

**Component with a reflector layer
and method for producing the same**

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The present invention relates to a component with a reflector layer, comprising a base body of quartz glass having a surface that is covered at least in part with a reflector layer.

Moreover, the present invention relates to a method for producing such a
10 component with a reflector layer by covering the surface of a base body of quartz glass at least in part with a reflector layer.

Quartz glass is characterized by a low coefficient of expansion, by optical
transparence over a wide wavelength range and by high chemical and thermal
resistance. Quartz glass components are used for many applications, e.g. in lamp
15 manufacture as cladding tubes, bulbs, cover plates or reflector carriers for lamps and radiators in the ultraviolet, infrared and visible spectral range. For obtaining special characteristics quartz glass is doped with other substances.

In lamp manufacture, time constancy and efficiency of the emitted operative
radiation often play an important role. To minimize radiation losses, optical
20 radiators are provided with a reflector. The reflector is firmly connected to the radiator, or it is a reflector component separated from the radiator. The surfaces of high-quality reflectors which can be used in a chemically aggressive environment without damage to the reflector and without a noticeable decrease in reflectivity are made of gold.

25 A generic component in the form of an infrared irradiator equipped with a gold reflector is known from DE 40 22 100 C1. The infrared irradiator serves as a surface irradiator and is composed of a plurality of adjacently arranged lamp tubes of quartz glass that are mounted on a joint carrier plate of quartz glass, each having a heating coil extending therein. The top side of said lamp tube
30 arrangement forms the irradiation surface of the infrared surface irradiator. The

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free bottom side of the oppositely arranged carrier plate of quartz glass is provided with a reflector layer of gold.

DE 198 22 829 A1 describes a short-wave infrared radiator in which the lamp tube is configured in the form of a so-called twin tube. A cladding tube of quartz glass is
5 here divided by a longitudinal web into two partial sections extending in parallel with one another, a heating coil extending in one or in both sections. The side of the twin tube that faces away from the main irradiation direction of the IR radiation is coated with a gold layer which serves as a reflector.

Reflective layers of gold are however expensive and only resistant to a limited
10 degree to temperatures and temperature variations.

To reduce transmission or to change the transmitted light wave spectrum, it is known to mat lamp bulbs, e.g. by etching with acid or by coating the lamp bulb in the interior with a particulate light-scattering powder, such as a mixture of clay and silica.

15 It is therefore the object of the present invention to provide a component, particularly for use in lamp and reflector production, which is equipped with an efficient, chemically and thermally resistant and, nevertheless, inexpensive reflector layer.

Furthermore, it is the object of the present invention to provide a method for
20 producing such a component.

As for the component, this object starting from the above-described quartz glass component is achieved according to the invention by providing an SiO₂ cover layer which acts as a diffuse reflector and consists of at least partly opaque quartz glass.

25 In the quartz glass component of the invention, the reflector layer consists of at least partly opaque quartz glass. The SiO₂ cover layer covers the base body either wholly or in part and acts as a diffuse optical reflector. It is made completely or for the greatest part from doped or undoped SiO₂.

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The quartz glass component is preferably used in lamp and reflector manufacture, and it is present in the form of a tube, bulb, a chamber, shell, spherical or ellipsoidal segment, plate, heat shield, or the like. The quartz glass component is either part of an optical radiator with integrated reflector, said reflector being
5 formed by the SiO_2 cover layer, or the component forms a separate reflector and is used in combination with an optical radiator.

The base body is a body of quartz glass which is made from synthetically produced or from naturally occurring raw materials. The quartz glass of the base body is transparent as a rule.

10 It has been found that a cover layer consisting of at least partly opaque quartz glass has a reflectivity that is adequate for most applications. The SiO_2 cover layer is characterized by an excellent chemical and thermal resistance and mechanical strength. Particular reference should be made to the high resistance to heat shocks of the SiO_2 cover layer on the base body of quartz glass.

15 Furthermore, the SiO_2 cover layer can be produced at low costs. A suitable procedure will be explained in more detail further below. The surface of the base body which is provided as the reflector has applied thereto a layer of a slip containing SiO_2 particles, from which the SiO_2 cover layer is obtained by subsequent drying and vitrification. Attention must be paid during vitrification that
20 the SiO_2 cover layer remains opaque at least in part so that an adequate reflectivity is maintained.

It has turned out to be advantageous when the SiO_2 cover layer consists of material that is generic with regard to the material of the base body.

"Generic material" means in this context that the SiO_2 contents of cover layer and
25 base body differ by not more than 10% by wt., preferably not more than 3% by wt. from one another. This yields a particularly high adhesion of the cover layer to the base body and, in particular, a high resistance of the composite to thermal shocks.

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In a preferred embodiment of the quartz glass component of the invention, the base body is designed as a cladding body of quartz glass for receiving a radiation emitter.

