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LUMINESCENT MATERIALS FOR COMMUNICATION DEVICES: AN OVERVIEW

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Abstract:
The luminescent material is microcrystalline powders or thin-films designed to provide visible colour emission on excitation by different sources. These are also called phosphors they can be developed in to a potential candidate for applications like Solar cell device, LEDs, Display devices.etc. Present paper is an Review of the phosphors materials for Light emitting devices (LED), their present status and challenges.

Keywords: *Luminescent Devices, LED's.*

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1. Introduction

Phosphors are luminescent materials that emit light when excited by radiation, and are usually microcrystalline powders or thin-films designed to provide visible colour emission. Luminescence can be stimulated in a material by variety of sources and accordingly it is classified as Photoluminescence, electroluminescence, catholuminescence, thermoluminescence etc. Photoluminescence refers to phenomena where the luminescence is stimulated by UV or visible light, materials exhibiting it finds application in solid state lamps. Electroluminescence finds applications in panel lighting used in some liquid-crystal display (LCD), in inorganic light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs). Both organic and inorganic systems can display luminescence, but here we focus primarily on inorganic luminescent materials for LED applications.

With the advent of near UV and blue light-emitting diodes (LEDs) research on photoluminescent materials is revived. The basic requirement of efficient LEDs are defined to have strong absorption in the near UV/blue region and emission in the visible region. This has induced a world-wide research activity for search of inorganic phosphors with new compositions and doped with transition/rare earth ions and tune the optical properties of these activator ions as to their suitability in LEDs.

2. Luminescencet Materials

The Inorganic materials like metal sulphates, aluminates, oxides, silicates, if synthesised by special procedures under controlled conditions were found to show luminescence, luminescent efficiency in these materials can be enhanced by adding small amount of impurity called activators. The activator ions added to host lattice are surrounded by host ions and form centers of excitation–emission process. These centers must be separated by an appropriate distance in crystal lest they inactivate each other. For high efficiency, even a trace of the activator may be inserted into the host crystal, and its distribution must be as regular as possible. The activators in high concentration act as "killers" and thus inhibit luminescence, killer term is used especially for iron, cobalt, and nickel ions, whose presence, even in small quantities, can inhibit the emission of light from phosphors. Were-as the luminescence efficiency can be increased by addition of flux, the flux facilitates incorporation of activator ions symmetrically in host matrix. Thus flux acts as a co-activator by increasing number of luminescent centres hence resulting in strong activation. The description of a luminescent material (phosphor) requires information of its chemical constituents like, the host crystal, activator (type and percentage), coactivator (intensifier activator), emission spectrum and persistence.

3. Essential Requirements for Display Phosphors

The particle size, shape and their distribution within lattice defines characteristic features of a phosphor. As mentioned earlier the morphology of phosphor can be modified by adding appropriate flux. It is well established that spherical shape of the phosphor particles enables to minimize the quantity of binder thereby enhancing the luminescent properties of a phosphor. Additionally phosphor for display applications should possess high quantum efficiency (QE), high reflectivity for visible light and hence high brightness. This feature of phosphor materials not only ensure reduction in cost of fabrication of display electronics but also minimize the power consumption. The color purity of a phosphor depends on the spectral energy distribution, it can be determined by measuring its x,y coordinates on a standard CIE color chart. The color gamut of a phosphor is represented as an area in the CIE 1931 chromaticity diagram Fig [1]. The color of spectral energy distribution of phosphor is determined by amount of contribution from each point on spectral curve to the total output. The color temperatures of most TV displays are in the 6,000 to 9,000 K range, higher color temperatures are due to higher brightness. Phosphor saturates with increasing excitation energy, this must be minimised as it leads to image sticking in a display. Presence of even a small amount of impurities change the phosphor properties tremendously, this implies the starting materials used for synthesis must be of high analytical grade and special cautions should be taken to avoid contamination at time of synthesis. In chemical synthesis route of phosphor preparation the rate of reaction between the two solid reactants is rapid in the beginning and slows as the reactants are used up. It is stated the reaction never becomes 100 %complete and results in formation of impure phosphor with poor luminescent efficiency. Thus synthesis of a phosphor with reproducible efficiency and chromaticity requires careful control on the purity, stoichiometry and particle size of the starting raw materials [1-4]. First the high purity materials of the host crystal, activators, and the fluxes are blended, mixed and then fired in a container. Practical phosphors are prepared so that they can form a dense, pinhole-free coating of Phosphor.

