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Infrared absorber and thermal sensor produced using it

Prior Art

5 The invention relates to an infrared absorber, in particular for thermal sensors, which is applied in the form of a layer of one or more organic and/or inorganic compounds over a thermosensitive structure located on or in a substrate, in order to convert incident
10 infrared radiation into heat.

Many commercially available integrated infrared radiation sensors are based on the principle of converting radiation into heat, which is measured
15 thermoelectrically or on the basis of a change in the resistance of a thermosensitive layer, such as thermoelements, bolometers, thermoelectric piles and so on. The basic precondition for a high sensitivity of such a sensor is the most efficient conversion of the
20 infrared radiation from specific wavelength ranges into heat. An example which may be mentioned is the detection by sensors of human heat radiation in the wavelength range from 2-14 μm .

25 As a simple and cost-effective alternative to conventional absorber layers, such as black coloured gold or structured multi-layer systems, organic/inorganic polymers, which can be easily modified and are simple to structure are suggested. The
30 use of organic/inorganic compounds for the aforementioned purpose is already known. They are used, for example, as an absorber layer in a thermal sensor from the Heimann company. This absorber layer consists of an organic ester, of the isophthalic acid alkyd type
35 with proportions of polystyrene. By adding carbon in



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solid form, the surface is highly roughened, which results in a very inhomogeneous layer coverage.

One group of commercially obtainable organic/inorganic compounds is represented by the ORMOCERs from FhG-ISC, which are currently used in particular in fibre optics. In this case, inorganic oxidic groups are coupled with functional organic groups by means of a combination of polycondensation processes (sol-gel synthesis) and crosslinking reactions. For the purpose of subsequent UV structuring, a photostarter is added.

A further material which has high absorption bands in the spectral range from 8-10 μm is SiO_2 .

Object and advantages of the invention

The object of the invention is to make possible an infrared absorber which is particularly suitable for the construction of thermal sensors and a thermal sensor which is produced using it, which permits the adjustment of the optical properties of the absorber over a wide range by means of simple measures, the lowest possible thermal loading of the layers located underneath, good adhesion to many substrates and a simple and cost-effective production process, in which processing and structuring by standard processes is possible.

According to a first aspect of the invention, the above object is achieved by the absorber layer having an ORMOCER as an essential constituent. Such ORMOCERs are already completely synthesized and obtainable as liquid compounds. The basis for ORMOCERs are catalysed alkoxysilanes, that is to say inorganic oxidic groups, ethoxysilanes and methoxysilanes. These comprise Si-O groups and ester groups whose bands already absorb radiation in the wavelengths ranges 5.5-6, 8-10 and

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10-13 μm . By synthesizing the alkoxysilanes with fluorinated aromatics (organic groups), the absorption in the range from 8-10 μm is enhanced. In addition, further bands from the aromatics are added, which
5 absorb infrared radiation in the ranges 3.2-3.6, 6 and 13-14 μm .

In an advantageous development, such an absorber layer having an ORMOCER as an essential constituent is
10 additionally modified with organic and/or inorganic components, in order to adapt it to optimum use as an absorber layer.

In order to enhance the absorption further, a dark,
15 opaque dye is introduced. Furthermore, pigments can be introduced into the absorber layer in order to increase the porosity and the associated increase in the absorption components.

20 In addition, the absorption coefficient can be raised still further by modification of the inorganic oxidic groups by means of other types of organic components.

The further processing of these compounds is done by
25 means of standard processes. Inorganic/organic polymers, before the final crosslinking, are liquid media of high viscosity and are applied to a substrate by a process referred to as "spin-coating". This permits a homogeneous layer coverage and, as a result,
30 leads to a very good heat distribution. ORMOCERs generally exhibit a better thermal stability (up to about 250°C) than varnishes (e.g. PMMA) and are therefore more suitable for thermal application than varnishes.