5 In this case the cladding body of quartz glass envelopes a radiation emitter, such as a heating coil, a carbon ribbon or a radiation-emitting gas filling, and at the same time part of the cladding body is provided with the SiO₂ cover layer acting as the reflector.

10 In a first preferred variant of the component of the invention, the SiO₂ cover layer is provided on the outside of the cladding body that faces away from the radiation emitter.

This prevents impairment of the radiation emitter or of the atmosphere inside the cladding body.

15 In a second, equally preferred variant of the component of the invention, the SiO₂ cover layer is provided on the inside of the cladding body which is oriented towards the radiation emitter.

20 The reflector layer provided on the inside is directly adjacent to the radiation emitter, so that absorption losses due to the material of the cladding body are avoided. It is often easier to apply the cover layer on the inside of the cladding body than on the outside, and said layer is particularly protected by the cladding body against mechanical damage.

25 The following explanations refer to a particularly preferred embodiment of the component of the invention, in which the at least partly opaque SiO₂ contains a dopant which in the ultraviolet, visible or infrared spectral range produces an optical absorption, thereby accomplishing a selective reflection of the reflector layer.

The SiO₂ cover layer contains one or several dopants that are causing a selective reflection of the reflector layer. To this end a dopant is used that in the ultraviolet, visible and/or infrared spectral range produces one or several absorption lines in quartz glass. As a consequence, the light wave spectrum reflected by the reflector

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layer does not contain a portion of the absorbed radiation any more. In this respect the reflector layer also acts as a filter and can thereby substitute or supplement an otherwise necessary filtering measure, such as doping of the quartz glass of the base body or a coating with a filter material.

- 5 The selectively reflecting SiO_2 cover layer within the meaning of the invention can be produced at low costs via a slip method by means of the method described further below. For the production of a reflector having a wavelength-selective action one or more dopants or a preliminary product from which the dopant is formed in the course of processing is added to the slip or the porous SiO_2 cover
10 layer (prior to vitrification).

A preferred embodiment of the component of the invention with the selectively acting reflector layer is distinguished in that the SiO_2 cover layer has a reflection coefficient of at least 0.3 in the wavelength range of 200 nm to 300 nm, and that the dopant produces an optical absorption line in the wavelength range above 300
15 nm.

This embodiment is particularly suited for applications where the reflected operative radiation from the ultraviolet spectral range is to be freed completely or in part of portions of the visible or infrared spectral range, for instance, in order to prevent heating up of an article irradiated with UV radiation by IR radiation.

- 20 Reflection coefficient means the intensity ratio of the radiation vertically impinging on the reflectors to the reflected radiation. An Ulbricht ball is suited for the measurement of the diffusely reflecting radiation.

In an alternative, but equally preferred, variant of the component with selectively acting reflector layer, it is intended that the SiO_2 cover layer in the wavelength
25 range of 400 nm to 800 nm has a reflection coefficient of at least 0.3, and that the dopant produces an optical absorption line in the infrared wavelength range above 1000 nm.

This embodiment of the optical component of the invention with selectively acting reflector layer is particularly suited for applications where the reflected operative

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radiation from the visible spectral range is to be freed completely or in part of portions from the infrared spectral range, for instance, to prevent heating up of lamps or parts thereof, such as electrodes or the like, by IR radiation.

5 The dopant which in quartz glass absorbs in the infrared spectral range preferably comprises one or more of the following substances: hydroxyl groups, V, Yb, Eu, Nd.

To absorb a larger intensity and wavelength portion of the IR radiation in the reflector material, the SiO₂ cover layer advantageously contains several dopants of said group.

10 In a further preferred variant of the component, it is intended that the SiO₂ cover layer in the wavelength range of 1000 nm to 2000 nm has a reflection coefficient of at least 0.3, and that the dopant produces an optical absorption line in the ultraviolet wavelength range between 150 nm and 400 nm.

15 This embodiment of the optical component of the invention with selectively acting reflector layer is particularly intended for applications where the operative radiation in the IR range due to the reflection on the selectively reflecting layer is to be freed completely or in part of portions from the ultraviolet range, for instance, in order to prevent a possible harmful UV portion of the IR light spectrum in the case of radiant heaters in the medical, private or industrial sector.

20 In a further preferred variant of the component of the invention with selectively acting reflector layer, the SiO₂ cover layer in the wavelength range of 400 nm to 800 nm has a reflection coefficient of at least 0.3, and the dopant produces an optical absorption line in the ultraviolet wavelength range between 150 nm and 400 nm.

25 This embodiment is particularly intended for applications where the reflected operative radiation from the visible spectral range is to be freed completely or in part of portions from the ultraviolet spectral range; for instance, in luminescent means, such as halogen emitters in which an UV portion that might be harmful to health is to be removed from the visible light spectrum.

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The dopant which in the quartz glass of the SiO₂ cover layer absorbs UV radiation is preferably selected from the group consisting of Ti, Fe, Ce.

