

A luminescent glass ceramic and the preparation method thereof and the use in LED lighting device thereby

TECHICAL FIELD OF THE INVENTION

The invention belongs to the field of inorganic luminescent material, specifically relates to a luminescent glass ceramic and the preparation method thereof and the use in LED lighting device thereby.

BACKGROUND OF THE INVENTION

At present, solid-state lighting is widely praised for its low pollution, resource saving, and long lifetime. The most widely used solid-state device in the market is the white LED combining a blue GaN chip and Ce^{3+} :YAG phosphor. Firstly, this type of white LED tends to have a relatively high color temperature ($>5000\text{ K}$), which can easily make human eyes fatigue by prolonged irradiation and thus it is unfavorable for daily-life lighting. Secondly, the common packaging method in the market is to mix the phosphor directly with the epoxy resin and coat it on a blue chip. Although this method is simple, the corresponding light emitting device is prone to color aberration after a long period of operation. This is due to the low thermal conductivity of epoxy resin, and the heat generated by the light-emitting device during operation will promote ageing of epoxy resin, thereby affecting the quality of the device. Finally, the heat generated by the chip which is used for high-power LED devices has risen dramatically, and the corresponding demand for packaging materials has become more urgent.

Luminescent glass ceramics not only possess high thermal conductivity and excellent stability, but also can emit light with various colors after being directly incorporated with different rare-earth ions or combined with phosphors. Such properties allow them as the color convertors to be successfully applied to high-power remote white LEDs. The luminescent glass ceramics reported on the

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current literatures can be divided into two kinds, which are rare earth doped glass ceramics and phosphor-in-glass. Compared with the former, the latter is easier to achieve the desire luminescent needs. The mainstream research in phosphor-in-glass focus on mixing Ce^{3+} : YAG phosphor with the precursor glass powder and then obtaining the corresponding phosphor-in-glass sintering at a low sintering temperature ($<1000^{\circ}\text{C}$). Such phosphor-in-glass show more stable and the embedded phosphors are not easily affected by the external condition. However, Ce^{3+} : YAG-phosphor-in-glass based white LED still faces the problems including low color-rendering index and high correlated color temperature. In order to solve above problems, most of the literature reports adding red phosphor to improve the color-rendering index and correlated color temperature, which undoubtedly increases the difficulty and cost of preparation.

SUMMARY OF THE INVENTION

In order to overcome the disadvantages and deficiencies of the prior art described above, the primary object of the present invention is to provide a luminescent glass ceramic, which has uniform color and good luminescence performance, and can be packaged with an ultraviolet light emitting chip to produce a high-power remote warm white LED, which enriches the existing luminescent materials and makes up for the deficiencies of the existing technology.

Another object of the present invention is to provide a method for preparing the above-described luminescent glass ceramic.

A further object of the present invention is to provide the use of the above-mentioned luminescent glass ceramic in preparing a LED device.

The objects of the present invention are achieved by the following scheme:

A luminescent glass ceramic, comprising silicate red luminescent glass powder and azure blue phosphor powder $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ with a mass ratio of 100:0 to 99.1:0.9.

Wherein, the silicate red luminescent glass powder is composed of the

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following components by molar ratio:

SiO ₂	50~60%
Na ₂ CO ₃	20~30%
Al ₂ O ₃	9%
CaO	6%
Eu ₂ O ₃	5%.

A method for preparing the above-mentioned luminescent glass ceramic, including the following steps:

(1) mixing SiO₂, Na₂CO₃, Al₂O₃, CaO and Eu₂O₃ together homogeneously, then placing them in a high temperature box-type resistance furnace; rising the temperature to conduct the reaction; after finish of the reaction, cooling the reaction product to the room temperature and grinding the reaction product to obtain silicate red luminescent glass powder;

(2) mixing the silicate red luminescent glass powder obtained in the step (1) and the Sr₄Al₁₄O₂₅:Eu²⁺ phosphor together homogeneously, then tableting and placing them in a high temperature box-type resistance furnace; rising the temperature to conduct the reaction; after finish of the reaction, cooling the reaction product to the room temperature and obtaining a polished luminescent glass ceramic after polishing.

The said rising the temperature described in step (1) refers to rising the temperature to 1300~1500°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 3~6h.

Preferably, the said rising the temperature described in step (1) refers to rising the temperature to 1300°C at a speed of 5°C/min, and then maintaining the temperature to react for 3h.

The molar ratio of SiO₂, Na₂CO₃, Al₂O₃, CaO and Eu₂O₃ used in step (1) is (50-60):(20-30):9:6:5.

