Title: LED-FILAMENT AND ILLUMINANT WITH LED-FILAMENT

Abstract: This invention relates to a filament lamp (200) with a filament (100) comprising a plurality of light emitting semiconductor chips (110), wherein the light emitting semiconductor chips (110) are electrically connected and are located on a flexible carrier board (120). The filament lamp (200) further comprises a bulb (230) comprising a transparent material, wherein the filament (100) is located within the bulb (230), wherein the bulb (230) is filled with a gas, and wherein the gas is in contact with the filament (100) and wherein the bulb (230) is closed. This invention further relates to a production method of such a filament lamp (200).
LED-FILAMENT AND ILLUMINANT WITH LED-FILAMENT

DESCRIPTION

5 The invention refers to a filament, an illuminant and a production method of an illuminant. Classic filament lamps have a bad degree of efficiency, regarding the transformation of electrical power to optical power. To overcome these efficiency issues, light emitting diodes (LEDs) have been introduced to illuminants. To implement the LEDs and complex heat sink designs, these kinds of illuminants are designed significantly different to the traditional incandescent light bulb design.

10 An assignment of the invention is to provide an illuminant in the form of a filament lamp and a filament with LED technology, allowing for a bent shape of the filament. A further assignment of the invention is to provide a production method for such an illuminant.

15 Solution of these assignments are disclosed in the independent claims of this invention. Preferred embodiments are disclosed in the dependent claims.

20 A filament for a filament lamp comprises a plurality of light emitting semiconductor chips or LEDs. These light emitting semiconductor chips are located on a carrier board and electrically connected. The carrier board is a flexible carrier board. In contrast to the usually used rigid carrier boards, flexible carrier boards allow for a design of the LED filament resembling the classic filament for a filament lamp. Flexible in this context means, that the carrier board can be bent by an angle of above 90°.

25 In one embodiment the filament further comprises a converter which is embodied to convert a wavelength of light emitted from the light emitting semiconductor chips to light of an-
other wavelength. With this approach, white light can be obtained.

In one embodiment the filament comprises a first electrical connector pad and a second electrical connector pad and said electrical connector pads are connected to a contact pin each. These contact pins can then be used to mount the filament into a filament lamp.

In one embodiment the flexible carrier board is a flexible circuit board. Flexible circuit boards are extensively used in modern electronics and thus easily available. Flexible circuit boards exhibit features needed for a filament resembling the classical filament design.

In one embodiment the flexible carrier board comprises metal circuit paths arranged on top of a flexible polymer film. This polymer film particularly contains polyester, polyamide, polyethylene naphthalate, polyetherimide, fluropolymers and copolymers of the aforementioned. These materials are widely used for flexible electric circuit boards and therefore easily available and producible. The thickness of the polymer film can be within the range of 12 to 125 microns. Thinner and thicker materials are also possible.

In one embodiment the filament and thus its flexible carrier board is arranged in a bent shape. This means, that the flexible carrier board is bent by an angle of more than 45 degrees, preferably more than 90 degrees.

In one embodiment the flexible carrier board is arranged in the form of a spiral coil. Arranging the flexible carrier board in the form of a spiral coil leads to a filament closely resembling the traditional filament of a filament lamp.

In one embodiment the light emitting semiconductor chips are arranged linearly and equally spaced with a distance between centres of two adjoining light emitting semiconductor chips
on top of the flexible carrier board. The equally spaced arrangement of the light emitting semiconductor chips leads to a uniform emission of the light of the light emitting semiconductor chips.

In one embodiment the circumference of a winding of the spiral coil differs from an integer multiple of the distance between the centres of the adjoining light emitting semiconductor chips. Therefore, for adjoining windings of the spiral coil, the semiconductor chips are not positioned right next to each other and thus improving the thermal flow of heat from the semiconductor chips.

