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STUDY OF LUMINESCENCE PROPERTIES OF EU DOPED $Ba_2Al_2SiO_7$ PHOSPHOR

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Abstract:

Long persistent afterglow phosphor, $Ba_{(2-x)}Al_{(1-y)}SiO_7Y_yEu_x$ was prepared at high temperature by a solid state reaction in a weak reductive atmosphere. The prepared powder samples were characterized by UV-visible Spectroscopy, IR- Spectroscopy, X-ray Diffraction (XRD), Scanning electron microscope (SEM), Energy dispersive spectrum (EDS), Photoluminescence (PL). The crystal structure of the prepared $Ba_2Al_2SiO_7$ host, and Ce^{3+} doped $Ba_2Al_2SiO_7$ phosphors were calculated by XRD technique it has shown hexagonal structure. The band gap energies of prepared undoped, and Eu^{3+} doped $Ba_2Al_2SiO_7$ nano-phosphor were calculated using the UV spectroscopy technique. The bonding nature in the prepared samples was studied by the FT-IR technique. From XRD technique, the crystal structure of the prepared Eu^{3+} doped $Ba_2Al_2SiO_7$ phosphors was calculated and it was a trigonal (hexagonal axes) structure with with cell parameter a=4.7636A^0, c=15.5820A^0 and Particle size observed 28.776nm. The optical band gap energies of $Ba_2Al_2SiO_7$ host and Eu^{3+} doped $Ba_2Al_2SiO_7$ were calculated using the UV spectroscopy technique. The PL spectra were showed the maximum intensity for Eu^{3+} doped $Ba_2Al_2SiO_7Y$ at 450 nm and 510 nm under 600 nm excitation wavelengths. The CIE color co-ordinates of the Eu^{3+} doped $Ba_2Al_2SiO_7Y$ are calculated using radiant imaging color calculator program refer to the 1931 CIE Standard Source C

Key words:muffle furnace, Solid state diffusion method, spectrophotometer technique

The rare earth element activated phosphor materials have been investigated in recent 30 years and are applied in different fields. These rare earth elements attracted the minds of people because of their characteristic emission in visible and near visible (ultraviolet) regions. These emissions in visible region are attributed to the 5d → 4f transitions. Among these, the europium ion activated phosphors have been attracted much interest of researchers due to the characteristic emission of europium ions in the visible region. The europium ion activated phosphors has been applied in many field like display devices, solid state lighting, radiation dosimetry, x-ray imaging, CRO tubes, LED's and Hg discharge lamps. It is known that the luminescence property of the europium ion is strongly influenced by the surrounding crystal field and the symmetry acquired by it. Basically silicate materials have appropriate

Properties as far as application point view due to their excellent temperature stability, water resistance and capable to show the luminescence property when doped with the rare earth element and transition element such that europium (Eu), The emission due to rare earth elements affected by the size, charge and strength of the ligand to metal ion bonding due to the surrounding legands. This emission is well known as 5f→ 4d transition which is broad band emission covers the large wavelength region from ultraviolet to yellow.

Recently different silicates phosphors activated with Europium ion have to prepare study and investigate. From this, it is we observe that the Barium doped silicates phosphor having potential applications in different fields of lighting.

In this paper, we are going to present the synthesis of the Eu doped $Ba_2Al_2SiO_7$ nano phosphor and the characterization of it using UV-Visible spectroscopy, FT-IR spectroscopy, X-ray powder diffraction, FE-SEM technique, EDS-spectroscopy and spectrophotometer technique.

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

2._ Method of Preparation:

We have prepared the Eu doped $Ba_2Al_2SiO_7$ using the Solid state diffusion method. The mechanism of solid state reactions is diffuse reaction and hence, repeated grinding and repeated heating are required. So, Reaction is undergo for the grind for 15-20 Minutes and Heat the solid powder mixture (calcination) at elevated temperatures in air using muffle furnace (750^0c) for 24 hours of $Ba_2Al_2SiO_7$, the material cooled down for 24 hours, Again the repeated grinding and heating the e powder at 750^0c for 6 hours is controlled atmosphere is necessary to master the valence of the activator and the stoichiometry of the host lattice. Therefore, doping 1-3% of activator in oxide host has been delicate. Again sample is kept in a glass bottles with proper labeling. These samples are used for further characterization part.