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Thus, a thermal sensor which is built up with an absorber layer which has an ORMOCER as an essential constituent and which, if appropriate, is modified with

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organic and/or inorganic components, offers the following advantages:

- simple and cost-effective production process;
- processing and structuring by means of standard processes;
- the properties, in particular optical properties, of the layer can be adjusted simply;
- the absorber layer has good adhesion to many substrates;
- the absorber layer has a better thermal stability than many varnishes;
- the absorber layer forms an electrical insulator, so that no electrical insulation between the absorber and thermosensitive elements is needed;
- the absorber layer has a broad absorption spectrum with high absorption coefficients;
- in the absorber layer, both low and high layer thicknesses with aspect ratios up to 4 are possible;
- since the process temperatures lie in the range around 100°C, the layers located underneath are only slightly thermally loaded;

Finally, a further use of an absorber layer containing an ORMOCER as an infrared filter or as an optical protective layer is possible.

According to a second aspect of the invention, an alternative achievement of the above object is characterized in that the absorber layer consists of a photoresist which is present in a suspension with silicates and doped with a dark dye to produce a non-transparent absorber layer.

Silicates of low grain size, such as a few 100 nm, which are produced by sol-gel synthesis, are added to the photoresist. In order to increase the extinction coefficient, the varnish is additionally dyed with Sudan black dye. The present suspension is applied to

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the substrate by spin-coating. As an alternative to the Sudan black dye, other suitable, ester-soluble dyes can be used.

5 In the case of the absorber layer consisting essentially of a photoresist, the optical properties can be adjusted over wide ranges for the specific application by simple measures, such as by changing the dye or altering the concentration. The result of using
10 a conventional photoresist as a carrier substance for the silicate grains and the absorbent dye is that the process is particularly simple and cost-effective.

Using the appended drawing figures, the following
15 description describes non-restrictive exemplary embodiments of the infrared absorber layer according to the invention in conjunction with a production method preferred for this purpose.

20 Drawing

Figure 1 shows a micrograph of a structured infrared absorber layer produced with the aid of a positive photoresist as carrier material.

25 Figure 2 shows in graphic form the spectrum (transmission) of an infrared absorber layer according to Figure 1 produced with the aid of a positive photoresist as carrier substance.

30 Figure 3 shows the principle of the spin-coating process, in which a free-flowing infrared absorber layer is applied to a substrate rotating about an axis.

35 Figures 4A-4C show process steps for producing a thermal sensor, in which an infrared absorber layer according to the invention applied by spin-coating is

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located above a thermosensitive structure located on or in a thermosensitive substrate.

First exemplary embodiment

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Figure 1 illustrates a microscopically enlarged detail of an infrared absorber layer, which consists of a commercially available photoresist (e.g. AZ 81 12), which is present in a suspension with silicates and is doped with a dark dye, for example Sudan black. In this case, the average grain size of the silicates is a few 100 nm. Such silicates of low grain size, which have been produced by sol-gel synthesis, are added to the photoresist. The Sudan black dye with which the photoresist is dyed is used to increase the extinction coefficient.

This infrared absorber layer may be produced with the aid of a spin-coating method and subsequent structuring by means of conventional photolithography and then curing the absorber layer at a temperature of about 130°C, as described further below using Figures 3 and 4A-4C.

Figure 2 shows the spectrum, recorded with the aid of a spectrometer, in transmission of an infrared absorber layer, as shown in Figure 1. A pronounced absorption range for infrared radiation is established in the wavelength range between 8 and 10 μm .

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The optical properties of the infrared absorber layer can be adjusted over wide ranges for the specific application by simple measures, such as changing the dye or altering the concentration. As a result of using such a conventional photoresist as a carrier substance for the absorbent dye and the incorporated silicate grains, the production process for a thermal sensor is particularly simple and cost-effective.

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Second exemplary embodiment

As an absorbing material of an infrared absorber layer,
5 according to the invention an ORMOCER is used, which
consists of Si-O groups and ester groups, whose bands
absorb radiation in the wavelength ranges 5.5-6, 8-10
and 12-13 μm and in which, by synthesizing the
alkoxysilanes with fluorinated aromatics (organic
10 groups), the absorption in the range from 8-10 μm is
enhanced. Furthermore, further bands from the aromatics
are added, which absorb radiation in the ranges
3.2-3.6, 6 and 13-14 μm .