In one embodiment the circumference of a winding of the spiral coil differs from an integer multiple of the distance between the centres of the adjoining light emitting semiconductor chips by an amount of half this distance. Therefore, for adjoining windings of the spiral coil, a semiconductor chip on the first winding adjoins the middle of the gap between two semiconductor chips of the adjacent second winding. Therefore, the thermal properties of a coil like this are improved and the light emission is more homogenous.

In one embodiment the semiconductor chips on a first winding are located at given rotational angles relating to a centre line of the coil. The semiconductor chips on a second winding are located at rotational angles relating to a centre line of the coil different from the given rotational angles on the first winding.

In one embodiment the semiconductor chips on a first winding are located at given rotational angles relating to a centre line of the coil. The semiconductor chips on a second winding are located at rotational angles relating to a centre line of the coil in a way that the semiconductor chips on the first winding are located at a position on the first winding which corresponds to a position of a centre of a gap between two semiconductor chips on the second winding.
An illuminant comprises a filament according to the invention and a bulb comprising a transparent material. The filament is located within the bulb and the bulb is filled with a gas.

The gas is in contact with the filament and the bulb is closed. With an illuminant like this, the heat produced within the filament can be transported away from the semiconductor chips through the gas which with the bulb is filled. Therefore, a cooling of the semiconductor chips of the filament is possible.

In one embodiment the gas is helium. Helium is a well-suited choice for the gas within the bulb, as the thermal conductivity of helium is high.

In one embodiment the pressure of the gas within the bulb is within the range of 500 to 1200 mbar. With a pressure within these range, optimized heat transfer from the filament is achieved.

A method of production of an illuminant comprises the following steps:

- Providing a flexible carrier board with circuit paths;

- placement of light emitting semiconductor chips on top of the flexible carrier board;

- placement of the flexible carrier board within a transparent bulb;

- filling the bulb with a gas; and

- sealing the gas bulb to prevent leaking of the gas from the bulb. With this production method, an illuminant resembling the classic light bulb design can be achieved.
In one embodiment, the flexible carrier board is arranged in a bent shape. In one embodiment the flexible carrier board is arranged in the form of a spiral coil.

In one embodiment a converter is placed before the flexible carrier board is placed within the bulb. This allows for an easy production of the filament on top of the flexible carrier board before the placement of the filament.

In one embodiment a converter is placed after the flexible carrier board is brought to its final shape, particularly by a spray coating process. This allows for an easy process to obtain a filament resembling the traditional filament of a traditional light bulb.

The above described properties, features and advantages of this invention as well as the method of obtaining them, will be more clearly and more obviously understandable in the context of the following description of the embodiments, which are explained in more detail in the context of the figures.

In schematic illustration show

Fig. 1   a top view of a filament;

Fig. 2   a cross section of a filament;

Fig. 3   a cross section of a filament with converter and contact pins;

Fig. 4   a cross section of a bent filament;

Fig. 5   a top view of a filament arranged in the form of a spiral coil;

Fig. 6   a top view of another filament arranged in the form of a spiral coil;
Fig. 7 a top view of a third embodiment of a filament arranged in the form of a spiral coil; and

Fig. 8 a light bulb with such a filament.

Fig. 1 shows a top view of a filament 100 for a filament lamp. The filament 100 comprises a plurality of light emitting semiconductor chips 110, which are located on a flexible carrier board 120. The light emitting semiconductor chips 110 are electrically connected by contact areas 130.

Fig. 2 shows a cross section of the filament 100 of Fig. 1. The semiconductor chips 110 comprise a first electrical contact pad 111 and a second electrical contact pad 112 on a side of the semiconductor chip 100 facing the flexible carrier board 120. The contact areas 130 are formed in a way, that the contact areas 130 connect the second electrical contact pad 112 of a semiconductor chip 110 with the first electrical contact pad 111 of an adjoining semiconductor chip 110. Therefore, the semiconductor chips 110 are serially coupled.

