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(54) **VACUUM ULTRAVIOLET EXCIMER LAMP WITH UV FLUORESCENT COATING**

(57) The invention relates to a VUV excimer lamp (1) comprising a dielectric tube (3) for holding an excimer-forming gas (5), a first central electrode (2) disposed within said tube (3), a second electrode (4) arranged outside of said tube, wherein said dielectric tube (3) has a UV fluorescent coating (6) on the outside with phosphorus compounds.

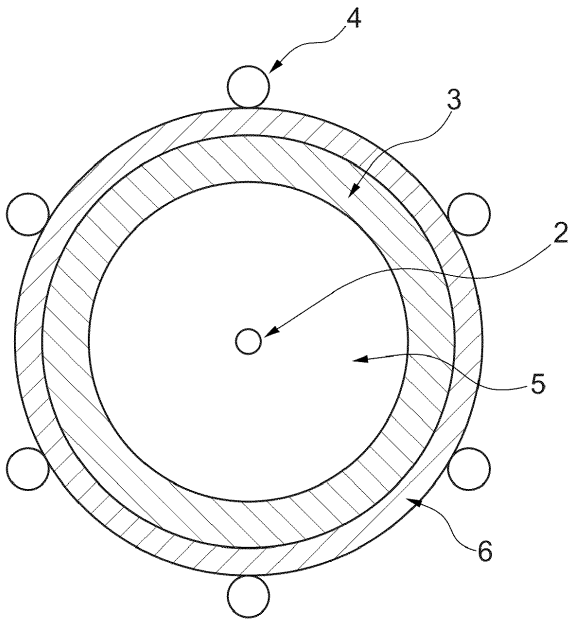

Fig. 2

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Description

[0001] The present invention relates to a VUV excimer lamp according to the preamble of claim 1 and to an excimer lamp system and a photochemical unit comprising such a VUV excimer lamp.

[0002] Excimer lamps are used for generating high-energy ultraviolet (VUV) radiation. The excimer emission is generated by means of silent electrical discharge in a discharge chamber filled with an excimer-forming gas. The discharge chamber has walls formed from a material transparent to ultraviolet (UV) light. A first electrode is disposed within the chamber. A second electrode is arranged outside of the chamber. Due to the electric field generated between the electrodes a discharge occurs, generating excimer molecules. When these excited molecules return to ground state, high-energy ultraviolet light is emitted.

[0003] It is known to use a phosphor layer on the inner surface of the discharge chamber for ultraviolet light generation. CN 103972040 discloses an excimer lamp for sterilization in a refrigerator. A phosphor layer converts the wavelength of light emitted by the discharge medium into a longer wavelength. By altering the materials of the phosphor layer, light with various wavelengths can be obtained. The phosphor layer being located on the inside of the discharge chamber is subject to the discharge plasma which has a negative effect on the lamps lifetime. Multiple phosphor layers for light conversion are known from prior art, e.g. US 6,734,631 B2 and US 2005/0073239 A1.

[0004] It is an objective of the present invention to provide an efficient VUV excimer lamp with an extended lifespan.

[0005] This problem is solved by a VUV excimer lamp with the features listed in claim 1 and by an excimer lamp system and a photochemical unit comprising such a VUV excimer lamp.

[0006] Accordingly, a VUV excimer lamp comprising a dielectric tube for holding an excimer-forming gas, a first central electrode disposed within said tube and a second electrode arranged outside of said tube, is provided, said dielectric tube having a UV fluorescent coating on the outside. The advantage of such an external coating is that the coating has no contact with the plasma and can't be destroyed by the discharge.

[0007] In the following Vacuum Ultra-Violet (VUV) radiation is used to describe the UV spectrum below 190 nm. Ultraviolet C (UV-C) is generally referred to a short wavelength (100-280 nm) radiation, which is primarily used for disinfection, inactivating microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions.

[0008] Preferably, said dielectric tube is made of quartz glass, which is transparent to VUV radiation. It is even more preferred that said dielectric tube is made of synthetic quartz glass, in particular without metal doping.