15 Such ORMOCERs can be modified with further organic and
inorganic components, with which they are matched to
their optimum use as an absorber layer.

In order to enhance the absorption further, a dark,
20 opaque dye can be introduced.

In addition, pigments can be introduced in order to
increase the porosity and the associated increase in
the absorption coefficients.

25 Furthermore, the inorganic oxidic groups can be
modified by means of other types of organic components
in order to increase the absorption coefficient in the
desired wavelength range.

30 Description of a preferred manufacturing method of a
thermal sensor with an absorber layer according to the
invention

35 Figure 3 shows the application of a liquid layer 2 by a
spin-coating method, in which the liquid medium 2 is
applied by means of a nozzle 3 to a substrate 1 set
rotating. This spin-coating method permits a

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homogeneous layer coverage and leads to a very good heat distribution.

5 According to Figure 4A, the layer 2 has been applied over the entire area over thermosensitive structures 4 located in or on the substrate 1 by means of the spin-coating method shown in Figure 3.

10 According to Figure 4B, the layer 2 is exposed through a mask 5 by means of UV light. In the process, the exposed area of the layer 2 is crosslinked, forming the absorber layer 2a (Figure 4C).

15 According to Figure 4C, the remaining non-crosslinked polymer is removed with a solvent.

It should be noted that the process steps illustrated in Figures 4A-4C are a conventional UV lithography method.

20 Finally, the absorber layer 2a is cured at a temperature around 100°C (130°C). At such a low temperature, barely any thermal loads are imposed on the layers located underneath, such as the
25 thermosensitive structures 4.

The process steps illustrated in Figures 3 and 4A-4C can be used both for an infrared absorber layer 2a consisting of a photoresist (according to the first
30 exemplary embodiment) and for an infrared absorber layer 2a having an ORMOCER as an essential constituent (according to the second exemplary embodiment).

It should also be mentioned that, as an alternative to
35 the use as an infrared absorber layer, a layer according to the invention can also be used for an infrared filter or an optical protective layer.

PATENT CLAIMS

1. Infrared absorber, in particular for thermal sensors, which is applied in the form of a layer of one or more organic and / or inorganic compounds over a thermosensitive structure located on or in a substrate, in order to convert incident infrared radiation into heat, whereby the absorber layer has an ORMOCER as an essential constituent, characterized in that the absorber layer is additionally modified with organic and / or inorganic components in order to adapt it to its use as an IR-absorber layer or that dark, opaque dye is additionally introduced into the absorber layer.
2. Infrared absorber, in particular for thermal sensors, which is applied in the form of a layer of one or more organic and / or inorganic compounds over a thermosensitive structure located on or in a substrate, in order to convert incident infrared radiation into heat, characterized in that the absorber layer consists of a photoresist which is present in a suspension with silicates and doped with a dark dye.
3. Infrared absorber according to Claim 2, characterized in that silicates with a small grain size are added to the photoresist.
4. Infrared absorber according to Claim 3, characterized in that the average grain size of the silicates is a few 100nm.
5. Infrared absorber according to Claim 2, characterized in that the dye is an ester-soluble dye.
6. Infrared absorber according to Claim 5, characterized in that the dye is Sudan black.

7. Method of producing a thermal sensor having an infrared absorber, according to one of Claims 1 to 6, characterized by the following steps:

- the absorber layer is applied to the substrate on which or in which the thermosensitive structure is located, by spin-coating, so that the said layer covers the thermosensitive structure;
- the layer applied is structured and exposed by a mask technique, so that the exposed area crosslink;
- the remaining non-crosslinked areas of the absorber layer applied are removed, and
- the crosslinked areas are cured at a temperature in the range of about 80-150°C.

8. Method according to Claim 7, characterized in that the absorber layer is exposed using UV light.

9. Thermal sensor, characterized in that it has an infrared absorber layer according to one of Claims 1-6.