To absorb a major intensity or wavelength portion of the UV radiation in the reflector material, the SiO₂ cover layer advantageously contains several dopants
5 of said group.

In a further preferred variant of the component of the invention with selectively acting reflector layer, the SiO₂ cover layer in the wavelength range of 600 nm to 800 nm has a reflection coefficient of at least 0.3, the dopant producing an optical absorption line in the visible wavelength range between 300 nm and 600 nm.

10 This embodiment is particularly adapted to applications where the selected operative radiation from a first, more long-wave range of the visible spectrum is to be freed completely or in part of portions from a second, more short-wave range of the visible spectral range.

The SiO₂ cover layer appears colored in this embodiment due to the filtering of
15 portions of the visible light spectrum by selective reflection. This permits a colored design of the quartz glass component. For instance, the quartz glass appears red if only or mainly red portions of the impinging light spectrum are reflected and the more short-wave portions of the visible light are absorbed completely or in part in the reflector material.

20 A suitable dopant for the absorption in the short-wave range of the visible spectral range is e.g. Cu or Sm.

Inversely, it is of advantage to other optical applications when the reflected operative radiation from a more short-wave range of the visible spectrum, for instance 300 nm to 400 nm, is freed completely or in part of portions from a more
25 long wave visible spectral range, for instance above 400 nm. This is e.g. possible by means of the component according to the invention by doping the reflector material with Nd.

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In a particularly preferred embodiment of the component according to the invention with selectively acting reflector layer, the SiO₂ cover layer contains nanoscale crystalline particles.

- On account of their size and composition, the nanoscale crystalline particles
- 5 produce special optical effects, such as scattering, polarization, or absorption. They are added to the slip in the manufacture of the SiO₂ cover layer and they do not fuse during sintering or vitrification of the slip layer.

Preferably, the nanoscale crystalline particles are diamond or are carbon nanotubes.

- 10 These are high-melting carbon modifications which are chemically inert in the quartz glass. Carbon nanotubes are microscopically small tubular structures.

The optical effects of the nanoscale crystalline particles are enhanced if the SiO₂ cover layer comprises transparent regions. The remaining opacity of the SiO₂ cover layer is here fully or partly due to the added nanoscale crystalline particles.

- 15 The thicker the SiO₂ cover layer is made, the more completely is the reflection of the radiation carried out. However, it is difficult to produce layer thicknesses of more than 3 mm, and the additional effect of the increased layer thickness is hardly noticeable any more. SiO₂ cover layers having thicknesses below 0.1 mm require a high concentration of the dopant, which may change the physical and
- 20 chemical properties of the quartz glass of the cover layer in a disadvantageous manner.

Succeeding layers with different optical properties can achieve special effects, for instance antireflection or also different absorption curves inside the SiO₂ cover layer.

- 25 As for the method, the above-indicated object starting from the above-mentioned method is achieved according to the invention in that a slip containing amorphous SiO₂ particles is produced and applied to the surface of the base body with formation of a slip layer, the slip layer is dried and is then vitrified forming the SiO₂ cover layer.

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In the method of the invention, the base body of quartz glass is provided by means of a slip casting method with a cover layer of SiO_2 . A special technical challenge is that any tearing of the slip layer is avoided during drying or vitrification, though the volume of the layer is shrinking, without the quartz glass of
5 the base body being able to yield accordingly.

To this end a castable slip is first produced that contains amorphous SiO_2 particles. The slip is applied as a "slip layer" to the base body and is subsequently dried and vitrified. Due to interactions among one another the amorphous SiO_2 particles already stabilize the slip layer in the pasty and dry state and they
10 promote the sintering action, which permits the sintering of the dried slip layer at a comparatively low temperature with formation of a dense and crack-free SiO_2 cover layer.

The SiO_2 particles consist of synthetically produced SiO_2 or of purified and naturally occurring raw material, as is e.g. described in DE 44 40 104 C2.

15 Apart from the amorphous SiO_2 particles, the slip may also contain precursor components for the formation of SiO_2 particles. These are hydrolyzable silicon compounds as are used in sol-gel methods for producing SiO_2 . Such precursor components form molecular bonds in the slip layer due to their hydrolysis, they effect a consolidation, thereby facilitating sintering. On the other hand, however,
20 high concentrations of them lead to high shrinkage in drying, and they may contribute to the formation of cracks, which limits the amount of such precursor components in the slip.

Particle size and distribution of the SiO_2 particles have effects on the drying shrinkage of the slip layer. For instance, the shrinkage in drying can be reduced
25 by using coarse SiO_2 particles.

The drying of the slip layer is carried out by removing moisture at room temperature, by heating or by freeze drying. After drying the slip layer is vitrified in that it is heated to a high temperature that leads to a sintering of the SiO_2 particles and to the formation of a dense and crack-free cover layer of opaque or partly

opaque quartz glass, which covers the whole surface of the base body, or part thereof.