The mass ratio of silicate red luminescent glass powder and Sr₄Al₁₄O₂₅:Eu²⁺

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phosphor used in step (2) is 100:0 to 99.1:0.9.

The tableting described in step (2) refers to pressing into a tablet under a pressure of 20 to 40 MPa, preferably under a pressure of 20 MPa.

The said rising the temperature described in step (2) refers to rising the temperature to 650~700°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 0.5~10h.

Preferably, the said rising the temperature described in step (2) refers to rising the temperature to 680°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 0.5h.

The use of the above-mentioned luminescent glass ceramic in preparing a LED device, including the following steps: directly covering the luminescent glass ceramic on a 385 nm ultraviolet LED chip, and obtaining the LED lighting device after fixing the luminescent glass ceramic and the LED chip in the periphery with high-temperature-resistant packaging glue.

The mechanism of the invention is:

In the present invention, azure blue phosphor powder $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ and silicate red luminescent glass powder are mixed and sintered at a low temperature, so as to obtain an ultraviolet-excited luminescent glass ceramic. Because the emission wavelength of the phosphor used ranges from 450 nm to 550 nm, meantime the precursor glass powder can provide red light, the resulting luminescent glass ceramic can laminate warm white light under the excitation of a 385 nm UV chip. By regulating the ratio of phosphor powder and glass powder, the types of warm white light can also be different, which provides more choices for practical applications.

Compared with the prior art, the present invention has the following advantages and beneficial effects:

(1) The present invention adopts a luminescent glass ceramic material as coating, which largely blocks the contact of the phosphor with the outside

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environment and thus reduces the probability of erosion of the phosphor. Since the luminescent glass ceramic has a high thermal conductivity, it can be applied well in high power remote LED.

(2) The glass powder used in the present invention is specially designed to emit red light by itself under the excitation of a certain wavelength by adding element Eu, and it is more favorable for the application in warm white LED with low color temperature when compounding with the phosphor. Warm white LEDs with different color temperatures can be obtained by regulating the ratio of the glass powder and the phosphor.

(3) The preparation method of the luminescent glass ceramic of the present invention is simple in the process, cost saving and advantageous for industrialized production. It expands the categories of luminescent materials and their application range, and thus it has a broad application prospect.

(4) The luminescent glass ceramic of the present invention is stable, which can withstand high temperature and high-pressure environments and maintain high luminous efficacy. The high-power remote warm white LED packaged with the luminescent glass ceramic and a UV chip can maintain satisfactory performance under different input current and operation time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is the excitation and emission spectra of the $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor and the silicate red luminescent glass powder used in embodiment 4, and the emission spectrum of the prepared luminescent glass ceramic in embodiment 4.

FIG. 2 is the emission spectra of the luminescent glass ceramic prepared in embodiment 1~6.

FIG. 3 shows the emission spectra of the high power remote LED packaged in embodiment 1~ 6.

FIG. 4 shows the color coordinates and the working effect corresponding to

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the high-power remote LED packaged in embodiments 1~ 6.

FIG. 5 shows the change of color coordinates corresponding to the high-power remote LED in embodiment 11 when it operates under different currents.

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

The present invention will be further described in detail with reference to the embodiments and the accompanying drawings, but the embodiments of the present invention are not limited thereto.

The raw materials used are all commercially available from the market.

Embodiment 1

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 100:0. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of $5^\circ\text{C}/\text{min}$ for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 2

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According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.9:0.1. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of $5^\circ\text{C}/\text{min}$ for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 3

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.7:0.3. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are

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heated to 680°C at a speed of 5°C/min for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 4

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO₂, 20% of Na₂CO₃, 9% of Al₂O₃, 6% of CaO, and 5% of Eu₂O₃ are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of 5°C/min. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and Sr₄Al₁₄O₂₅:Eu²⁺ phosphor powder are mixed by a mass ratio of 99.5:0.5. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of 5°C/min for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

FIG. 1 shows the excitation and emission spectrum of the Sr₄Al₁₄O₂₅:Eu²⁺ phosphor powder and the silicate red luminescent glass powder used in embodiment 4, and the emission spectrum of the prepared luminescent glass

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ceramic in embodiment 4. In FIG.1 it can be seen that the emission range of $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor and the silicate red luminescent glass powder partially overlaps (e.g. 385 nm), therefore a mixed light emitted by them can be obtained after excitation by a single wavelength.

Embodiment 5

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.3:0.7. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of $5^\circ\text{C}/\text{min}$ for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 6

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to

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room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.1:0.9. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of $5^\circ\text{C}/\text{min}$ for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

FIG. 2 shows the emission spectrums of the luminescent glass ceramic prepared in embodiment 1~6. From FIG. 2 it can be seen that the larger the ratio of the phosphor power is, the stronger the emission peak is, which is favorable for the control of light color. The optical performances of the luminescent glass ceramics obtained in embodiment 1~6 are shown in Table 1.