3._ Characterization of Europium doped $Ba_2Al_2SiO_7$:

The prepared Eu doped $Ba_2Al_2SiO_7$ samples are characterized by the UV Visible spectroscopy, FT-IR spectroscopy, X-ray powder diffraction, FESEM Technique, EDS-spectroscopy and spectrophotometer technique.

3.1 UV-visible spectra (UV):

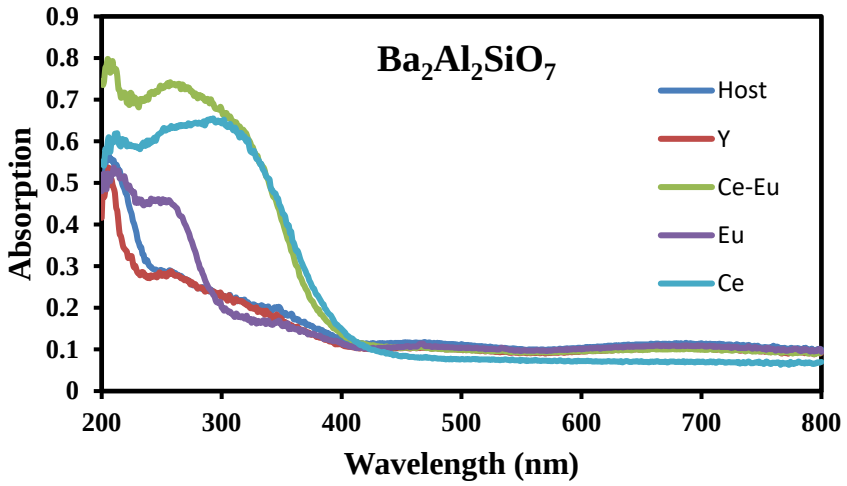


Fig.1.1 Band gap energy of **$Ba_2Al_2SiO_7$**

Table no 1.1: band gap energy of the prepared sample of $Ba_2Al_2SiO_7$are enlisted below.

