Effect of precursor salt on phase evolution, powder morphology and photoluminescence behaviour of zinc oxide and mixed zinc oxide-zinc borate systems

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Abstract:

Inorganic phosphor materials consisting of a host (especially oxide and borate based) and activator have performed as a potential candidate in different areas including lighting applications. In this present study, zinc oxide as well as mixed zinc oxide-zinc borate is selected as a host material and rare earth europium is used as an activator for the development of phosphors. The phase evolution of zinc borate along with zinc oxide in a single step wet-chemical synthesis process is a challenge. So, the objective of the present work is to develop a host consists of zinc oxide as well as mixed zinc oxide-zinc borate using borohydride method by selecting two precursor salts and optimizing calcination temperature. In addition, photoluminescence of Eu-doped zinc oxide as well as mixed zinc oxide-zinc borate is also studied. Pure phase of zinc oxide was observed starting from 450 °C to 800 °C, while using zinc chloride. In case of zinc acetate, zinc borate was evolved along with zinc oxide above 600 °C. The particles are agglomerated in nature within the range between 100 nm to 300 nm in both precursor salts. The emission spectra, while using an excitation wavelength of 390 nm (i.e. near visible), shows a clear indication of the transition peaks of Eu^{3+}-ion at 590 nm, 612 nm and 640 nm, which corresponds to $5D_0 \rightarrow 7F_1$, $5D_0 \rightarrow 7F_2$ and $5D_0 \rightarrow 7F_3$ transition, respectively. Further, samples prepared using acetate precursor was found better luminescence than the samples prepared using chloride precursor.

(**Keywords:** *Zinc oxide; zinc borate; Phosphor; Photoluminescence*)

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Objectives

- To develop a host material consists of zinc oxide as well as mixed zinc oxide-zinc borate using borohydride method by selecting two precursor salts.
- To optimized the calcination temperature is studied by using zinc acetate and zinc chloride precursors.
- To study the photoluminescence behaviour of Eu-doped zinc oxide as well as mixed zinc oxide-zinc borate is also studied.

Introduction

- Phosphor materials in the nano regime usually exhibit enhanced electronic and optical properties depending on their size, structure and shape.
- A phosphor is usually comprised of a host crystal material (insulator or semiconductor) and one or more intentionally introduced impurities, which act as luminescence centre, called activators (rare earth).
- Performance requirements for a phosphor need study of five parameters such as excitation energy, emission energy, luminescence efficiency, temperature stability and luminescence decay time.
- Various researchers have developed different varieties of novel host materials that can be used as phosphor based materials for luminescent by doping suitable activator ions.
- In this present study, zinc oxide as well as mixed zinc oxide-zinc borate is selected as a host material and rare earth europium is used as an activator for the development of phosphor

✓Purpose of selecting ZnO

- Zinc oxide (ZnO) is a wide bandgap (3.3eV) semiconductor material with large exciton binding energy (60meV) at room temperature. ZnO is an ecofriendly and low toxicity which is used as a nanodevice material.
- Zinc oxide is a very good host material because of its excellent chemical and thermal stability. It has been very wide applications including optical, electrical, optoelectronic, catalytic, and photochemical properties.
- In this work, sodium borohydride ($NaBH_4$) is chosen as a precipitating agent to prepare ZnO nanopowders. . So, there may be a chance of formation of borate phase along with the oxide phase. So, in this work, a novel host material may develop during synthesis process.
- So, it may interesting to study the luminescence behaviour of rare earth doped ZnO and/or ZnO-zinc borate based system.

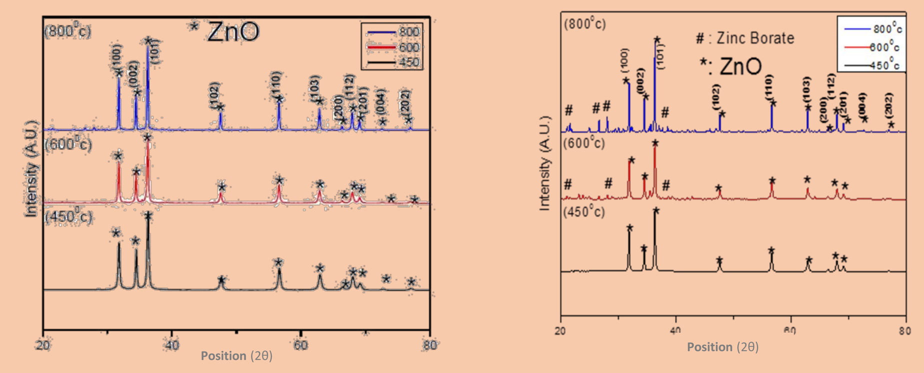
Methodology

The materials will be synthesized using conventional precipitation method using acetate and chloride based salts and $NaBH_4$.