With the method of the invention it is possible to produce SiO₂ cover layers having a high density, so that said method offers a preferred possibility of producing the reflector layer from at least partly opaque SiO₂.

For the formation of the cover layer SiO₂ particles are preferably used that have a particle size in the range of up to not more than 500 µm, preferably of up to not more than 100 µm, SiO₂ particles with particle sizes in the range between 1 µm and 50 µm accounting for the greatest volume fraction.

SiO₂ particles in this order of magnitude show an advantageous sintering behavior and a comparatively low shrinkage in drying. It has been found that in such a slip the slip layer can be dried and vitrified in a particularly easy way without the formation of cracks. This may be due to a sufficiently low shrinkage in drying and to interactions of the SiO₂ particles with one another that may even lead to the formation of molecular SiO₂ bonds and facilitate drying and sintering.

This is promoted by the polar nature of the aqueous phase of the slip and by a procedure in which the SiO₂ particles are produced by wet milling SiO₂ starting grains.

The desired particle size distribution is here adjusted by the homogenization process of the slip. Starting from comparatively coarse grains with diameters ranging e.g. between 200 µm and 5000 µm, the SiO₂ particles are reduced in size during homogenization, depending on their degree of consolidation. Wet milling creates SiO₂ particles of any size within the aqueous slip, i.e. also those that, interacting with one another, form the above-described bonds already in the slip, which improves the stability of the slip layer.

The cristobalite amount in the dried SiO₂ slip layer should be not more than 1% by wt. because, otherwise, crystallization might occur during vitrification of the slip layer, which may lead to waste of the component. What is here essential is the use of SiO₂ particles that are amorphous from the start.

For the application of the slip layer, the methods known per se, such as spraying, electrostatically supported spraying, flow coating, spinning, dipping or application by a brush, have turned out to be useful. Preferably, however, the slip layer is formed by dipping.

- 5 A previous roughening of the base body surface can improve the adhesion of both the slip layer and the dense SiO₂ cover layer produced therefrom by vitrification.

The risk of crack formation during vitrification can also be reduced through a suitable temperature control. Preferably, the vitrification of the dried slip layer is carried out at a comparatively low maximum temperature in the range between
10 1000°C and 1600°C, preferably between 1100°C and 1400°C. In a particularly preferred variant of the method, the dried slip layer is vitrified in a hydrogen atmosphere.

Due to its high diffusion rate in quartz glass, hydrogen is particularly suited for a heat transmission. A high heat transmission has the effect that a temperature
15 gradient that is as flat as possible is formed between the high temperature prevailing on the surface and the lower temperature inside the SiO₂ cover layer or the portion that has not been vitrified yet. Even at low vitrification temperatures the progress of the melt front from the outside to the inside and thus a vitrification also of inner portions of the slip layer are thereby ensured. A hydrogen content of at
20 least 70% is sufficient therefor. Apart from hydrogen, the atmosphere during vitrification may e.g. also contain nitrogen, and preferably helium.

If the heat action during vitrification is to be short in time and substantially limited to the portions that are covered with an SiO₂ slip layer to be vitrified, a burner flame or a laser may also be used for vitrification. Plastic deformations of the
25 component can thereby be avoided to a large extent.

The thickness of the SiO₂ cover layer can be reinforced in successive steps by carrying out the method of the invention repeatedly.

Furthermore, it has turned out to be useful when dopants are added to the slip in the form of compounds containing aluminum, nitrogen or carbon.

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In this variant of the method, a dopant or several dopants are introduced into the SiO₂ cover layer, the dopants giving the quartz glass a specific property, such as a decrease in absorption and thus an improved reflection.

For instance, an addition of aluminum in the quartz glass of the cover layer forms Al₂O₃ which enhances the stiffness of the glass structure and thus the temperature resistance of the cover layer and also changes the refractive index. Suitable start substances are distributed in the slip in a particularly uniform manner, which in the end results in a homogeneous doping of the quartz glass of the cover layer.

The SiO₂ cover layer produced in this way is characterized by high adhesion to quartz glass and can easily be modified in its properties by simply changing the method, e.g. the vitrification temperature or the addition of dopants, and can be adapted to many concrete applications.

For producing a selectively acting reflector layer, as explained above with reference to the component of the invention, at least one dopant is preferably introduced into the slip, the dopant producing an optical absorption in quartz glass in the ultraviolet, visible or infrared spectral range, thereby effecting a selective reflection of the reflector layer.

The dopant is evenly distributed in the slip, which results in the final analysis in a particularly homogeneous doping of the quartz glass of the cover layer. However, it is also possible to introduce the dopant into the liquid, dried or pre-sintered slip layer as long as said layer is not porous yet.

