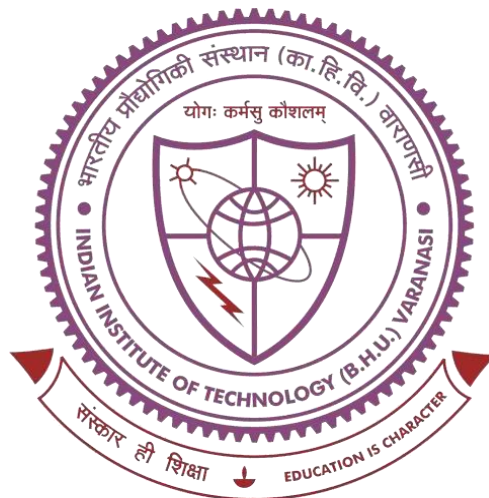


# Lanthanide-doped optical materials for temperature sensing and latent fingerprint detection



Thesis submitted in partial  
fulfilment For the Award of Degree

**DOCTOR OF PHILOSOPHY**

In

Physics

By

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## Chapter 6 : Conclusions and Future Perspective

### 6.1 Conclusion of the Present Investigation

This thesis explores lanthanide-doped  $\text{CaMoO}_4$  phosphors ( $\text{Er}^{3+}$ ,  $\text{Yb}^{3+}$ ,  $\text{Ho}^{3+}$ , and  $\text{Tm}^{3+}$ ) for temperature sensing and latent fingerprint detection. The  $\text{Er}^{3+}$  ion enabled thermally coupled level (TCL)-based temperature sensing, while  $\text{Ho}^{3+}$  and  $\text{Tm}^{3+}$  ions supported non-thermally coupled level (NTCL)-based sensing and multicolor fingerprint visualization.

Chapter 1 established the theoretical background, motivations, and potential of  $\text{CaMoO}_4$  for optical applications. Chapter 2 covered synthesis via solid-state, hydrothermal, and sol-gel combustion routes, with characterization using XRD, SEM/TEM, Raman, and PL spectroscopy.

In Chapter 3, we studied  $\text{Er}^{3+}/\text{Yb}^{3+}:\text{CaMoO}_4$  in bulk and nano forms, showing enhanced temperature sensitivity in nanoscale materials due to improved surface area and energy transfer. Chapter 4 introduced  $\text{Bi}^{3+}$  co-doping into  $\text{Er}^{3+}/\text{Yb}^{3+}$  systems, leading to improved upconversion and temperature sensitivity through lattice distortion and reduced non-radiative pathways. Chapter 5 demonstrated dual-functionality of  $\text{Ho}^{3+}/\text{Tm}^{3+}/\text{Yb}^{3+}:\text{CaMoO}_4$  for NTCL-based thermometry and vivid fingerprint imaging under NIR excitation.

The thesis confirms the suitability of  $\text{CaMoO}_4$  as a robust multifunctional host, capable of supporting both TCL and NTCL mechanisms. The materials synthesized and studied herein are promising for non-contact thermometry and forensic imaging.

### 6.2 Future Work

Building on these findings, several promising avenues for future research have been identified, aimed at further enhancing the performance of these materials and exploring new applications.

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## 6.2.1 Development of Hybrid Materials for Advanced Applications

*Hybrid Materials in Fluorides and Perovskites:* Explore halide perovskites (e.g., CsPbBr<sub>3</sub>) and fluoride-based systems for upconversion, anti-counterfeiting, and optical encryption applications.

## 6.2.2 Enhancing Luminescent Properties through Novel Strategies

- Introduce plasmonic coupling and energy transfer strategies to enhance UC emission.
- Broaden absorption cross-sections via IR dye coupling.
- Synthesize perovskite QDs for LEDs and Yb<sup>3+</sup>-activated thin films for solar cells.
- Engineer emissions from Ce<sup>3+</sup>/Eu<sup>2+</sup> or transition metals (Mn<sup>4+</sup>, Cr<sup>3+</sup>, Ni<sup>2+</sup>) for NIR pc-LEDs and pc-WLEDs.