	Energy (EV)
Host	5.04
Y	5.18
Eu	4.41

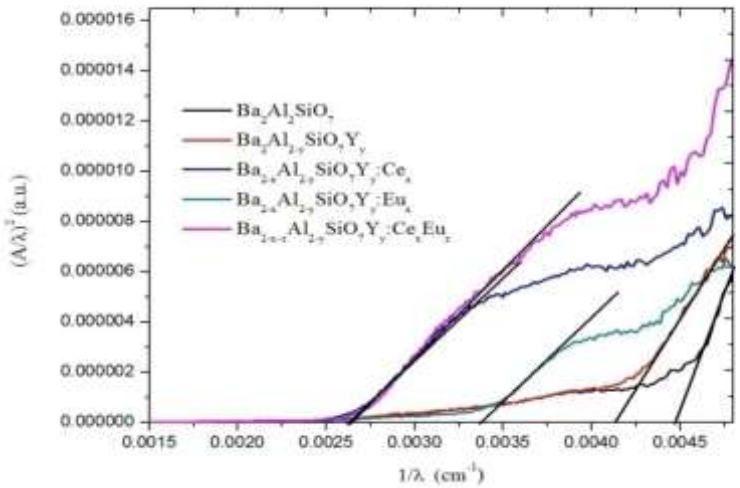


Fig.1.2 Band gap energy of **$Ba_2Al_2SiO_7$**

3.2 IR-Spectroscopy

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

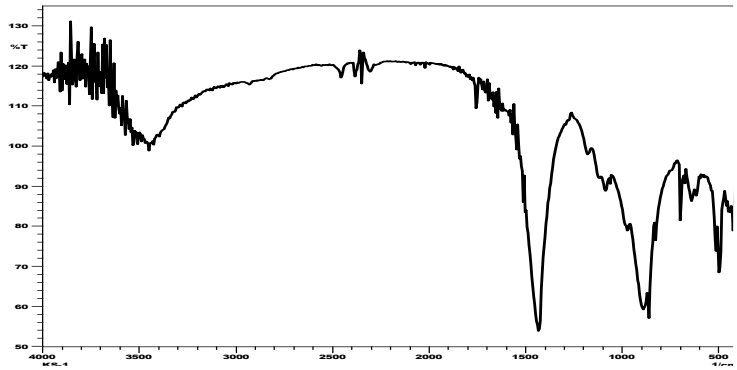


Figure.(1.3a): IR spectra transmittance **$Ba_2Al_2SiO_7$** : Host

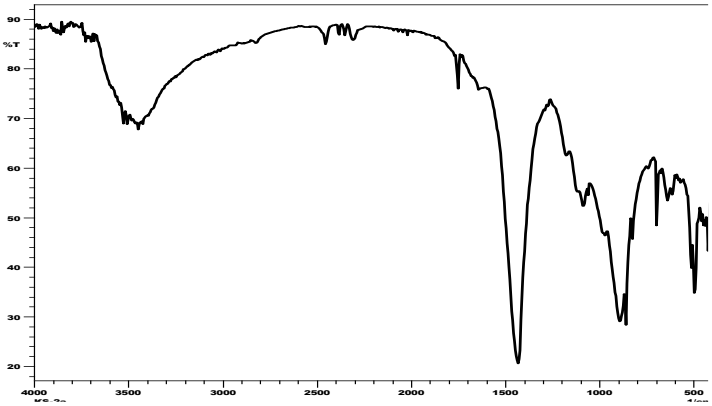


Figure.(1.3b): IR spectra transmittance **$Ba_2Al_2SiO_7$** :Y

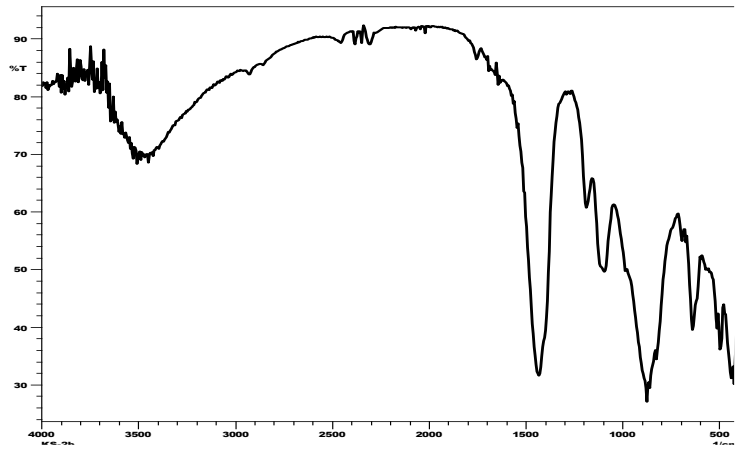


Figure.(1.3c): IR spectra transmittance **$Ba_2Al_2SiO_7$** : Eu

Table. 1.2:

Vibrations	Bonds	Nature of Vibrations
1400	Ba – O	Vibrations
1200 – 800	Si–O–Si Si–O-Al	Stretching Vibrations in SiO_4
935	Si-O	Terminal Stretching Vibrations
750 – 600	Al-O, Si-Si, Si-Al	Stretching Vibrations
600 – 300	Si-O-Si, Si-O-Al	Bending Vibrations

The IR spectra are shown in Figure. (1.3a)(1.3b)(1.3c). Broad bands in the spectrum indicate the amorphous nature of the sample. A broad band centered at 950 cm^{-1}in the 1200-800 cm^{-1} region is characteristic of asymmetric vibrations of Si-O within different Si structural units. Intense broad band in the 300-600 cm^{-1}region is assigned to bending vibration of Si-O-Si linkages in different structural units. A less intense band in the region of 600-800cm^{-1} is due to the symmetric

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

stretching of Si-O and Si-O-Si units. For the presence of crystalline phases is depicted by splitting of the broad bands into number of sharp bands at around 1010, 970, 900, 830, 662, 600, 482 and 452 cm^{-1}. As reported in the literature these sharp bands are exactly matching with the vibration of crystalline. Thus, in accordance with XRD, FTIR also indicates the starting of the crystallization phase. With the increase in temperature and dwell time these vibration bands become more sharp and ntense thus reflecting the increase in the crystalline phase in the glass-ceramics. Some additional bands also start appearing at around 1060, 930, 706, 625, 550 cm^{-1}, which become more intense with increase in dwell time and temperature. According to the literature these vibrational bands are characteristics of $Ba_2Al_2SiO_7$ crystalline phase. With a further increase in the dwell time at higher temperature these bands become sharper and more intense, thus suggesting an increase in the amount of $Ba_2Al_2SiO_7$ crystalline phase. The number of sharp and intense vibrational bands, corresponding to both the crystalline phases is present.

