Development of polymeric based cerium activated YAG film for luminescent applications

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Abstract

Cerium activated yttrium aluminium garnet i.e., Ce-doped YAG is an efficient phosphor material and has gained potential as an active material in cathode ray tubes, field emission, vacuum fluorescent displays, UV-sensors/filters, tapered fiber-optic radiation sensors, and aerospace applications. Development of polymeric based Ce-doped YAG and its photoluminescence behaviour have been explored in this research work. Initially, 10 mol % Ce^{3+} ions doped YAG phosphor powder was prepared via precipitation method using precursor solution containing yttrium nitrate, aluminium nitrate, and cerium nitrate along with ammonia as a precipitating agent. X-ray diffraction analysis of the calcined powders confirmed the phase YAG along with intermediate phases including YAM and YAP. With the increase in calcination temperature i.e., from 1000 °C to 1400 °C, the morphology of the powder changes from rod-like to nearly spherical. Further, an appropriate amount of the calcined powder was mixed with PVDF-DMF solution, and then casted on a glass substrate followed by drying overnight at ~ 40 °C. Further, FTIR, Raman, emission behaviour along with CIE chromaticity coordinates of the powders and film was analysed. Based on the excitation spectrum, the emission behaviour shows a broad peak ranging from 450 nm to 670 nm corresponding to 5d-4f transitions attributing to yellow-green colour. The flexible polymeric Ce-doped YAG based luminescent film has great significance for device, luminescent applications, and optoelectronic sensor to detect harmful UV radiations.

Keywords: Ce-doped YAG; PVDF; Film; Emission; Luminescent; Phosphor

DEVELOPMENT OF POLYMERIC BASED CERIUM ACTIVATED YAG FILM FOR LUMINESCENT APPLICATIONS

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INTRODUCTION

❑ **Why YAG as a luminescent material?**
- Rare earth doped yttrium aluminium garnet (YAG) is an efficient phosphor material.
- Has potential application as active material in cathode ray tubes, field emission, vacuum fluorescent displays, UV-sensors/filters, tapered fiber-optic radiation sensors, and as a laser igniter for aerospace applications.

❑ **Why Cerium ions as activators (Ce^{3+})?**
- High light yield.
- Efficient fluorescence due to the uncommon electronic configuration and numerous optical transitions possible between the 4f or 5d levels of the Ce-ions.

❑ **Luminescent properties of Ce- doped YAG:**
- Ce doped YAG absorbs blue light and converts it to emit yellow/ greenish yellow light.

❑ **Applications as Luminescent film using Ce-doped YAG:**
- Applied as luminescent labels for anti-counterfeiting.
- Active waveguide, displays, X-ray imaging.
- Information coding, information storage, and information protection.
- For fabrication of integrated optical and optoelectronic devices.

METHODOLOGY

❑Aluminum nitrate, yttrium nitrate and cerium nitrate were chosen as starting precursors, and the materials were prepared via wet chemical precipitation method.

❑The precipitates were washed, dried and calcined at 1000 °C to 1400 °C.

❑Luminescent films were obtained using calcined powder mixed with PVDF-DMF solution, and then casted on a petri disc followed by drying overnight at ~ 40 °C.

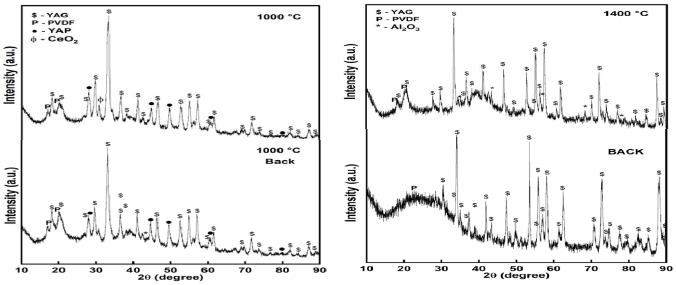
❑The calcined powders as well as polymeric film were characterized using XRD, FESEM, and PL.