The invention shall now be explained in more detail with reference to embodiments and a drawing. The drawing shows in detail in

Fig. 1 a schematic illustration of a reflector plate of quartz glass with a reflector layer in the form of an SiO₂ cover layer, viewed in cross section;

Fig. 2 a schematic illustration of an infrared radiator in the form of a twin-tube radiator with a cladding tube, whose upper side is partly covered with a slip layer or a reflector layer;

Fig. 3 shows a heating profile for vitrifying a slip layer on a base body of quartz glass;

Fig. 4 a reflection curve for an SiO_2 cover layer doped with cerium praseodym aluminate; and

5 **Fig. 5** a diagram with several reflection curves for comparison.

Example 1

A homogeneous base slip is produced. For a batch of 10 kg base slip (SiO_2 water slip) 8.2 kg of amorphous quartz glass grains of natural raw material with grain sizes ranging from 250 μm to 650 μm are mixed with 1.8 kg deionized water of a conductivity of less than 3 μS in a drum mill lined with quartz glass and having a volume contents of about 20 l. The quartz glass grains were purified in a hot chlorination method before. Attention is paid that no cristobalite is contained.

This mixture is ground by means of milling balls of quartz glass on a roller block at 23 rpm for three days to such a degree that a homogeneous base slip is formed with a solids content of 79%. In the course of the grinding process the pH value is lowered to a pH of about 4 due to the dissolving SiO_2 .

Further amorphous SiO_2 grains in the form of spherical particles with a grain size of about 5 μm are admixed to the resulting homogeneous and stable base slip until a solids content of 84% by wt. is obtained. This mixture is homogenized in a drum mill at a speed of 25 rpm for 12 hours. The resulting slip has a solids content of 84% and a density of about 2.0 g/cm^3 . The SiO_2 particles obtained in the slip after milling of the quartz glass grains have a particle size distribution characterized by a D_{50} value of about 8 μm and by a D_{90} value of about 40 μm . This slip is dilatant. The rheological property of the slip, which is designated as "dilatancy", becomes apparent in that the viscosity thereof increases with the shear rate. This has the effect that in the absence of shear forces, i.e. after application of the slip as a slip layer to the component of quartz glass, the viscosity increases, which facilitates the formation of a uniform slip layer.

A quartz glass plate from which a reflector plate is to be produced for an IR radiator is immersed into the slip for a few seconds. The surface of the quartz glass plate was cleaned in alcohol before and adjusted by chemical etching (deep freezing) to a mean surface roughness R_a of 2 μm .

- 5 A uniform, continuous slip layer having a thickness of about 2.5 mm is formed on the quartz glass plate. This slip layer is first dried at room temperature for about five hours and subsequently by means of an IR radiator in air. The dried slip layer is free from cracks and has a mean thickness of slightly less than 2.2 mm.

- 10 The slip layer produced and dried in this way is then vitrified in air in a sintering furnace. The heating profile comprises an initially steep heating ramp while the slip layer is heated from room temperature within one hour to a lower heating temperature of 1000°C. The slip layer is kept at the lower heating temperature for one hour and is then heated through a second flat heating ramp for four hours to an upper heating temperature of 1350°C. The holding time at the upper heating
15 temperature is two hours in the embodiment. Subsequently, the slip layer is completely sintered, it is opaque and without bubbles as far as can be seen with the naked eye.

- The subsequent cooling process takes place in the furnace in air down to a temperature of 500°C at a controlled cooling rate of 15°C/min and then in the still
20 closed state of the furnace by way of free cooling.

- The resulting reflector plate is schematically shown in **Fig. 1**. It consists of the quartz glass plate 8 having the dimensions 300 mm x 300 mm x 2 mm, whose flat sides are fully covered with an SiO_2 cover layer 9 which consists of opaque quartz glass and has a mean layer thickness of about 2 mm, and which is characterized
25 by freedom from cracks and by a high density of about 2.15 g/cm³. The SiO_2 cover layer 9 in Fig. 1 is drawn with an exaggerated thickness for reasons of illustration.

This reflector plate is thermally resistant up to temperatures above 1100°C and is e.g. suited as a substitute for reflector plates of molybdenum, which are otherwise used for such high-temperature applications.

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Instead of the formation of an opaque SiO_2 cover layer at both sides, the quartz glass plate may also be provided with such a layer at one side. The slip layer is preferably applied here by spraying instead of the above-described dipping.

5 The SiO_2 cover layer 9 effects a diffuse undirected reflection on phase boundaries. Due to a curved or arched geometry of the component, as is otherwise also usual in reflectors, a directed portion can be applied to the diffuse reflection.

Example 2

10 A base slip is produced, as described with reference to Example 1, the slip being used for producing a reflector layer on a cladding tube for an infrared radiator in the form of a so-called "twin tube" of quartz glass.