Depending on the used embodiment also another way of electrically connecting the semiconductor chips 110 may be used. For example at least some of the semiconductor chips 110 may be connected in parallel.

The filaments 100 of the figs. 1 or 2 can comprise contact pads electrically connected to the contact areas 130. These contact pads can be used to electrically connect the filament 100 to an external voltage- or current-source. The connection to the external source can be established via a spot-welding, a soldering or a gluing process. If a gluing process is used, it is advantageous to use an electrically conductive glue.

Fig. 3 shows a cross section through a filament 100 with the features of the filament of the Fig. 2. Additionally, the semiconductor chips 110 are arranged within a conversion layer 140. This conversion layer 140 is capable of converting a
wavelength of light emitted from the light emitting semiconductor chips 110 to light of another wavelength. Therefore, for instance white light can be achieved. On the left hand side and the right hand side of the flexible circuit board 120 two contact pins 150 are located, which are in electrical contact with the contact areas 130. These contact pins 150 can be used to mount the filament 100 within a bulb.

It is also possible to just implement the conversion layer 140 without the contact pins 150 and vice versa.

Alternatively to this embodiment, it is possible that a converter is placed on top of the semiconductor chips 110 individually before the placement of the semiconductor chips 110 on top the flexible carrier board 120 or after the placement of the semiconductor chips 110 on top of the flexible carrier board 120. Additionally, a second conversion layer in the form of the conversion layer 140 of Fig. 3 is possible.

In one embodiment the flexible carrier board 120 is a flexible circuit board 120. The flexible circuit board consists of metal circuit paths, which are the contact areas 130. The bulk material of the flexible circuit board 120 is a flexible polymer film. This polymer film can contain polyester (PET), polyamide (PI), polyethylene naphthalate (PEN), polyetherimide (PEI), fluoropolymers (FEP) and copolymers of the aforementioned. The thickness of the flexible circuit board 120 can be within the range of 12 microns to 125 microns.

In one embodiment the flexible carrier board 120 comprises a flexible material and supports the semiconductor chips 110. The electrical connection of the semiconductor chips 110 is established using bond wires.

Fig. 4 shows the filament 100 of Figs. 1 and 2 with additional contact pins 150. The flexible carrier board 120 is arranged in a bent shape, constituting three quarters of a full circle. The light emitting semiconductor chips 110 are locat-
ed on the outside of this three quarter circle. This filament 100 more closely resembles the filament traditionally used in filament bulbs, allowing for an illuminant with increased overall similarity to this traditional light bulb. Also other shapes like wavelike shapes, zigzag shapes or semicircles are possible and more closely resemble the filament traditionally used in filament bulbs.

The contact pins 150 can be used to electrically connect the filament 100 to an external voltage- or current-source. The connection to the external source can be established via a spot-welding, a soldering or a gluing process. If a gluing process is used, it is advantageous to use an electrically conductive glue.

Fig. 5 shows a top view of a filament 100 with many light emitting semiconductor chips 110 on top of a flexible carrier board 120. The flexible carrier board 120 is arranged in the form of a spiral coil. This coil consists of five windings 121, 122, 123, 124, 125. It is also possible to design a spiral coil with fewer or more windings. The first winding 121 and the second winding 122 are next to each other. The circumference of a winding 121, 122, 123, 124, 125 of the spiral coil of the filament 100 is similar to an integer multiple of the distance between the centres of two adjoining light emitting semiconductor chips 110. Therefore, the semiconductor chips 110 are on the same position for each winding 121, 122, 123, 124 and 125. This filament 100 more closely resembles the classic filament of a classic light bulb.

Fig. 6 shows a top view of a filament in the form of a spiral coil basically similar to the filament shown in Fig. 5. In contrast to the filament 100 shown in Fig. 5, the circumference of a winding 121, 122, 123, 124, 125 of the spiral coil formed by the flexible carrier board 120 differs from an integer multiple of the distance between the centres of the adjoining light emitting semiconductor chips 110. Therefore, the position of the light emitting semiconductor chips 110 is
different for each winding indicated by dash lines throughout the filament 100. Using this approach, the thermal properties of the filament are improved.