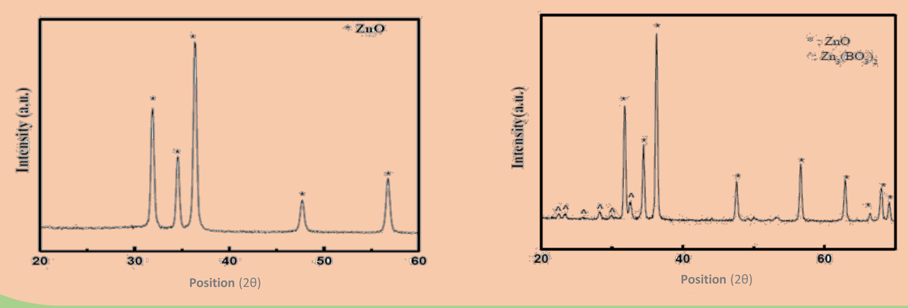
Result and Discussion

Phase Analysis

XRD patterns of calcined powders prepared by using chloride and acetate precursors

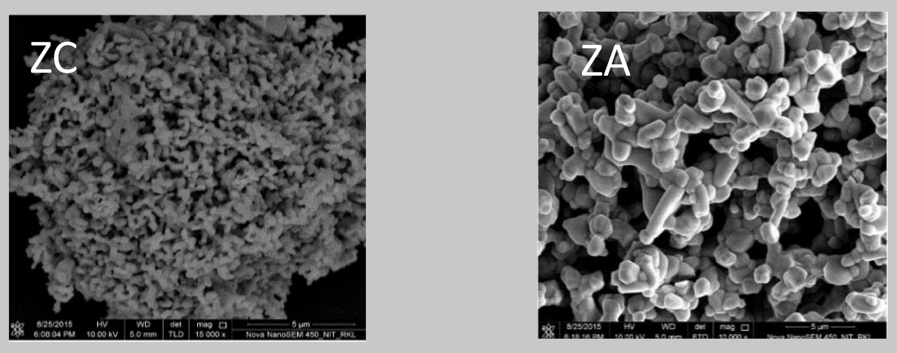


XRD patterns of Eu-doped ZnO calcined powders prepared by using acetate precursors

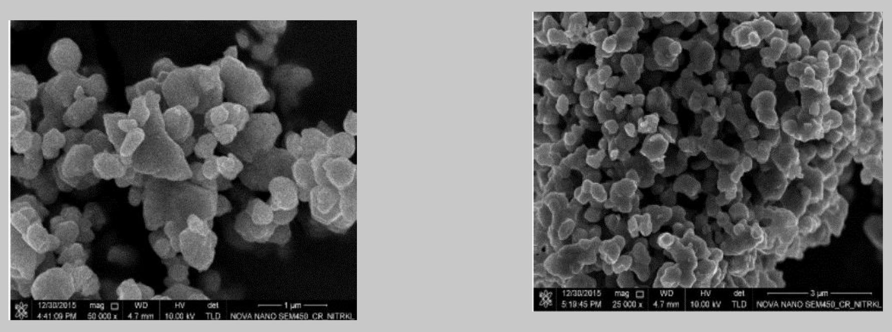


Powder Morphology

FESEM micrograph of calcined at (450 °C) ZnO powders prepared by chloride and acetate precursor

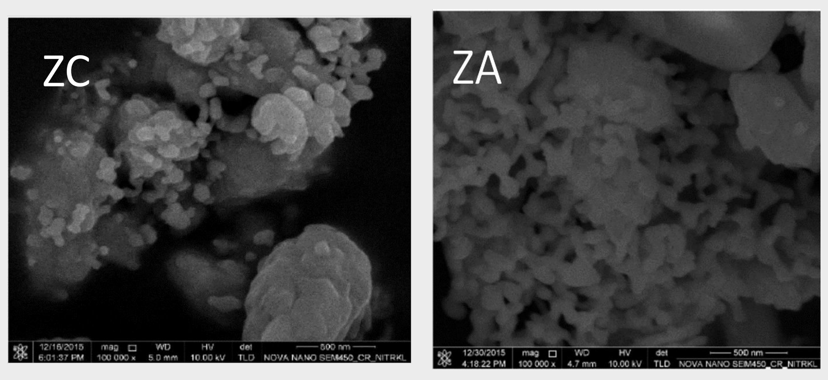


FESEM micrograph of calcined at (600 °C and 800 °C) ZnO powders prepared by chloride precursor



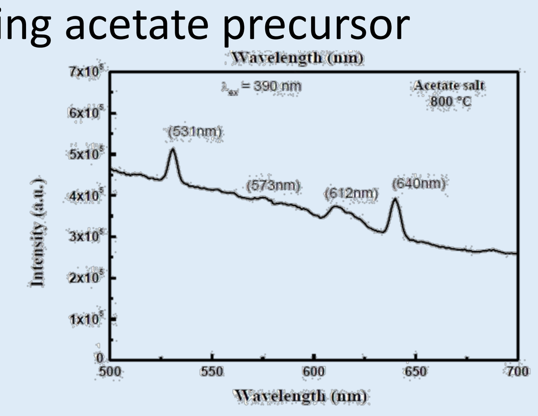
Powder Morphology

FESEM micrograph of calcined at (450 °C) Eu-doped ZnO powders prepared by chloride and acetate precursor



Photoluminescence Study

Photoluminescence behaviour of 10 mol% Eu-doped ZnO using acetate precursor



Conclusion

- In this present study, zinc oxide and mixed zinc oxide-zinc borate were successfully prepared by borohydride synthesis.
- Pure phase of zinc oxide was observed starting from 450 °C to 800 °C, while using zinc chloride. In case of zinc acetate, zinc borate was evolved along with zinc oxide above 600 °C.
- Eu-doped ZnO were also prepared using zinc acetate salt via borohydride route.
- The emission spectra, while using an excitation wavelength of 390 nm (i.e. near visible), shows a clear indication of the transition peaks of Eu^{3+}-ion at 590 nm, 612 nm and 640 nm, which corresponds to $5D_0 \rightarrow 7F_1$, $5D_0 \rightarrow 7F_2$ and $5D_0 \rightarrow 7F_3$ transition, respectively.

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