15 Such a twin tube is schematically shown in Fig. 2. This tube consists of a cladding tube 1 of quartz glass which is in the form of an 8 when viewed in cross section, the tube being subdivided by a central web 2 into two sections 3, 4. Each of the sections 3, 4 serves to receive a heating coil, the electrical connections being guided out of the cladding tube 1 via crimps provided at the ends (not shown in Fig. 2). The main radiation direction of the twin tube 9 is oriented downwards in the embodiment and symbolized by the directional arrow 5.

20 A reflector is to be formed on the upper side 6 of the twin tube 9 which is oriented away from the main radiation direction 5. To this end the surface of the twin tube 9 is cleaned by means of alcohol and then in 30% hydrofluoric acid for eliminating other surface impurities, e.g. alkali and alkaline-earth compounds.

25 The base slip is subsequently applied to the upper side 6 of the cladding tube 1. To this end the cladding tube 1 is mounted on a mounting device and the free-flowing slip is sprayed to the upper side 6 by means of a spray nozzle. The spraying operation will be terminated as soon as a uniform coating has been achieved. The slip dries in air very rapidly. The layer thickness of the slip layer 7 produced in this way is about 1 mm.

The slip layer 7 is then slowly dried by resting in air for 6 hours. Complete drying is accomplished in air using an IR radiator. The dried slip layer 7 is without any cracks, and it has a maximum thickness of about 0.9 mm.

5 The dried slip layer 7 is then vitrified in a sintering furnace in air atmosphere. The heating profile for vitrifying the slip layer 7 is shown in **Fig. 3**. It comprises a heating ramp in which the slip layer 7 is heated from room temperature within one hour to a lower heating temperature of 1000°C. The component is kept at this heating temperature for one hour. Subsequently, a slow heating process takes place for four hours to achieve a final temperature of 1400°C, which is held for two
10 hours. Cooling takes place with a cooling ramp of 15°C/min to a furnace temperature of 500°C and then in an uncontrolled manner in the closed furnace.

The slip layer is fully sintered and consolidated by this temperature treatment. The resulting SiO₂ cover layer 7a has a high density of about 2.15 g/cm³, but is substantially still opaque. Opacity is demonstrated in that the direct spectral
15 transmission is below 10% in the wavelength range between 190 nm and 2650 nm. This yields a correspondingly high degree of reflection around 80% in the infrared wavelength range. The twin tube 9 is used for producing an infrared radiator, the SiO₂ cover layer 7a, which is produced thereon, is also suited as a reflector layer for high temperatures above 1000°C.

20 The use of quartz glass components that are provided with such a diffuse reflector in the form of an SiO₂ cover layer is not limited to lamp manufacture. Such reflectors are also used as separate components, e.g. for radiators in analyzing systems or for heating means in solar cell production.

Example 4

25 A homogeneous SiO₂ slip is produced, as described with reference to Example 1. 1.25% by wt. cerium praseodym aluminate (Ce_{0.4}Pr_{0.6}AlO₃) is added to said slip. The cerium amount is chosen such that it will be about 0.32% by wt. in the later SiO₂ cover layer and the praseodym amount about 0.49% by wt.

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This mixture is further processed, as described with reference to Example 1, including the admixture of amorphous, spherical SiO_2 grains with a grain size of about 5 μm and subsequent homogenization in a drum mill.

5 The slip obtained in this way has a solids content of 84% and a density of about 2.0 g/cm^3 . The SiO_2 particles obtained after grinding of the quartz glass grains in the slip 14 show a particle size distribution which is characterized by a D_{50} value of about 8 μm and by a D_{90} value of about 40 μm . It is used for coating a quartz glass plate from which a reflector plate for an IR radiator is to be produced. To this end the slip is applied to the quartz glass plate which was first cleaned in alcohol
10 and adjusted by chemical etching (deep freezing) to a mean surface roughness R_a of 2 μm , resulting in the formation of a uniform closed slip layer with a thickness of about 2.5 mm.

This slip layer is first dried at room temperature for about 5 hours and subsequently by means of an IR radiator in air. The dried slip layer is without
15 cracks, and it has a mean thickness of about 2.2 mm. The slip layer which has been produced and dried in this way is then vitrified in air in a sintering furnace, as described with reference to Example 1.

Thereafter the slip layer is completely sintered, opaque and, as far as can be seen with the naked eye, free from bubbles.

20 The subsequent cooling process takes place in the furnace in air down to a temperature of 500°C at a controlled cooling rate of 15°C/min and then in the still closed state of the furnace by way of free cooling.