Table 1. The optical performances of the luminescent glass ceramics obtained in embodiment 1~6

Items	Embodi- ment1	Embodi- ment 2	Embodi- ment 3	Embodi- ment 4	Embodi- ment 5	Embodi- ment 6
Color coordinate X	0.6625	0.3584	0.2584	0.2322	0.2168	0.2074
Color coordinate Y	0.3224	0.4233	0.4592	0.4637	0.4716	0.4757
Quantum efficiency (excited at 385nm, detected at 450~ 550nm)	0.33%	10.98%	27.05%	28.40%	33.15%	35.20%
Quantum efficiency (excited at 385nm, detected at 550~ 720nm)	52.53%	37.95%	33.39%	24.55%	22.43%	17.88%

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According to Table 1, due to different mass ratio of the raw material, the light color of the luminescent glass ceramics in embodiment 1~6 changes from red to sky blue, and meantime the quantum efficiency at the corresponding wavelength changes periodically. Therefore, the luminescent glass ceramics can satisfy needs in practical application.

FIG. 3 shows the emission spectrums of the high power remote LED packaged in embodiment 1~ 6. It can be seen from FIG. 3 that the obtained LED emission spectrums and the glass ceramic emission spectrums can well match. FIG. 4 shows the color coordinates and the working effect corresponding to the high-power remote LED packaged in embodiments 1~ 6. It can be seen from FIG. 4 that as the content of the phosphor power increases, different kinds of warm white LEDs can be obtained.

Table 2 shows the optical performance of the high power remote LEDs packaged in embodiment 1~6:

Table 2 the composition and optical performance of the LEDs packaged in embodiment 1~6

Composition	Color coordination X	Color coordination Y	Color temperature
UV chip + the luminescent glass ceramic in embodiment 1	0.5651	0.2624	56930
UV chip + the luminescent glass ceramic in embodiment 2	0.5024	0.3061	3116
UV chip + the luminescent glass ceramic in embodiment 3	0.4301	0.3508	2496
UV chip + the luminescent glass ceramic in embodiment 4	0.3706	0.3861	4320
UV chip + the luminescent glass ceramic in embodiment 5	0.3575	0.3961	4752
UV chip + the luminescent glass ceramic in embodiment 6	0.3329	0.4131	5531

According to Table 2, the light color of the high power remote LEDs packaged in embodiment 1~6 can change from red to warm white, and different color temperature can be achieved, which greatly enlarges the application range of

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the LED.

Embodiment 7

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 50% of SiO_2 , 30% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.5:0.5. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of $5^\circ\text{C}/\text{min}$ for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 8

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 50% of SiO_2 , 30% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1500°C at a speed of $10^\circ\text{C}/\text{min}$. After maintaining the temperature for 5h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass

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ratio of 99.5:0.5. Then they are pressed into a tablet under a pressure of 20 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 680°C at a speed of 5°C/min for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 9

According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO₂, 20% of Na₂CO₃, 9% of Al₂O₃, 6% of CaO, and 5% of Eu₂O₃ are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of 5°C/min. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and Sr₄Al₁₄O₂₅:Eu²⁺ phosphor powder are mixed by a mass ratio of 99.5:0.5. Then they are pressed into a tablet under a pressure of 40 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 650°C at a speed of 10°C/min for 0.5h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

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According to the molar ratio of each raw material in the silicate red luminescent glass powder, 60% of SiO_2 , 20% of Na_2CO_3 , 9% of Al_2O_3 , 6% of CaO , and 5% of Eu_2O_3 are fully mixed and placed in a high temperature box-type resistance furnace. The temperature of the furnace is risen to 1300°C at a speed of $5^\circ\text{C}/\text{min}$. After maintaining the temperature for 3h, cool the materials down to room temperature. Then they are ground to obtain a silicate red luminescent glass powder.

The glass powder and $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor powder are mixed by a mass ratio of 99.5:0.5. Then they are pressed into a tablet under a pressure of 40 MPa and placed in a high temperature box-type resistance furnace. After that, they are heated to 700°C at a speed of $10^\circ\text{C}/\text{min}$ for 1h and cooled down to room temperature. Finally they are polished to obtain a luminescent glass ceramic.

Directly cover the obtained luminescent glass ceramic on a 385 nm ultraviolet light emitting chip, and a high-power remote LED is obtained after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue. Its light color performance is tested after operating at 90 mA input current and 16 V input voltage for 0.5 h.