[0009] It is advantageous, if the UV fluorescent coating is arranged between the dielectric and the second electrode.

[0010] Preferably, said gas consists essentially of Xe.

[0011] In order to reach high efficiency, said gas should contain less than about 10 ppm of impurities.

[0012] Preferably, the UV fluorescent coating has phosphorus compounds.

[0013] In a preferred embodiment said UV fluorescent coating is a UV-C fluorescent coating.

[0014] Further, a photochemical unit with a previously described lamp is provided. Photochemical units can be for example UV disinfection units, UV bleaching units, UV curing units, UV enhanced chemical vapor deposition units and the like.

[0015] A preferred embodiment of the present invention will be described with reference to the drawings. In all figures the same reference signs denote the same components or functionally similar components.

Figure 1 is a schematic side view of a VUV excimer lamp with a phosphor coating arranged on the outside of the dielectric according to the present invention, and

Figure 2 is a cross section of a principle arrangement of the excimer lamp shown in figure 1.

[0016] Figure 1 shows a side view of an excimer lamp 1 with a first high voltage central electrode (inner electrode) 2 arranged in a discharge chamber formed by a dielectric tube 3. Said first electrode 2 includes an elongated thin wire with an outer diameter of less than 0.5 mm. It was found that the efficiency of the lamp improved with a thin wire electrode. In addition, the thin wire electrode 2 shields and absorbs the VUV radiation to a much lower proportion than conventional wider electrodes, which leads to efficiency improvement. Preferably, said elongated thin wire is substantially straight and defines a straight axis of elongation. In other words, the tube has an elongated wall with cylindrical shape and it extends linearly along the axial direction of the lamp body. The wire has preferably a circular cross section.

[0017] It is even more preferred that said elongated thin wire has an outer diameter between 0.02 mm and 0.4 mm. Preferably, the inner electrode has a thickness according to the following equation: $(R/ro)/\ln(R/ro) > 10$, wherein $2*R$ is the inner diameter of the dielectric tube 3 and $2*ro$ the outer diameter of the inner electrode 2. Said elongated thin wire inner electrode 2 is tensioned and centered with a spring arranged on one side of the elongated thin wire. This allows to avoid shadow over the length of the lamp compared to an inner electrode helically wound over the full length around a rod and to ensure tensioning of the electrode at high temperature, which allows to keep the coaxial symmetry. The inner electrode 2 is physically connected to each end of the dielectric tube. The dielectric tube 3 is made of a dielectric, which is transparent for UV radiation. The space with-

in the dielectric tube 3, between the high voltage electrode 2 and the dielectric 3 is filled with high purity Xenon gas 5. The water content is smaller than 10 ppm for performance reasons. A second electrode (outer electrode) 4 surrounds the dielectric tube 3. This ground electrode 4 can be formed in different ways. The second electrode 4 is made of a conductive material. For instance, to form the second electrode 4, a tape or a conductive wire made of a metal (e.g., aluminum, copper) may be used. The second electrode 4 is in contact with the outer surface of the dielectric tube 3. The second electrode 4 can include linear electrodes 40,41. The linear electrodes 40,41 are arranged substantially in parallel with each other and they extend along the longitudinal axis of the dielectric tube. In another embodiment the electrodes 4 can be formed in a spiral form on the outer surface of the dielectric tube 3. This configuration allows discharge to be generated uniformly in a circumferential direction of the dielectric tube 3, making it possible to obtain emission with more uniform distribution of brightness. Further, it is possible that the ground electrode 4 is a mesh or formed by water, which can act with minimal conductivity as electrode with a vessel being grounded. The first and second electrodes 2 and 4 are connected to a driving circuit (not shown).