Fig. 7 shows a top view of a third filament 100 in the form of a spiral coil with basically the properties of Figs. 5 and 6. For the spiral coil of the filament of Fig. 7, the circumference of a winding 121, 122, 123, 124, 125 differs from an integer multiple of the distance between the centres of the adjoining light emitting semiconductor chips 110 by an amount of half this distance. This means, that on the first winding 121 a first semiconductor chip 113 is located. At this position, the second winding 122 exhibits the middle of the gap between a second semiconductor chip 114 and a third semiconductor chip 115. A fourth semiconductor chip 116 on the third winding on the other hand is located at this very spot again. This distance relation also holds true for the other semiconductor chips 110 of the filament 100. This leads to a filament 100 with optimized thermal properties.

Fig. 8 shows an illuminant with a filament 100, which is one of the filaments of Figs. 5 to 7. It is also possible, but not shown in Fig. 8, that the filament 100 is similar to one of the filaments depicted in Figs. 1 to 4. The filament 100 is connected to a socket 240 with a first contact wire 210 and a second contact wire 220 which are in electrical contact only via the filament 100. Around the filament and attached to the socket 240 a bulb 230 is placed. The bulb 230 and the socket 240 form a closed entity, which is filled with a gas. This gas therefore is in thermal contact with the filament 100 and leads to thermal conductivity from the filament 100 to the bulb 230.

In one embodiment the gas within the bulb 230 is helium. In one embodiment the gas within the bulb 230 has a pressure within the range of 500 to 1200 mbar.
A method of production of an illuminant according to Fig. 8 comprises the following steps:

- Providing a flexible carrier board 120 with circuit paths 130;
- placement of light emitting semiconductor chips 110 on top of the flexible carrier board 120;
- placement of the flexible carrier board 120 within a transparent bulb 230;
- filling the bulb 230 with a gas; and
- sealing the gas bulb 230 to prevent leaking of the gas from the bulb 230.

The last sealing process can be performed by implementing a socket 240 to the bulb 230. Another possibility is to connect the bulb 230 to the socket 240.

In one embodiment the flexible carrier board 120 is arranged in a bent shape within the bulb 230. In one embodiment the flexible carrier board 120 is arranged in the form of a spiral coil.

In one embodiment a converter is placed on top of the flexible carrier board 120 before the flexible carrier board 120 is placed within the bulb 230. In one embodiment a converter is placed after the flexible carrier board 120 is brought to its final shape, particularly by a spray coating process. In this case, it is possible to place the converter after the spiral coil is formed.

Although the invention was described and illustrated in more detail using preferred embodiments, the invention is not limited to these. Variants of the invention may be derived by a
person skilled in the art from the described embodiments without leaving the scope of the invention.
REFERENCE NUMERALS

100 filament
110 semiconductor chip
5 111 first electrical contact pad
112 second electrical contact pad
113 first semiconductor chip
114 second semiconductor chip
115 third semiconductor chip
10 116 fourth semiconductor chip
120 flexible carrier board
121 first winding
122 second winding
123 third winding
15 124 fourth winding
125 fifth winding
130 contact area
140 conversion layer
150 contact pin
20 200 illuminant
210 first contact wire
220 second contact wire
230 bulb
240 socket
CLAIMS

1. A filament (100) for a filament lamp comprising a plurality of light emitting semiconductor chips (110), wherein the light emitting semiconductor chips (110) are located on a carrier board, wherein the light emitting semiconductor chips (110) are electrically connected, characterized in that the carrier board is a flexible carrier board (120).

2. The filament (100) according to claim 1, further comprising a converter (140), wherein the converter (140) is embodied to convert a wavelength of light emitted from the light emitting semiconductor chips (110) to light of another wavelength.