4. Characteristics Requirement of Led Phosphors

The phosphors used in LED should have overlapping excitation spectra to emission spectra 420-490 nm or 360-400 nm for blue, near UV LEDs respectively. Further their emission spectra should lie in the green and red (500-650 nm) region for blue LED and RBG region for near UV LED. These phosphors should not absorb the visible light emission from blue LED or those from other phosphors and should exhibit high quantum efficiency. These phosphors must have high quenching temperatures so as to withstand temperatures up to 150^0C without remarkable change in luminescence efficiency. Above all color rendering index (CRI) of Led phosphors should be > 80.

5. Potential Phosphors for Led Applications

Copper-activated zinc and cadmium sulfides exhibit a rather long afterglow when their irradiation has ceased, and this is favourable for application in radar screens and self-luminous phosphors. Silicates, borates, and phosphates, such as zinc silicate, zinc beryllium silicate, zinc and cadmium borates, and cadmium phosphates, become efficient phosphors when activated with manganese ions, emitting in the red to green region of the spectrum. They have been incorporated into colour television screens to emit the colours blue (silver-activated zinc sulfide), green (manganese-activated zinc orthosilicate), and red (europium-activated yttrium vanadate). Alkaline earth aluminate phosphors $MA_{l2}O_4{:}Eu^{2+}$ (M: Ca, Sr, Ba) doped with Eu^{2+} exhibits strong photoluminescence at the blue-green visible region. The afterglow lifetime and intensity enhances by co-doping with the second rare earth ion [5]. Nanosize of these materials made them excellent photoluminscent materials suitable for display technology. The phosphor $Ba_2LaV_3O_{11}{:}Eu^{3+}$ synthesized at 1100 °C by solid-state reaction is observed to exhibit the red emission of $Eu^{3+}$and emission intensity is dependent on Eu^{3+}concentrations, further $Ba_2LaV_3O_{11}{:}Eu^{3+}$ displays tunable CIE color coordinates from yellow orange to red depended on Eu^{3+} content, which may have a potential application for illuminating and display device. The multifunctional phosphors $Gd_2MO_3O_9$: Eu^{3+}/Yb^{3+} have potential applications in color display. Its luminescence efficiency is enhanced by order of 53 and 21 times in green (524nm) and red (660nm) by incorporation of Li^{+}/Mg^{2+} ions [6]. Orange-Red, red warm white and green emission was obsereved from single Eu,Sm,Pr/Dy or Tb doped $Ca_2GdZr_2A_{l3}O_{12}$ phosphors respectively[3]. The phosphor series comprising of Sm3+ doped barium borophosphate Ba^{3-} 2xSmxNaxBPO7(x=0.01,0.02,0.03,0.05,0.1) were synthesised by solid state reaction, when excited with 404nm light generates orange red light, thus is a potential candidate for application in white- light emitting diodes [7].$Zn_2SiO_4{:}Mn^{2+}$ phosphors showed strong 525nm green emission spectrum the maximum luminance was 0.96cd/$m^2$where the power consumption was 250 W/m^2at 420 Vp and 400Hz and thus Luminous efficiency was 0.012lm/W[8]. $ZnO.B_2O_3.H_2O$ phosphors obtained by co-doping of Eu^{3+} and Tb^{3+} a combination of blue green and red emission emerges to achieve white emission. And hence could serve as a potential white emitting phosphor. Review of existing Phosphors for LED's establishes that a blend of three rare-earth ion containing phosphors activated by Eu^{2+} (blue), Tb^{3+} (green), and Eu^{3+} (red) exhibits good color rendering, higher efficiency, and better Luminescence. It should lie in the green and red (500-650 nm) region for blue LED and RBG region for near UV LED. These phosphors should not absorb the visible light emission from blue LED or those from other phosphors and should exhibit high quantum efficiency. These phosphors must have high quenching temperatures so as to withstand temperatures up to 150^0C without remarkable change in luminescence efficiency. Above all color rendering index (CRI) of LED phosphors should be > 80