[0018] The VUV excimer lamp 1 is used for generation of UV-C radiation for disinfection purpose. Upon application of a voltage across the first and second electrodes 2 and 4 by a driving circuit, glow discharge occurs inside the dielectric tube 3, which excites the discharge medium xenon 5. When the excited discharge medium 5 makes a transition to a ground state, the discharge medium emits ultraviolet light with a wavelength of 172 nm. The dielectric 3 is coated on the outer surface, with a UV-C fluorescent material 6, e.g. a layer of phosphorus compounds like YP04: Bi. For a schematic cross-section of the VUV excimer lamp see figure 2. The ultraviolet light passes the dielectric tube 3 and excites a phosphor of the phosphor layer 6. The excited phosphor reemits light in the UV-C range (Stokes shift). The wavelength of the emitted radiation depends on the composition of the phosphorus layer. It can be adapted to the application.

[0019] The advantage of such an external coating is that the phosphor layer 6 has no contact with the plasma and can't be destroyed by the discharge. However, a special dielectric sleeve 3 is necessary which is able to resist as well as transmit the VUV radiation to the phosphor. Applicable is for example synthetic quartz, e.g. Suprasil 310, product and trademark of Heraeus Quarzglas GmbH & Co. KG. It is preferred to use a synthetic quartz which has no metal doping.

[0020] With the proposed phosphor coating on the outside of the dielectric an efficient mercury-free UV-C lamp can be provided, which has no warm-up time,□is fully dimmable (0 to 100% without loss in efficiency) whileD-tolerating a wide range of operational temperature.

Claims

1. VUV excimer lamp (1) comprising a dielectric tube (3) for holding an excimer-forming gas (5), a first central electrode (2) disposed within said tube (3), a second electrode (4) arranged outside of said tube, **characterized in that** said dielectric tube (3) has a UV fluorescent coating (6) on the outside.

2. VUV excimer lamp according to one of the preceding claims, **characterized in that** said dielectric tube (3) is made of quartz glass.

3. VUV excimer lamp according to one of the preceding claims, **characterized in that** said dielectric tube (3) is made of synthetic quartz glass.

4. VUV excimer lamp according to one of the preceding claims, **characterized in that** said dielectric tube (3) is made of synthetic quartz glass without metal doping.

5. VUV excimer lamp according to one of the preceding claims, **characterized in that** the UV fluorescent coating (6) is arranged between the dielectric (3) and the second electrode (4).

6. VUV excimer lamp according to one of the preceding claims, **characterized in that** said gas (5) consists essentially of Xe.

7. VUV excimer lamp according to one of the preceding claims, **characterized in that** said gas (5) contains less than about 10 ppm of impurities.

8. VUV excimer lamp according to one of the preceding claims, **characterized in that** said UV fluorescent coating (6) has phosphorus compounds.

9. VUV excimer lamp according to one of the preceding claims, **characterized in that** said UV fluorescent coating (6) is a UV-C fluorescent coating.

10. Excimer lamp system with an VUV excimer lamp (1) according to one of the preceding claims 1 to 9 and a power supply for supplying AC electric power to the first electrode (2) and second electrode (4).

