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Nano Phosphors

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Abstract: *Semiconductor nanoparticles have been widely investigated in the past two decades, particularly due to their size-dependent optical properties. Nano phosphors are explored due to their potential applications along with nanotechnology. Nano phosphors are preferred over micron size phosphors in a number of applications not only due to their particle size but also due to their better physical properties. With the development of advanced display and lighting technologies, new phosphors with improved properties are required in flat panel displays (FPDs) based on electroluminescence (EL) or field emission displays (FED) and plasma display panels (PDPs) or for energy efficient solid state lighting based on light emitting diodes(LED) and Organic Light Emitting diodes(OLEDs).*

Keywords: *Nano materials, Synthesis and Characterization, Applications.*

I. Introduction

In recent years the phrase nano has become popular in several fields. It is a catch phrase for obtaining research funding, a hot topic for holding seminars and symposia. The popularity can be gauged from the fact that several consumer products, which include a car, use the phrase nano. However, promising and hoping for good results is one thing and achieving them is another. Several projects failed as these promises could not be kept and hopes dashed.

The rare earth elements have had and still have a unique and important impact on our lives. The unfilled 4f electronic structure of the rare earth elements makes them have special properties in luminescence, magnetism and electronics, which could be used to develop many new materials for various applications such as phosphors, magnetic materials, hydrogen storage materials and catalysts. Synthesis of nanophosphors and display phosphors of various host matrices by different preparative methods are very important in the phosphor industry. Nanophosphors are preferred over micron size phosphors in a number of applications not only due to their particle size but also better optical properties. Some of the techniques such as solid state diffusion, flame and laser pyrolysis and sol-gel process are being employed to manufacture. The main advantages of nanophosphors in potential applications such as solid state lighting, medical, security, displays, remote thermometry and thermo luminescence radiation dosimetry. Rare-earth doped luminescent materials (i.e. phosphors) are known to emit at distinct and different wavelengths in the electromagnetic spectrum and have been widely used in color cathode ray tubes(CRT), tri-phosphor fluorescent lamps, X-ray intensifying screens and newly developed vaccum mercury-free lamps, as well as various types of displays such as plasma display panels, field emission displays and projection TVs. Recently, breakthroughs in inorganic light emitting diodes (LEDs) technology are significantly catalyzing the development of energy-efficient solid-state lighting (SSL) with long lifetime. Solid-state lighting technology has now already penetrated in a variety of special applications in effect ,LEDs have completely changed the "world of luminance". For example automobile brake lights, traffic signals, liquid crystal displays and mobile backlights, flashlights and all manner of architectural spotlights.

Doping of trivalent rare earths into the host can help and modify the emission characteristics of the phosphor. Doping forms an integral part of any material to be synthesized or the core area, be it semiconductors used in display or insulators like phosphor for the industry. Judicious use of the dopants enhances and sometimes changes the emission characteristics of phosphor. Rare earth based research has been the backbone of the display industry and still the $4f^n$ levels play significant role in enhancing and improving the industry with their charming and fascinating spectroscopic transitions. Laser detection phosphors (LDP) are used to detect the presence of lasers in the infra-red region by converting the energy to visible. Storage phosphors react to a broad spectrum of infra-red but require daylight to be released resulting in a gradual drop in output. "Anti-Stokes" phosphors directly convert the energy from infra-red to visible with a continuous output. They do not exhibit the same broad response to infra-red though.

Nanophosphors are being extensively investigated due to potential applications during last few years along with nano technology development. Medieval artisans unknowingly became first nanotechnologists when they made red stained glass by mixing gold chloride (nano) into molten glass. Selection of host lattice and suitable activators/ coactivators, doping process and physics of nanophosphors such as quantum confinement, quantum size, surface area, surface morphology, band gap variations, shift in excitation are some of the parameters one has to study before selecting and synthesizing nanophosphors.

