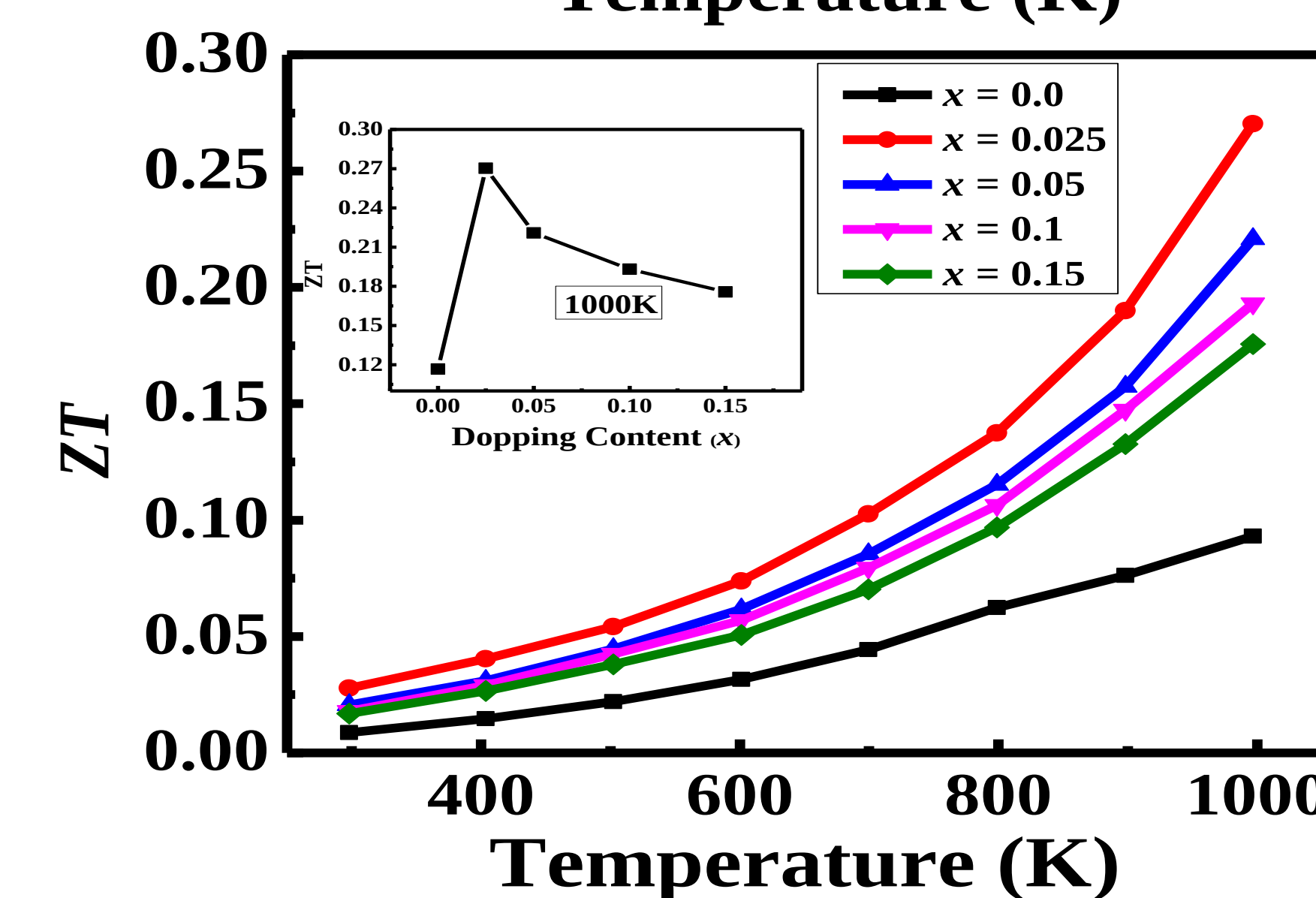
$\text{Ca}_3\text{Co}_4\text{O}_9$ Crystal Structure