A reflector plate is obtained having flat sides that are fully covered with an SiO_2 cover layer which consists of opaque quartz glass and has a mean layer thickness
25 of about 2 mm, and which is characterized by freedom from cracks and by a high density of about 2.15 g/cm^3 , and the reflection curve of which is shown in Fig. 4 in the wavelength range between 200 nm and 800 nm. Plotted on the y-axis is the degree of reflection "R" in %, which refers to the intensity ratio of the reflected radiation to the radiation impinging on the SiO_2 cover layer, and the wavelength λ
30 is plotted in nm on the x-axis. In the infrared spectral range (not shown) and in the

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visible spectral range down to about 350 nm, the sample exhibits a reflection of more than 90%. In the ultraviolet spectral range below 350 nm the reflection decreases, due to the beginning absorption of the added dopant, to a few percent. A slightly higher residual reflection with a maximum of about 10% just remains in the wavelength range between 250 nm and 270 nm.

When the reflector plate is used for the reflection of infrared operative radiation, the greatest part of the UV radiation is thus absorbed in the SiO₂ cover layer and thus removed from the reflected wavelength spectrum.

The SiO₂ cover layer effects a diffuse, undirected and wavelength-selective reflection. Due to a curved or arched geometry of the component, as is otherwise also usual in reflectors, a directed portion can be applied to the diffuse reflection.

Example 5

A slip is produced, as has been described with reference to Example 4, but, instead of the dopant cerium praseodym aluminate (Ce_{0.4}Pr_{0.6}AlO₃), a powder mixture of Al₂O₃ and Fe₂O₃ is added that is dimensioned such that in the later SiO₂ cover layer the aluminum portion is about 3% by wt. and the Fe portion is 10 wt ppm.

The slip is applied to a flat side of a quartz glass plate, dried and vitrified, as has been described above with reference to Example 4. A reflector plate is obtained having one flat side covered with an SiO₂ cover layer which consists of opaque quartz glass and has a mean layer thickness of about 2 mm, and which is distinguished by the absence of cracks and by a high density of about 2.15 g/cm³.

After vitrification of the dried slip layer in the sintering furnace in air, an opaque SiO₂ cover layer is obtained that almost within the whole wavelength range of 200 nm to 3000 nm shows high absorption and low reflection. It is only in the wavelength range of about 700 nm that a low reflection degree below 60% is measured.

Example 6

An SiO₂ cover layer is produced on a quartz glass plate, as described with reference to Example 5. The slip layer, however, is not vitrified in air, but by heating to an upper heating temperature of 1300°C for a period of four hours in a
5 reducing atmosphere in the presence of hydrogen.

This treatment considerably changes the reflection behavior of the SiO₂ cover layer in comparison with Example 5. In the wavelength range of 400 nm to 700 nm an adequately high reflection degree around 75% now manifests itself. The absorption in the UV range below 300 nm and in the IR range above 1000 nm is
10 however not changed significantly.

Hence, the reflector is suited for the reflection of operative radiation in the visible spectral range, the greatest part of the UV radiation and the IR radiation being absorbed in the SiO₂ cover layer and thus removed from the reflected wavelength spectrum. This avoids a heating of the illuminated object. For the discharge of the
15 heat generated in the reflector the known cooling measures can be taken.

Example 7

A slip is produced, as has been described with reference to Example 5, but, instead of the dopant mixture consisting of Al₂O₃ and Fe₂O₃, only an Fe₂O₃ powder is added that is dimensioned such that the Fe portion will be 8 wt ppm in
20 the later SiO₂ cover layer.

The slip is further processed into a vitrified SiO₂ cover layer of a thickness of 2 mm on a quartz glass plate, as has been described with reference to Example 5. The reflection behavior of the iron-doped SiO₂ cover layer in the wavelength range of 240 nm to 850 nm is shown in Fig. 5 as curve 52. The diagram of Fig. 5 shows
25 reflection curves of two different SiO₂ cover layers according to the present invention as compared with the reflection curve of a gold layer over the wavelength range between 240 nm and 850 nm. Plotted on the y-axis is there the reflection degree "R" in relative units (based on the reflectivity of the Teflon lining

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of the Ulbricht ball) and the wavelength λ of the operative radiation is plotted in nm on the x-axis.

Curve 51 shows the reflection behavior in the vapor-deposited gold layer; curve 52 shows the reflection behavior in an SiO₂ cover layer having a thickness of 2 mm, which has been produced according to Example 7, wherein the quartz glass is thus doped with 8 wt ppm Fe and vitrification has been carried out in air, and curve 53 shows the reflection behavior in an SiO₂ cover layer of undoped SiO₂ having a thickness of 2mm, which has been produced according to Example 1.

As can be seen therefrom, the SiO₂ cover layer of undoped SiO₂ (curve 53) in the wavelength range between 250 nm and 850 nm has an approximately uniform degree of reflection R of about 80%. The reflection degree R in this wavelength range is higher than the reflection degree R of the gold coating (curve 51). The iron-doped SiO₂ cover layer (curve 52) shows a distinct decrease in reflection in the ultraviolet spectral range, at wavelengths below 350 nm. The iron-doped SiO₂ cover layer is thus suited for the selective removal of the UV portion from the reflected radiation of a lamp.

