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Optical Properties of Silicate Based Phosphors

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Abstract:
Luminescence is the emission of optical radiation by matter. Phosphors are solid luminescent material which emits photons when excited by an external energy source, such as electron beam or ultraviolet light. Silicate based phosphors have good stable crystal structure, high physical and chemical stability, heat stability and water resistance property over the sulphide and aluminate based phosphors. Synthesis and optical properties of the silicate based long afterglow phosphors have been discussed.

Keywords: Silicate Based Phosphors, Mechanoluminescence, Thermoluminescence, Photoluminescence

1. INTRODUCTION

Luminescence is the emission of optical radiation by matter. Luminescence is defined as a phenomenon in which the electronic state of a substance is excited by some kind of external energy and the excitation energy is given of as light. Here, the light includes not only electromagnetic waves in the visible region of 400 to 700 nm, but also those in the neighboring regions on both ends, i.e., the near-ultraviolet and the near-infrared regions. This phenomenon is to be distinguished from incandescence, which is the emission of radiation by a substance by virtue of it being at a high temperature (black body radiation). Luminescence can in occur in a wide variety of matter and under many different circumstances. In general light emission from the cold sources is called luminescence and light emission from the hot sources is called incandescence. By recording the spectra we can identify the hot and cold sources of light. Whereas the light coming from hot sources has continuous spectra and light coming from cold sources has band spectra or line spectra or combination of both. In luminescence, some energy sources kicks an electron of an atom of its ground state into an excited state by supplying extra energy, then as this excited is not stable, electron jumps back to its ground state by giving out this energy in form of light.

2. PHOSPHORS

Luminescent material is called phosphors. Phosphors are solid luminescent material which emits photons when excited by an external energy source, such as electron beam or ultraviolet light. Phosphors are consists of a host lattice and a luminescent center often called as an "Activator". The activator absorbs the exciting radiations and is raised to an excited state. The excited state returns to the ground state by emission of radiation. In some material the activator does not absorbs the excitation radiation but the other ion may absorb the exciting radiation and subsequently transfer it to the activator. In this case the absorbing ion is called as a sensitizer. In many cases the host lattice transfers the excitation energy to the activator, so the host lattice act as a "Sensitizer". The host lattice is constituted of at least one kind of oxide selected from the sulphide aluminate, alumino silicate, silicate, tantalite, niobate, phosphate, halophosphate, Borate, tungstate etc.

3. LONG AFTERGLOW PHOSPHORS

Long persistent phosphors are phosphors that have very long afterglow emission or phosphorescence. Afterglow is caused by trapped electrons produced by an excitation source. Long persistent phosphors are also called long lasting, long duration, long lived, or long afterglow phosphors. The mechanism for long persistent phosphors can be explained in terms of a simplified three-level diagram including a ground state, an excited state, and a meta-stable trapping state for the active electron. As novel function material, these long afterglow phosphors are drawing more and more attention in recent years. Long afterglow materials absorb light, store the energy under excitation and release the energy as visible light for several hours after the removal of the excitation source in a room temperature.

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4. PROPERTIES

In the nineteenth century the traditional long afterglow phosphors of sulphide series have been improved greatly, several typical products have been produced during ZnS: Cu (Which emits green light), (CaSr)S:Bi (Which emits blue light), (ZnCd)S : Cu (Which emits yellowish -orange light) and they have been applied in some commercial fields. However the disadvantage of these phosphors are: poor stability, short afterglow, low brightness, easy to decompose in air and easy to turn gray even black when irradiated under sun light. The commercial applications of these phosphors were limited and these phosphors have once been used in air dashboard, clock fields etc.

The aluminate long afterglow luminescent was invented at the beginning of the nineties, its luminescent brightness, long afterglow character and stability were obviously superior to the above sulphide series products and it has already been used in the article for daily use, low illumination indicator board, clock etc. The disadvantage of these phosphors are still have bad anti-moisture character, and they have strict restriction over the raw materials purity and form, besides the production cost was higher, as well as single luminescent color etc., therefore it also can not satisfy the requirement of usage very well.

In order to solve the above problem existed in the prior art, the invention provides a kind of series silicate long afterglow luminescent material that having various luminescence colors from blue to yellow, wide scope spectrum, better anti-moisture property, nice stability, long afterglow, high brightness, low production cost.

The silicate based phosphors also have good stable crystal structure, high physical and chemical stability, heat stability and water resistance property. In the same condition putting the long afterglow phosphors of aluminates and long afterglow silicate phosphors into water, it is found that the aluminates' phosphors are decomposed after three days and decomposed entirely after a week and losing a luminescent property, but the silicate based phosphors didn't decompose even after three months. The afterglow property still existed. A new type of series long afterglow luminescent materials, it is a kind of long afterglow luminescent material which use silicate as host material, rare earth or the transitions metal ions are act as a activator, and add some compounds as a flux to make the improvement of long afterglow performance.

5. DIFFERENT METHODS FOR PHOSPHORS PREPARATION

Most of the commercial phosphors are synthesized by high temperature solid state reaction method and few by sol-gel method, combustion synthesis method and wet-chemical method. During synthesis, a host matrix is formed from raw materials and the impurities, also known as activator and co-activator in the required quantities are diffused into the crystal lattice. The activators are mostly responsible for the luminescence. In some cases, co-activators play an important role in diffusing the activators effectively into the crystal lattice and sometimes participate in keeping crystal neutrality through charge compensation. The synthesis technique varies depending on the type of phosphors being manufactured.

(a) Solid state reaction method
(b) Sol-gel method
(c) Combustion synthesis method
(d) Wet-chemical method

6. OPTICAL PROPERTIES OF SILICATE BASED PHOSPHORS

Silicate based phosphors shows the properties of Thermoluminescence (TL), Mechanoluminescence (ML) and Photoluminescence (PL). The intensity of luminescence emission depends on the ratio of alkaline earth and rare earth elements.

7. APPLICATIONS

The silicate based long afterglow phosphors uses as indicators or ornaments, in dark environment, combined with paint; plastics, printing ink; rubber, textile printing etc., this series of luminescent materials has good effect in architecture, traffic signs, art and graphics, decoration, watch and clock dials, fishing tackles, toys and other goods for daily use. It also uses in the field of optoelectronic devices, tricolor fluorescent lamps, scintillators, optical memory, imaging storage and so on.

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