3.3 X-RAY DIFFRACTION (XRD):

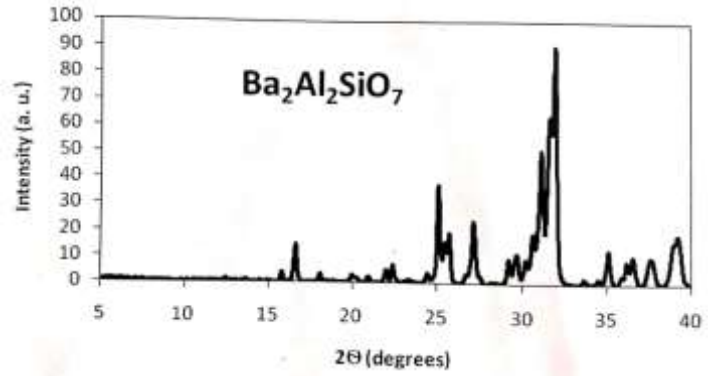


Fig (1.4) - XRD spectrum for EU doped in $Ba_2Al_2SiO_7$

The XRD pattern of the $Ba_2Al_2SiO_7$ is showing in fig. (1.4). XRD pattern of $Ba_2Al_2SiO_7$ match with ICDD file no. 96-900-1420. It has shown trigonal (hexagonal axes) structure with cell parameter a=4.7636A, c=15.5820A°

In the XRD pattern, peaks are well seen with high intensity which confirms the high crystalline nature of the prepared host $Ba_2Al_2SiO_7$ sample.

The particle size from the XRD data is calculated by formula and it is observed to be 28.776nm.