11. Photochemical unit with a VUV excimer lamp (1) according to one of the preceding claims 1 to 9.

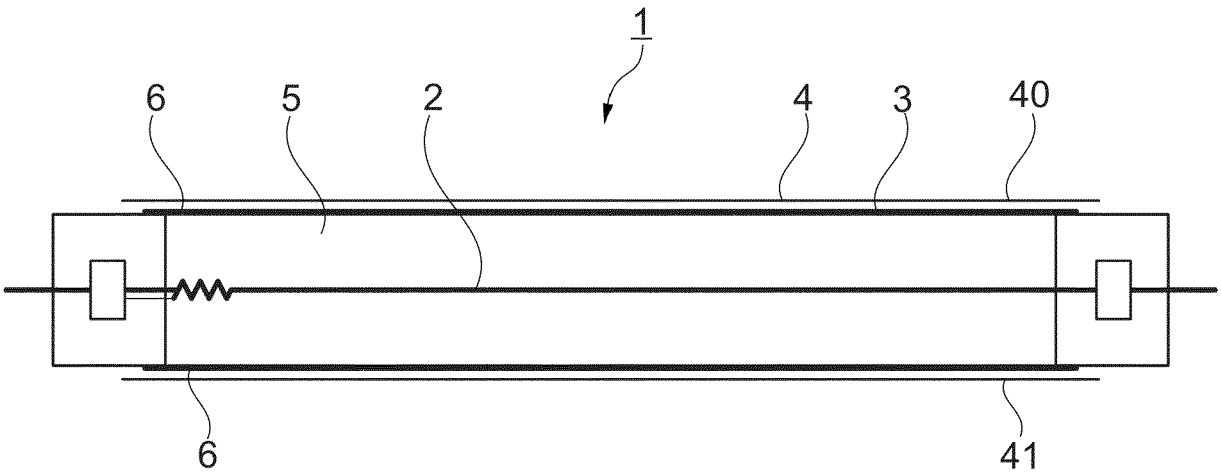

Fig. 1

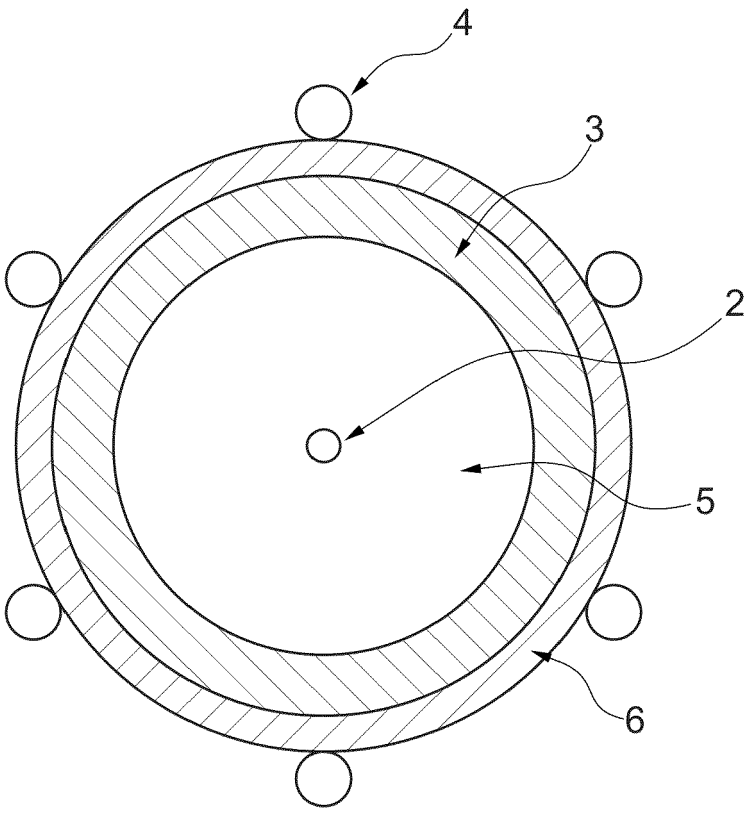

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 4298

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2014/125217 A1 (WEI BEE-YU [TW] ET AL) 8 May 2014 (2014-05-08) * paragraphs [0003], [0033] - [0035]; figure 1D *	1,10,11 1-3,5,6, 8-11	INV. H01J65/04 H01J61/42
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Y	DE 199 42 443 A1 (TOSOH CORP [JP]; NIPPON SILICA GLASS [JP] ET AL.) 9 March 2000 (2000-03-09) * paragraph [0044] *	4	
Y	US 6 343 089 B1 (MANOS DENNIS M [US] ET AL) 29 January 2002 (2002-01-29) * column 4, line 14 - line 26 *	7	
A	JP 2014 182916 A (USHIO ELECTRIC INC) 29 September 2014 (2014-09-29) * paragraphs [0042], [0044]; figure 2 *	1-11	

TECHNICAL FIELDS SEARCHED (IPC)
H01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 April 2019	Zuccatti, Stefano

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- US 6734631 B2 **[0003]**
- US 20050073239 A1 **[0003]**