3. The filament (100) according to any one of the claims 1 or 2, wherein the filament (100) comprises a first electrical connector pad and a second electrical connector pad, and wherein the electrical connector pads are connected to a contact pin (150) each.

4. The filament (100) according to any one of the preceding claims, wherein the flexible carrier board (120) is a flexible circuit board.

5. The filament (100) according to any one of the preceding claims, wherein the flexible carrier board comprises metal circuit paths arranged on top of a flexible polymer film, the polymer film particularly containing polyester (PET), polyimide (PI), polyethylene naphthalate (PEN), Polyetherimide (PEI), fluropolymers (FEP) and copolymers of the aforementioned.

6. The filament (100) according to any one of the previous claims, wherein the flexible carrier board (120) is arranged in a bent shape.
7. The filament (100) according to claim 6, wherein the flexible carrier board (120) is arranged in the form of a spiral coil.

8. The filament (100) according to claim 7, wherein the light emitting semiconductor chips (110) are arranged linearly and equally spaced with a distance between centres of two adjoining light emitting semiconductor chips (110).

9. The filament (100) according to claim 7 or 8, wherein the semiconductor chips (110) on a first winding (121) are located at given rotational angles relating to a centre line of the coil and wherein the semiconductor chips (110) on a second winding (122) are located at rotational angles relating to a centre line of the coil different from the given rotational angles on the first winding (121).

10. The filament (100) according to any one of the claims 7 to 9, wherein the semiconductor chips (110) on a first winding (121) are located at given rotational angles relating to a centre line of the coil and wherein the semiconductor chips (110) on a second winding (122) are located at rotational angles relating to a centre line of the coil in a way that the semiconductor chips (110) on the first winding (121) are located at a position on the first winding (121) which corresponds to a position of a centre of a gap between two semiconductor chips (110) on the second winding (122).

11. The filament (100) according to claim 9, wherein the circumference of a winding of the spiral coil differs from an integer multiple of the distance between the centres of the adjoining light emitting semiconductor chips (110) by an amount of half the distance between the centres of the adjoining light emitting semiconductor chips (110).
12. An illuminant (200) with a filament (100) according to any one of the preceding claims, a bulb (230) comprising a transparent material, wherein the filament (100) is located within the bulb (230), wherein the bulb (230) is filled with a gas, and wherein the gas is in contact with the filament (100) and wherein the bulb (230) is closed.

13. The illuminant according to claim 11, wherein the gas is helium.

14. The illuminant according to any one of the claims 11 or 12, wherein a pressure of the gas within the range of 500 to 1200 millibar.

15. A method of production of an illuminant according to any one of the claims 11 to 13, comprising the steps:
   - providing a flexible carrier board with circuit paths;
   - placement of light emitting semiconductor chips on top of the flexible carrier board;
   - placement of the flexible carrier board within a transparent bulb;
   - filling the bulb with a gas; and
   - sealing the gas bulb to prevent leaking of the gas from the bulb.

16. The method according to claim 14, wherein the flexible carrier board is arranged in a bend shape.

17. The method according to claim 14 or 15, wherein the flexible carrier board is arranged in the form of a spiral coil.

18. The method according to any one of the claims 14 to 16, wherein a converter is placed before the flexible carrier board is placed.
19. The method according to any one of the claims 15 to 16, wherein a converter is placed after the flexible carrier board is brought to its final shape, particularly by a spray coating process.
**INTERNATIONAL SEARCH REPORT**

**PCT/EP2016/052341**

### A. CLASSIFICATION OF SUBJECT MATTER

INV. F21K9/232 F21K9/90
ADD. F21Y103/10 F21Y107/70 F21Y115/10 F21Y110/90

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F21K F21V F21Y

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search: 29 September 2016

Date of mailing of the international search report: 10/10/2016

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