$$d = \frac{0.9\lambda}{\beta cos\theta}$$

3.4 SCANNING ELECTRON MICROSCOPE (SEM):

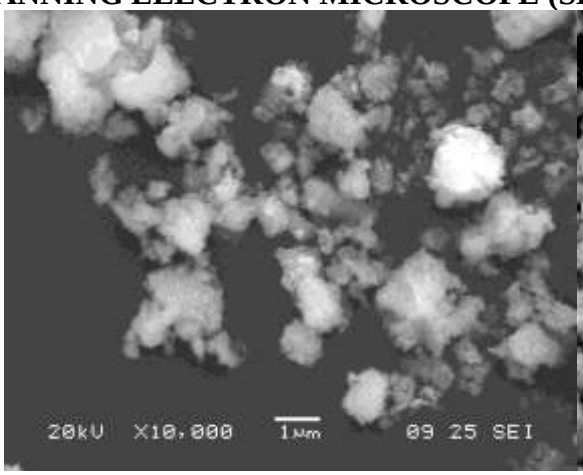


Fig (1.5a) - SEM for 1micrometer size

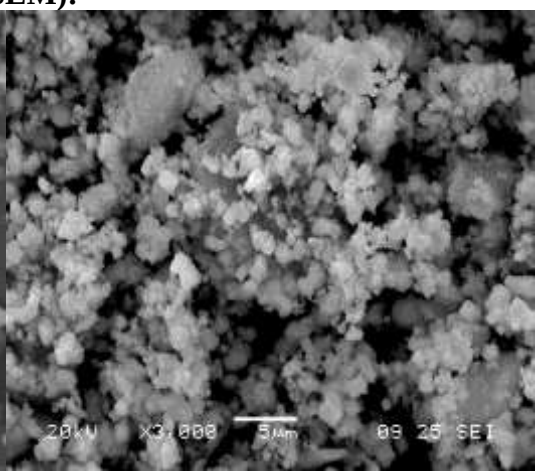


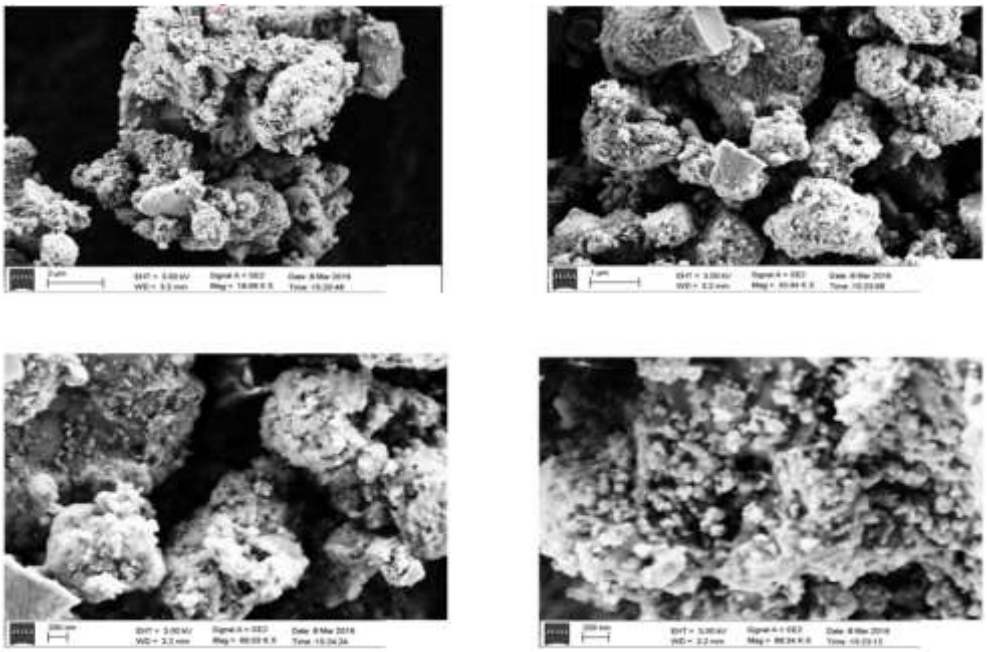
Fig. (1.5b)- SEM for 5 micrometer size

SEM micrographs different magnifications are shown in fig. (1.5a), fig (1.5b), this figure clearly indicates the occurrence of surface crystallization. Figure also indicates the dendrite growth

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

of crystals. Figure shows two different types of crystallites in the microstructure. So, we take FESEM for the particle.

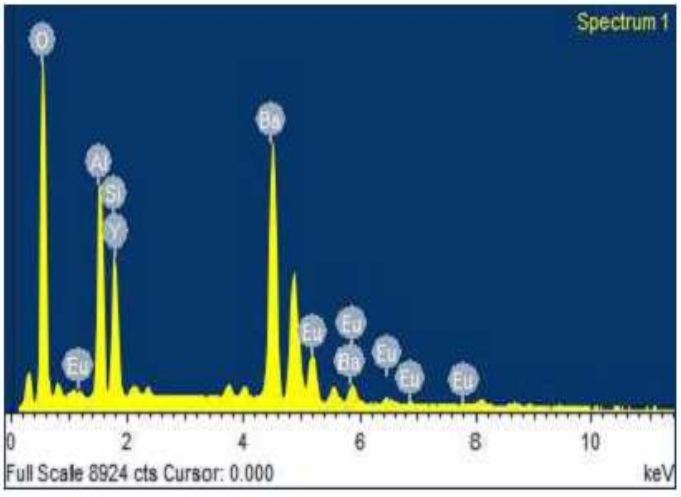
3.5 FESEM:



Figures 1.6: Field Emission Scanning Electron Microscope.

From FE-SEM images of the host $Ba_2Al_2SiO_7$ (fig.1.6), it is seen that the host sample made in the nanostructure in nature of the order of 50 to 100 nm.

3.6 ENERGY DISPERSIVE SPECTRUM (EDS):



Elements	Weight %	Atomic %
O K	40.38	74.70
Al K	8.82	9.82
Si K	5.53	5.82
Y L	-0.07	-0.02
Ba L	42.32	9.12
Ce L	2.89	0.56
Total	100.00	

Figure 1.7 Energy dispersive spectrum of $Ba_{2-x}Al_{2-y}SiO_7Y_y$: Eu_x

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

Fig (1.7) represents the EDS spectrum and elemental composition of $Ba_2Al_2SiO_7$. The EDS spectrum of$Ba_2Al_2SiO_7$ show the signals for Ba, Al, Si, O in prepared host material. These observations combined with XRD analysis, confirm successfully prepared $Ba_2Al_2SiO_7$ phosphors.