Patent Claims

1. A component with a reflector layer, which either forms a reflector for an optical radiator or a part of an optical radiator, comprising a base body of quartz glass having a surface covered at least in part with a reflector layer, characterized in that there is provided an SiO₂ cover layer (7a; 9) which acts as a diffuse reflector and consists of at least partly opaque SiO₂, whereby the SiO₂ cover layer (7a; 9) consists of generic material with respect to the base body (1; 8), wherein the SiO₂ contents of cover layer and base body differ by not more than 3% by wt. from one another.
2. The component according to claim 1, characterized in that the base body is formed as a cladding body (1) of quartz glass for receiving a radiation emitter.
3. The component according to claim 2, characterized in that the SiO₂ cover layer (7a) is provided on the outside (6) of the cladding body (1) of quartz glass that is oriented away from the radiation emitter.
4. The component according to claim 2, characterized in that the SiO₂ cover layer (7a) is provided on the inside (6) of the cladding body (1) of quartz glass that is oriented towards the radiation emitter.
5. The component according to any one of the preceding claims, characterized in that the at least partly opaque SiO₂ contains a dopant which in the ultraviolet, visible or infrared spectral range produces optical absorption, thereby effecting a selective reflection of the reflector layer.
6. The component according to claim 5, characterized in that the SiO₂ cover layer in the wavelength range of 200 nm to 300 nm has a reflection coefficient of at least 0.3, and that the dopant produces an optical absorption line in the wavelength range above 300 nm.

7. The component according to claim 5, characterized in that the SiO₂ cover layer in the wavelength range of 400 nm to 800 nm has a reflection coefficient of at least 0.3, and that the dopant produces an optical absorption line in the infrared wavelength range above 1000 nm.
- 5 8. The component according to any one of claims 5 to 7, characterized in that the dopant comprises one or more of the following substances: hydroxyl groups, V, Yb, Eu and Nd.
9. The component according to claim 5, characterized in that the SiO₂ cover layer in the wavelength range of 1000 nm to 2000 nm has a reflection
10 coefficient of at least 0.3, and that the dopant produces an optical absorption line in the ultraviolet wavelength range between 150 nm and 400 nm.
10. The component according to claim 5 or claim 7, characterized in that the SiO₂ cover layer in the wavelength range of 400 nm to 800 nm has a reflection
15 coefficient of at least 0.3, and that the dopant forms an optical absorption line in the ultraviolet wavelength range between 150 nm and 400 nm.
11. The component according to any one of claims 5, 9 or 10, characterized in that the dopant comprises one or more of the following substances: Ti, Fe, and Ce.
12. The component according to claim 5 or 10, characterized in that the SiO₂
20 cover layer in the wavelength range of 600 nm to 800 nm has a reflection coefficient of at least 0.3, and that the dopant produces an optical absorption line in the visible wavelength range between 300 nm and 600 nm.
13. The component according to claim 5 or 12, characterized in that the dopant comprises one or more of the following substances: Cu, Sm and Nd.
- 25 14. The component according to any one of the preceding claims, characterized in that the SiO₂ cover layer contains nanoscale crystalline particles.
15. The component according to claim 14, characterized in that the nanoscale crystalline particles are diamond or are carbon nanotubes.

16. The component according to any one of the preceding claims, characterized in that the SiO₂ cover layer contains aluminum, nitrogen, or carbon.
17. A method for producing a quartz glass component with a reflector layer, which either forms a reflector for an optical radiator or a part of an optical radiator, the surface of a base body (1; 8) of quartz glass being covered at least in part with a reflector layer (7a; 9), characterized in that a slip containing amorphous SiO₂ particles is produced and applied to the surface of the base body (1; 8) with formation of a slip layer (7), the slip layer (7) is dried and then vitrified with formation of the SiO₂ cover layer (7a; 9), said cover layer (7a; 9) consists of generic material with respect to the base body (1; 8), wherein the SiO₂ contents of cover layer and base body differ by not more than 3% by wt. from one another, whereby the SiO₂ particles are produced by wet milling SiO₂ starting grains.
18. The method according to claim 17, characterized in that the SiO₂ particles have particle sizes in the range of not more than 500 µm, preferably of not more than 100 µm, SiO₂ particles with particle sizes in the range between 1 µm and 50 µm accounting for the largest volume fraction.
19. The method according to any one of claims 17 or 18, characterized in that the dried slip layer (7a) is vitrified in a hydrogen atmosphere.
20. The method according to any one of claims 17 to 19, characterized in that dopants are added to the slip in the form of compounds containing aluminum, nitrogen or carbon.
21. The method according to any one of claims 17 to 20, characterized in that at least one dopant is introduced into the slip, the dopant producing optical absorption in quartz glass in the ultraviolet, visible or infrared spectral range, thereby accomplishing a selective reflection of the reflector layer.