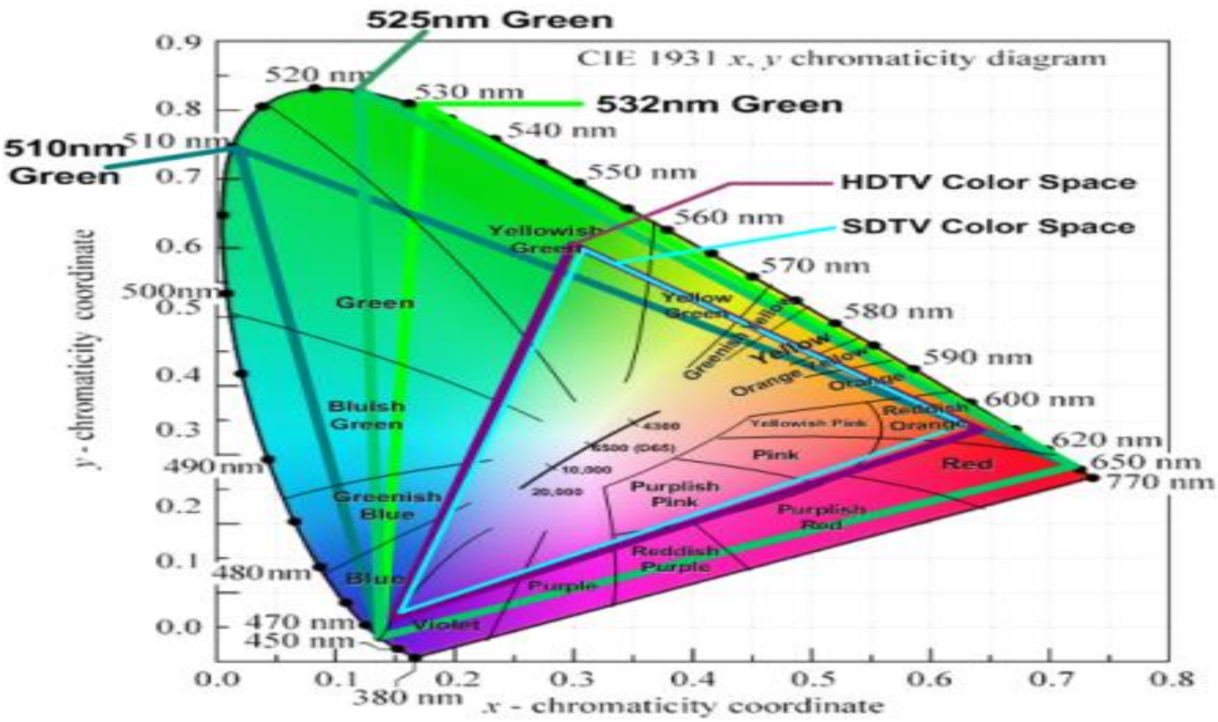

Figure 1: Chromaticity Diagram

6. Conclusion/Challenges

The light-converting material operates on principle of luminescence. Further it is established that the wavelength of the emitted light depends on the host lattice and the activators and can be tailored to emit all colors ranging from cyan to deep red. Combinations of different phosphors when used together may emit white light. A worldwide search is therefore aimed at finding efficient narrow band red emitting materials that can be excited by blue light, and which is nontoxic and does not produce hazardous wastes, which are stable and above all have low cost of production.

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