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(54) Title: LOW-PRESSURE GAS DISCHARGE LAMP COMPRISING HALIDES OF INDIUM AND SODIUM

(57) Abstract: The invention relates to a low-pressure gas discharge lamp comprising a gas discharge vessel with means for generating and maintaining a low-pressure gas discharge. It is an object of the invention to improve the luminous efficacy of a low-pressure gas discharge lamp containing a gas filling with an indium compound. According to the invention this is achieved by a low-pressure gas discharge lamp where less luminescence processes are employed. The low-pressure gas discharge lamp comprises a gas discharge vessel containing a gas filling on the basis of an indium halide InX, where X = F, Cl, Br, I, or a mixture of several indium halides. As a characteristic feature the gas filling includes additionally a sodium halide NaX, where X = F, Cl, Br, I, or a mixture of several sodium halides. The additional component consisting of one or more sodium halides emits light in the range of 590 nanometers. Use of a red phosphor in order to gain white light is superfluous then. The gas discharge emits light with a wavelength of 451 nanometers, blue and green light of one or more phosphors converting the UV radiation and light with a wavelength of 590 nanometers.



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## LOW-PRESSURE GAS DISCHARGE LAMP COMPRISING HALIDES OF INDIUM AND SODIUM

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The invention relates to a low-pressure gas discharge lamp comprising a gas discharge vessel with means for generating and maintaining a low-pressure gas discharge.

Light generation in low-pressure gas discharge lamps is based on the principle that charge carriers, particularly electrons but also ions, are accelerated so strongly by an electric field coupled into the lamp with or without electrodes, i.e. capacitively or inductively, that collisions with the gas atoms or molecules in the gas filling of the lamp cause the gas atoms or molecules to be excited or ionized. When returning to lower states or the ground state, a more or less substantial part of the excitation energy is converted to radiation.

15 Conventional low-pressure gas discharge lamps comprise mercury in the gas filling but it is known already that mercury in the gas filling of low-pressure gas discharge lamps can be substituted with other less harmful and toxic substances.

Indium compounds for example are a preferred gas filling. The emission of the discharge consists of the characteristic emission lines of indium at 410 and 451 nanometers, at 304 and 326 nanometers and a continuum between 320 and 450 nanometers. The specific choice of the indium compound used determines the exact position of the continuum.

A general drawback of conventional low-pressure gas discharge lamps for lighting purposes resides in the fact that the substances in the gas filling primarily emit radiation in the short-wave, high-energy, yet invisible range of the electromagnetic spectrum, which radiation must first be converted by phosphors to visible radiation with a much lower energy level. With indium the characteristic emission line at 451 nanometers provides blue light but all other emission lines fall within the invisible range.

Low-pressure gas discharge lamps therefore comprise a phosphor layer containing at least one phosphor emitting in the intended range of the spectrum.

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Depending on the application radiation with different wavelengths in a certain range is provided by an adequate phosphor layer.

5 DE 100 44 562 A1 discloses a low-pressure gas discharge lamp comprising a gas discharge vessel with a filling containing an indium compound and a buffer gas in combination with phosphors. With respect to high luminous efficacy it is most beneficial, when the visible light is generated from the discharge and not via conversion of discharge radiation into visible light because the intrinsic Stokes shift in  
10 case of the conversion reduces the luminous efficacy of the generated visible light.

The luminous efficacy, expressed in lumen/Watt is the ratio between the total luminous flux emitted by the lamp and the total optical power emitted by the lamp. The luminous efficiency, also expressed in lumen/Watt is the ratio between the total luminous flux emitted by the lamp and the total power input to the lamp. Luminous  
15 efficiency is equal to luminous efficacy multiplied by the efficiency with which electrical power is converted into optical power.

It is an object of the invention to improve the luminous efficacy and the  
20 luminous efficiency, respectively of a low-pressure gas discharge lamp containing a gas filling with an indium compound.

According to the invention this is achieved by a low-pressure gas discharge lamp where less luminescence processes are employed. The low-pressure gas discharge lamp comprises a gas discharge vessel containing a gas filling on the basis of  
25 an indium halide  $\text{InX}$ , where  $X = \text{F, Cl, Br, I}$ , or a mixture of several indium halides. As a characteristic feature the gas filling includes additionally a sodium halide  $\text{NaX}$ , where  $X = \text{F, Cl, Br, I}$ , or a mixture of several sodium halides. The additional component consisting of one or more sodium halides emits light in the range of 590 nanometers. Use of a red phosphor in order to gain white light is superfluous then.

30 The gas discharge lamp according to the invention emits light with a wavelength of 451 nanometers, blue and green light of one or more phosphors converting the UV radiation and light with a wavelength of 590 nanometers.

A further critical point is the partial vapor pressure  $p_{\text{NaX}}$  of the sodium halide being very small compared to the partial vapor pressure  $p_{\text{InX}}$  of the indium halide. Therefore it is impossible to vaporize both components to a similar degree. As an effect radiation of sodium halide in the characteristic range of 590 nanometers is  
5 very weak compared to radiation of indium halide in the characteristic range of 451 nanometers.

In a preferred embodiment the gas filling therefore comprises a salt mixture of indium monohalides and sodium halides with the indium monohalide content being very small. According to Raoult's Law the salt components are vaporized  
10 according to their concentration and therefore the relation between the vaporized components can be controlled by providing a certain mixing ratio. The molar ratio  $n(\text{InX}) : n(\text{NaX})$  is preferably  $< 1 \%$ , especially  $< 10^{-4}$  in order to gain corresponding partial vapor pressures:  $p_{\text{InX}}(T) = p_{\text{NaX}}(T)$ , dependent from the vessel temperature  $T$ .

15 In a further preferred embodiment the halogen employed is bromine.

In a further preferred embodiment the components are mixed in a ratio to gain white light.

In accordance with the invention a molecular gas discharge takes place at low pressure, which gas discharge emits radiation in the visible range of the  
20 electromagnetic spectrum. This way direct use is made from the radiation of the discharge and Stokes shift losses caused by a luminescence process are avoided or at least reduced.

In combination with a phosphor layer, the lamp in accordance with the invention has a luminescence process which is substantially more efficient than that of  
25 conventional low-pressure discharge lamps. As a consequence the lamp in accordance with the invention has in general a higher luminous efficacy.

## CLAIMS:

1. A low-pressure gas discharge lamp comprising a gas discharge vessel containing a gas filling on the basis of an indium halide InX, where X = F, Cl, Br, I, or a mixture of several indium halides, characterized in that the gas filling includes additionally a sodium halide NaX, where X = F, Cl, Br, I, or a mixture of several sodium halides.  
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2. A low-pressure gas discharge lamp as claimed in claim 1, characterized in that in the gas discharge vessel contains indium monohalide InX with a molar ratio  $n(\text{InX}) : n(\text{NaX}) < 1 \%$ .  
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3. A low-pressure gas discharge lamp as claimed in claim 2, characterized in that in the gas discharge vessel contains indium monohalide InX with a molar ratio  $n(\text{InX}) : n(\text{NaX}) < 10^{-4}$ .  
15
4. A low-pressure gas discharge lamp as claimed in one of the preceding claims, characterized in that X = Br.
5. A low-pressure gas discharge lamp as claimed in one of the preceding claims, characterized in that the components of the gas filling and the phosphors are chosen in order to gain emission from the phosphor layer together with the emission from the gas  
20 discharge forming white light in the visible range.