The work on nano structured luminescent materials received impetus with the discovery that luminescence efficiency increase due to quantum confinement. Nanoparticles, ribbons, rods, tubes, etc. were subsequently fabricated with the anticipation that phosphors with higher efficiencies and exotic properties will be obtained. Since the rapid advances in nanotechnologies, particularly, the development of new methods of materials synthesis, there have been growing interests in the spectroscopic properties and luminescence dynamic of activator ions in nanomaterials. Promising applications such as nano phosphors for high resolution display devices are driving forces of the research activities. In nanoparticles, particle size may affect emission lifetime, luminescence quantum efficiency, and concentration quenching.

At present a large fraction of the work on luminescent materials is related to the nano-structured materials. Synthesis and characterization of the nano materials, on the other hand, requires sophisticated instrumentation. Quite frequently, any new observation is assigned to the nano size without examining actual morphology of the phosphors. For nano-phophors one may anticipate modifications of emission and/pr excitation spectra, decrease in decay time, decrease in concentration quenching, decrease in non-radiative processes due to quantum confinement, increased quantum efficiency, tenability of host and activator energy levels for effective transfer, ease of dispersion for device fabrication, etc.

Majority of the phosphor community is focusing on obtaining nano phosphors with higher efficiencies. The efficiencies of nanophosphors seldom exceed those of the bulk, and researchers feel disappointed. However, apart from the high efficiencies there are several other aspects of the nano phosphors which can be exploited for the applications. It is not uncommon to find huge reduction in TL output when phosphor size is increased. However, this decrease can be exploited for obtaining TL phosphors for high level dosimetry. Irradiation as a quarantine treatment of fresh fruits and vegetables and as a method to ensure the hygienic quality of food of animal origin is increasingly accepted and applied.The effectilveness of processing of food by ionizing radiation depends on proper delivery of absorbed dose and its reliable measurement. For food dosimetry, it is important that the dosimetry techniques used for dose determination should be simple and accurate. If the drop in the radiation sensitivity leads to the extension of the linearity range upto KGy, the phosphors will be useful for such applications.

Another aspect of the nano phosphors not much exploited is their dispersibility. Owing to the dispersibility in liquids, these can be easily applied on the surfaces. This can be immensely useful for obtaining luminescent solar concentrators in general and Silicon photocells for harnessing solar energy, in particular (1). Crystal silicon (c-Si) solar cells most effectively convert photons of energy close to the semiconductor band gap. The mismatch between the incident solar spectrum and the spectral response of the c-Si have been estimated to be 29% by Shockley and Queisser (2). However, this limit is estimated to be improved up to 38.4% by modifying the solar spectrum by a quantum cutting down converting phosphor which converts one photon of high energy into two photons of lower energy (3).

Applications in the field of biomedicine is perhaps the most important glamorous, but neglected by the Indian phosphor community- aspect of nano phosphor research. Size of biomolecules matches that of the nano phosphors. In principle, it is possible to attach nano phosphor particles to biomolecules. This fact can be exploited for applications
in biomedical engineering. During the next decade this could be the near infrared (NIR) light holds enormous potential for a wide variety of molecular diagnostic and therapeutic applications. The recent emergence of infrared optical imaging systems has expanded the biomedical applications for infrared-emitting rare-earth doped naomaterials in diagnosis and imaging. Using conventional fluorescent probes with visible emissions to image deep organs such as liver and spleen are not adequate considering the low tissue penetration depth of visible light 9<1 cm. Tissue penetrating infrared light would be required for deep tissue imaging. By using near-infrared-emitting quantum dots and the tissue transparent regions centered at 840, 1110, 1320, and 1680 nm to enable detection depths of (5-10) cm, tumor imaging sensitivity was reported to potentially improve by atleast tenfold (4-6).

Conclusion: It is concluded that nano phosphor research may be directed to profiting areas rather than competing with the bulk phosphors in the traditional applications. Organisations have to develop capabilities to indigenously manufacture these materials as an effort towards self-reliance.

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