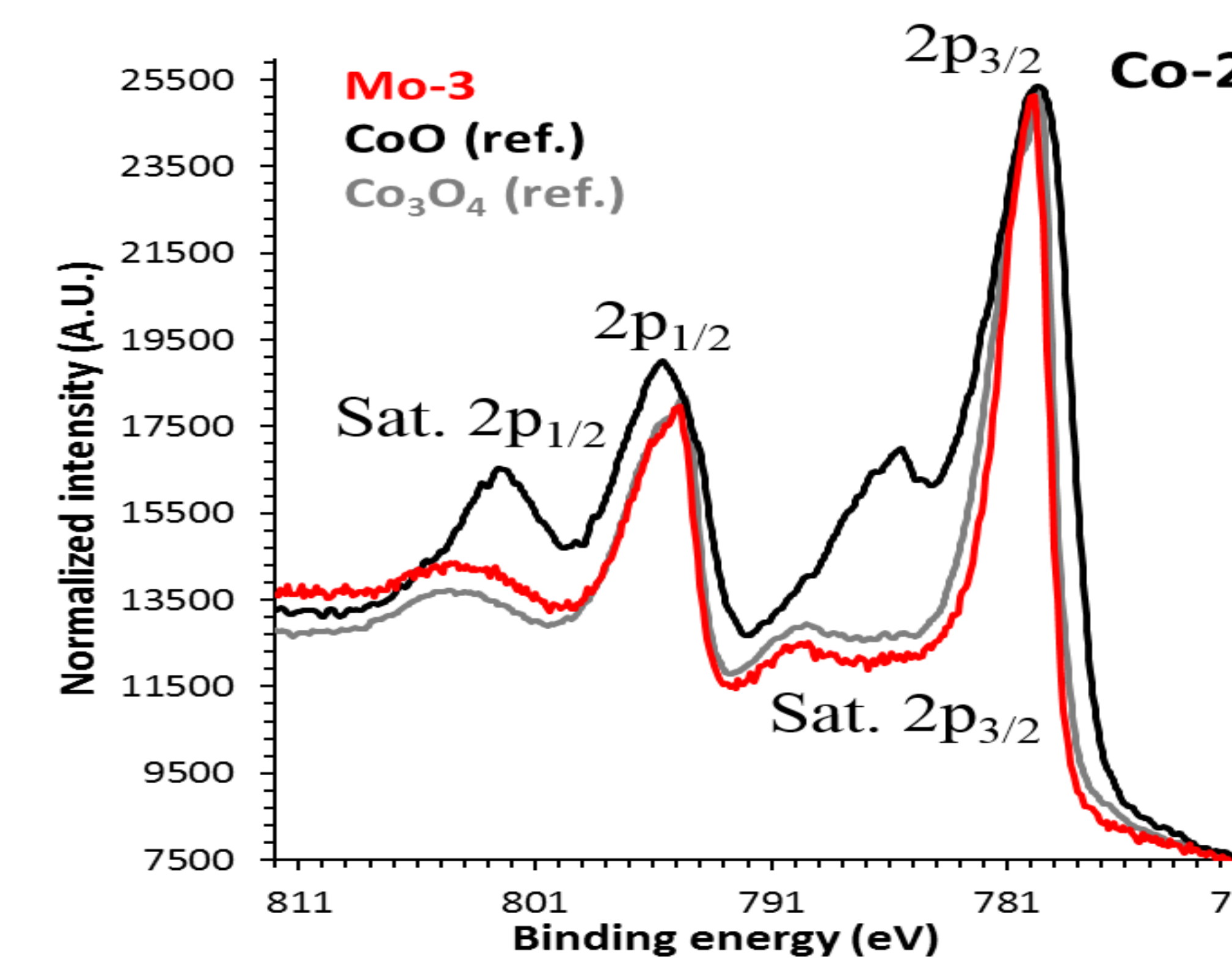
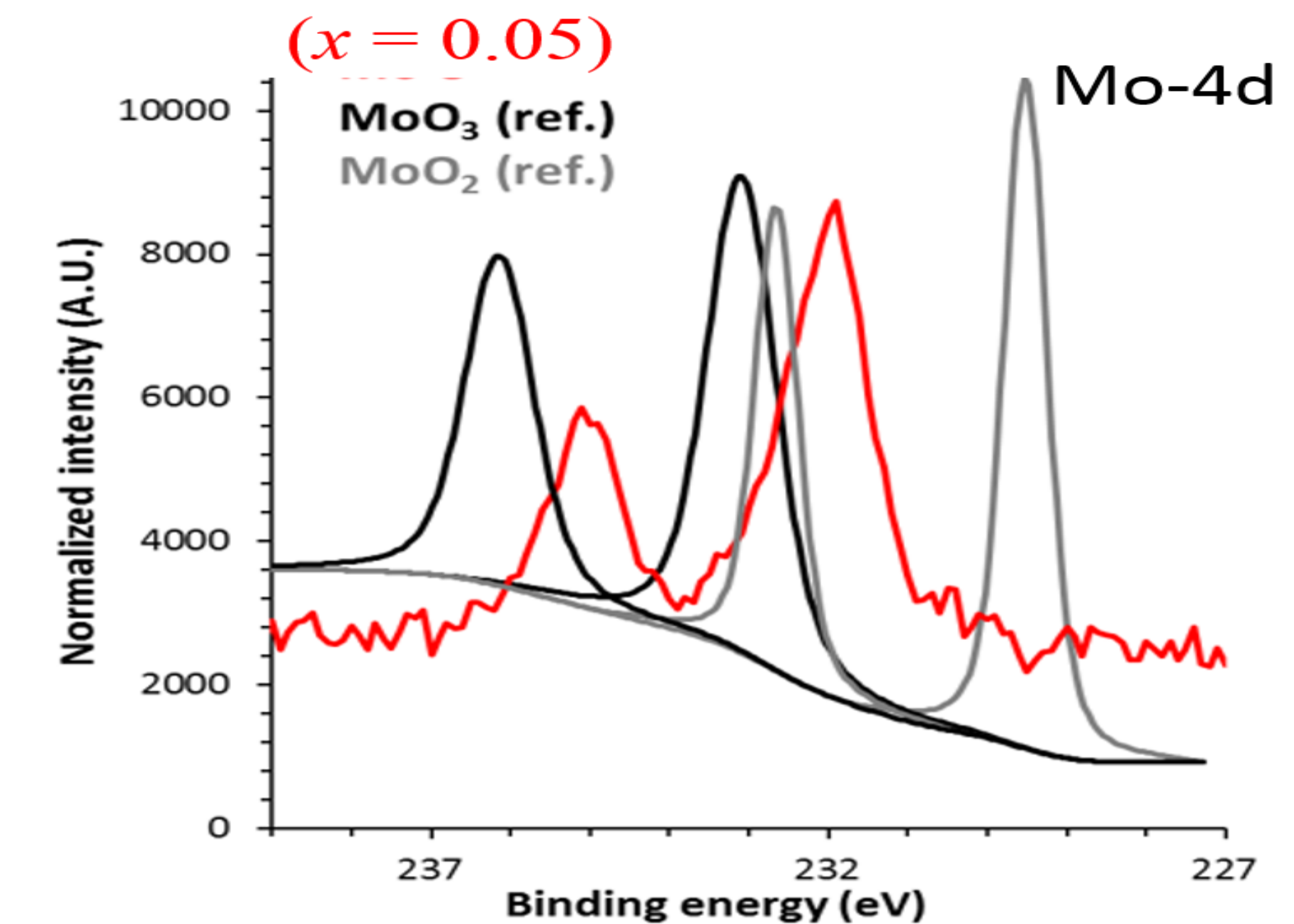
$\text{Ca}_{3-2x}\text{Na}_{2x}\text{Co}_{4-x}\text{Mo}_x\text{O}_9$ ($0 \leq x \leq 0.15$)



Thermoelectric Properties



XPS



Conclusions

- ❖ All samples are phase pure.
- ❖ The thermoelectric figure of merit (ZT) reaches a value of 0.27 near 1000 K which is 3 times higher than the pristine $\text{Ca}_3\text{Co}_4\text{O}_9$ sample.

Acknowledgement

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