❑ Emission spectra was performed at excitation wavelength of 354 nm and CIE Coordinates are also analyzed.

RESULTS AND DISCUSSION

PHASE ANALYSIS

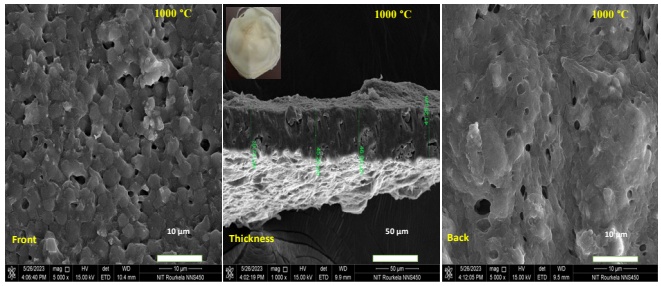
XRD pattern of luminescent film (at 1000 °C) represents a major phase of YAG with minor YAP. Also peaks of phases PVDF, CeO_2 were observed. Whereas luminescent films (at 1400 °C) represents a major phase of YAG with minor Al_2O_3. Also peaks of phase PVDF was observed.



XRD patterns of film indicating different phases.

MORPHOLOGY ANALYSIS

Morphology of calcined powder at 1000 °C was bundled of elongated shaped Front and back side of films shows the polymeric formation of film and distribution of phosphor powders. Average thickness of film calcined powder at 1000 °C was ~43 µm.

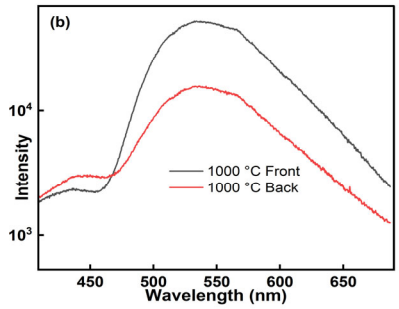


FESEM micrograph of the film samples

EMISSION BEHAVIOUR

Emission spectra of films are done at excited wavelength 354 nm.

CIE Coordinates indicates the greenish-yellow colour.



Emission spectra of YAG-based polymeric films

- **Both calcined powders and luminescent films shows similar emission behaviour.**
- **Broad emission with a range from ~ 450 nm – 650 nm was observed which can be attributed to the transition 5d → 4f of Ce ions.**
- **These emission give greenish-yellow colour.**
- **The emission spectra was utilised to calculate CIE coordinates shown in CIE diagram.**

SAMPLE	CIE Coordinates	
	x	Y
1000 °C front	0.35	0.56
1000 °C back	0.33	0.50

CIE coordinates of powder and films

CONCLUSIONS

➢Rare earth doped YAG samples formed at 1000 °C – 1400 °C with intermediate phases i.e., YAM and YAP. Minor phases such as Al_2O_3 and CeO_2 were also observed.
➢Luminescent films were made using calcined powder mixed with PVDF-DMF solution. XRD pattern of the films shows YAG and Al_2O_3 phases along with minor phase of PVDF.
➢Particles of YAG were agglomerated in nature, elongated in shape and well distributed within the polymeric matrix.
➢Both calcined powder and polymeric film showed broad emission peak ranging from 450 nm to 650 nm. These are attributed to transition 5d→4f of Ce-ions.
➢Based on the CIE diagram the colour of the film lies in the greenish-yellow region.
➢Emission behavior and CIE diagram reveals that films can be used in luminescence field.

PUBLICATIONS

- Indian Patent filed and published on my Ph.D. work title "One-pot synthesis process for making borate, mixed borate-oxide and oxide based luminescent materials" with application number 202331017503.
- Paper communicated with the tittle "Colour tunable and near white emitting Ce-doped mixed borate-oxide and oxide based phosphors evolved via yttrium-aluminium-borate complex"

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