Embodiment 11

The luminescent glass ceramic obtained in embodiment 4 is packaged with a 385 nm ultraviolet light emitting chip to assemble a high-power remote LED. Its light color performance is tested after operating at 20~90mA input current and 16V input voltage for 0.5 h.

FIG. 5 shows the change of color coordinates corresponding to the high-power remote LED in embodiment 11 when it operates under different currents. From FIG. 5 it can be seen that with the change of current, the LED light color changes within an acceptable range.

The optical performances of the high power remote LED packaged in embodiment 11 are shown in Table 3.

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Table 3. The composition and optical performances of the high power remote LED packaged in embodiment 11

Composition	Input current	Color coordinate X	Color coordinate Y
UV chip + the luminescent glass ceramic in embodiment 4	20	0.3708	0.4107
UV chip + the luminescent glass ceramic in embodiment 4	30	0.3706	0.4075
UV chip + the luminescent glass ceramic in embodiment 4	40	0.3705	0.4041
UV chip + the luminescent glass ceramic in embodiment 4	50	0.371	0.4008
UV chip + the luminescent glass ceramic in embodiment 4	60	0.3715	0.3972
UV chip + the luminescent glass ceramic in embodiment 4	70	0.3726	0.3935
UV chip + the luminescent glass ceramic in embodiment 4	80	0.3739	0.3896
UV chip + the luminescent glass ceramic in embodiment 4	90	0.3756	0.3855

According to Table 3, the color coordinates of the high power remote LED packaged in embodiment 11 do not change much with increasing input current, which proves the stability of the packaged LED.

The above embodiments are preferred embodiments of the present invention, but the embodiments of the present invention are not limited by the foregoing embodiments. Any other changes, modifications, substitutions, combinations and modifications made without significant difference from the spirit and principle of the present invention should all be included in the protection scope of the present invention.

Claims

What is claimed is:

1. A luminescent glass ceramic, comprising silicate red luminescent glass powder and azure blue phosphor powder $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ with a mass ratio of 100:0 to 99.1:0.9.

2. A luminescent glass ceramic as claimed in claim 1, wherein the silicate red luminescent glass powder is composed of the following components by molar ratio:

SiO_2	50~60%
Na_2CO_3	20~30%
Al_2O_3	9%
CaO	6%
Eu_2O_3	5% .

3. A method for preparing the luminescent glass ceramic as claimed in claim 1 or 2, including the following steps:

(1) mixing SiO_2 , Na_2CO_3 , Al_2O_3 , CaO and Eu_2O_3 together homogeneously, then placing them in a high temperature box-type resistance furnace; rising the temperature to conduct the reaction; after finish of the reaction, cooling the reaction product to the room temperature and grinding the reaction product to obtain silicate red luminescent glass powder;

(2) mixing the silicate red luminescent glass powder obtained in the step (1) and the $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$ phosphor together homogeneously, then tableting and placing them in a high temperature box-type resistance furnace; rising the temperature to conduct the reaction; after finish of the reaction, cooling the reaction product to the room temperature and obtaining a polished luminescent glass ceramic after polishing.

4. A method for preparing the luminescent glass ceramic as claimed in claim 3, wherein the said rising the temperature described in step (1) refers to rising the temperature to 1300~1500°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 3~6h;

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the said rising the temperature described in step (2) refers to rising the temperature to 650~700°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 0.5~1h;

the tableting described in step (2) refers to pressing into a tablet under a pressure of 20 to 40 MPa.

5. A method for preparing the luminescent glass ceramic as claimed in claim 3, wherein the said rising the temperature described in step (1) refers to rising the temperature to 1300 °C at a speed of 5 °C /min, and then maintaining the temperature to react for 3h;

the said rising the temperature described in step (2) refers to rising the temperature to 680°C at a speed of 5~10°C/min, and then maintaining the temperature to react for 0.5h;

the tableting described in step (2) refers to pressing into a tablet under a pressure of 20 MPa.

6. A method for preparing the luminescent glass ceramic as claimed in claim 3, wherein the molar ratio of SiO₂, Na₂CO₃, Al₂O₃, CaO and Eu₂O₃ used in step (1) is (50-60): (20-30):9:6:5;

the mass ratio of silicate red luminescent glass powder and Sr₄Al₁₄O₂₅:Eu²⁺ phosphor used in step (2) is 100:0 to 99.1:0.9.

7. The use of the luminescent glass ceramic as claimed in claim 1 or 2 in preparing a LED lighting device, including the following steps: directly covering the luminescent glass ceramic on a 385 nm ultraviolet light-emitting chip and obtaining the LED lighting device after fixing the luminescent glass ceramic and the light-emitting chip in the periphery with high-temperature-resistant packaging glue.