3.6 PHOTOLUMINESCENCE (PL)

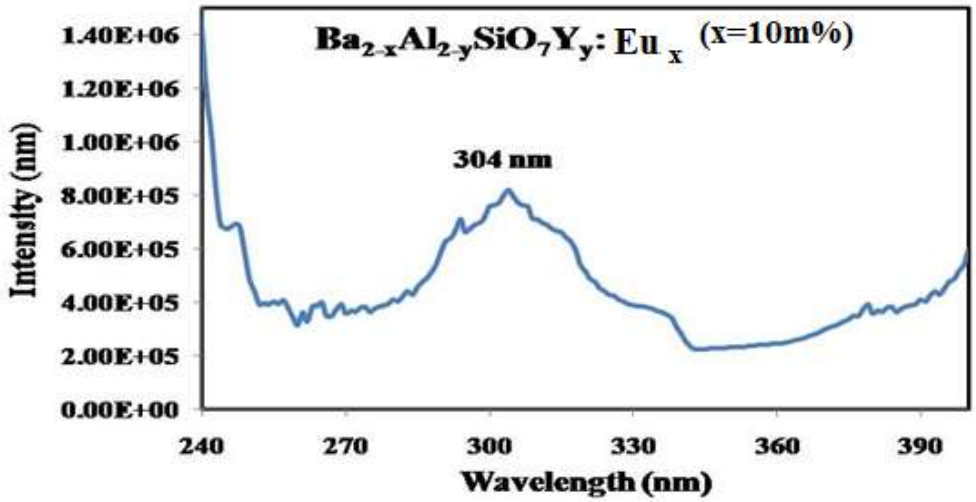


Fig.(1.8)- Excitation spectra of $Ba_2Al_2SiO_7$:Eu phosphor

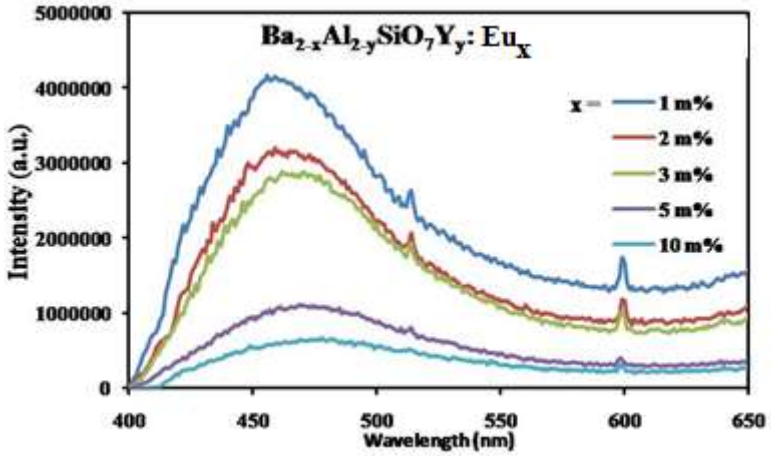


Fig (1.9) - Emission spectra of $Ba_2Al_2SiO_7$: Eu phosphor

We have taken photoluminescence spectra for $Ba_{2-x}Al_{2-y}SiO_7Y_y$: Eu_x. The excitation spectra for $Ba_{2-x}Al_{2-y}SiO_7Y_y$: Eu_x is shown in figure (1.8). The excitation spectra are carried out at 450nm emission wavelength. It shows only one peak at 304 nm and this wavelength is used as excitation wavelength for emission spectrum of the sample.

The emission spectrum is shown in figure (1.9) above. It showed broad emission peak at 450nm and other low intensity peaks at 510nm and 600 nm. The broad emission peck at 450nm is used for excitation spectrum.

Therefore, the prepared sample of $Ba_{2-x}Al_{2-y}SiO_7Y_y$: Eu_x may be used in UV excitation and emission LED's.

CONCLUSIONS:

The Europium ion doped $Ba_2Al_2SiO_7$ phosphor prepared by the solid state reaction. The XRD measurement shows that the prepared phosphor has hexagonal structure. The band gap energies are calculated using the UV spectroscopy and these values are 3.43 eV, 5.18 eV and 5.04 eV for pure $Ba_2Al_2SiO_7$, 0.1 m% Eu^{3+} doped $Ba_2Al_2SiO_7$ and 0.5 m% Eu doped $Ba_2Al_2SiO_7$ respectively. PL measurement shows the maximum intensity at 510 nm and 600 nm and therefore these phosphors are applicable for lighting purpose.

ISSN: 2278-4632
Vol-13, Issue-10, No.04, October: 2023

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