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(54) Benævnelse: **Indretning til mekanisk tilvejebringelse af en spænding på en tyndfilm**

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Description

Technical Area

The invention relates to a device for mechanically applying a tension to a thin film which is attached to a substrate and comprises an application portion which is surrounded by a piezoelectric actuator connected to the thin film in a shear-resistant manner.

Prior Art

The influence of elastic elongations on the material properties is used, for example, in microelectronics, nanoelectronics, and optoelectronics to improve the performance of semiconductors. However, thin films for optical purposes can also be deformed by regional elastic elongations, wherein electrically controllable actuators are advantageously used. Thus, *inter alia* to change the focal length of an optical system, surrounding a circular thin-film membrane, which is used either as a mirror surface or represent a boundary for a liquid volume forming a lens body, on the periphery with a ring-shaped, piezoelectric actuator connected to the thin-film membrane in a shear-resistant manner, and therefore upon application of an electrical voltage to the actuator via an inner and an outer ring electrode, a radial tensile stress can be applied to the thin-film membrane, which, in the case of a predefined starting curvature, causes an enlargement of the radius of curvature of the thin-film membrane and thus an extension of the focal length of the optical system based on such a thin-film membrane, is known (US 7 369 723 B1).

In a similar manner, according to US 2007/0206300 A1, the curvature of a central mirror surface is controlled with the aid of actuators, which are formed by piezo elements surrounding the mirror surface in a ring shape. The electrical voltages active between the ring-shaped electrodes cause radial distance changes of the piezo elements resulting between the electrodes with the consequence that the substrate which bears the mirror surface and is surrounded by the ring-shaped piezo elements deforms accordingly, specifically as a result of the tensions active substantially outside the mirror surface.

To be able to deform local regions of a mirror or lens surface in a targeted manner, applying piezo elements in the form of films onto the surface layer to be deformed is additionally known (EP 1 191 377 B1), wherein as a result of the pattern of the arrangement, for example, in radial paths lying opposite one another in pairs for rotationally-symmetrical deformations of optical elements, the respective deformations to be performed can be taken into consideration. Due to the use of individual piezo elements as sensors, the deformations can be monitored, which result due to the piezo elements used as actuators. These known applications of piezoelectric actuators have the goal of changing the geometrical surface shape of thin films for optical purposes and are therefore unsuitable for applying a tunable stress tensor to thin films to influence the physical properties thereof.

This also applies to piezoelectric actuators, which ensure a change of the shape of the membrane transversely to the membrane surface, in order to change the curvature of a liquid cushion terminated by the membrane in a central region by a peripheral pressure application to the membrane and the liquid displacement linked thereto from the peripheral region into the central region (US 2010/0182703 A1) or to set the thickness of an air gap bounded on one side by a membrane by way of a membrane curvature (US 6 515 791 B1).

Description of the Invention

The invention is therefore based on the object of designing a device for mechanically applying a tension to a thin film such that tension states can be generated in the thin film which are predefinable both in the direction and also in the size.

Proceeding from a device of the type described at the outset, the invention achieves the stated object in that the actuator comprises piezo elements lying in pairs opposite one another with respect to the application portion and extending in their operating direction radially with respect to the application portion, and that the application portion of the thin film is connected to the rest of the thin film by radial webs which are connected in a shear-resistant manner to the piezo elements.

As a result of the piezo elements lying in pairs opposite one another with respect to the application portion of the thin film, upon a corresponding application of electricity to the piezo elements, tensile stresses can be exerted on the application portion between the piezo elements lying opposite one another in at least two directions predefined by the piezo elements arranged in pairs, specifically independently of one another, because electric voltages independent of one another can be applied to the piezo element pairs. The piezo elements lying opposite one another are to be subjected to an equal electrical field to ensure symmetrical conditions, however, and therefore tensile stresses applied to the application portion cannot result in a displacement of the application portion. With the aid of the piezo elements lying in pairs opposite one another and aligned radially with respect to the application portion, the application portion of the thin film can therefore be subjected to tensile stresses in the direction predefined by the action direction of the piezo elements arranged in pairs, the size of which can be controlled via the electrical voltage which is applied to the pairs of piezo elements. Different tension states can therefore be set in the application portion of the thin film, in order to be able to study either the effect of different tension states on the physical properties of the thin film or to ensure specific physical properties of a thin film which can be influenced by tension states.

In order to avoid the influence of the thin-film regions to which the piezo elements are not applied, and which extend between the piezo elements adjacent in the circumferential direction and adjoining the application portion, the application portion of the thin film is connected to the rest of the thin film by radial webs which are connected in a shear-resistant manner to the piezo elements, and therefore as a result of the absence of these thin-film regions, the application of tension to the application portion takes place exclusively via the radial webs, which correspond in the course thereof to the arrangement of the piezo elements lying in pairs opposite one another.

Particularly advantageous conditions with respect to the application of mechanical tensions to the application portion result if the substrate forms the piezo elements lying opposite one another in pairs, because in this case the better piezoelectric properties of thicker piezo elements can be used in a constructively simple manner. Of course, however, it is also possible to use the construction conditions of thin-film piezo elements, which are advantageous for some applications, but which require a separate substrate for mounting the thin film to which a stress tensor is to be applied, however.

To be able to generate arbitrary tension states within the thin-film region given by the application portion, three pairs of mutually opposing piezo elements can be provided disposed offset by 60° with respect to one another in each case. By applying tension in directions inclined by 60 or 120° in relation to one another, the stress tensors required for taking a specific influence on the physical properties of the application portion can be implemented in a simple manner.

Brief Description of the Drawings

The subject matter of the invention is illustrated by way of example in the drawing. In the figures:

Figure 1 shows a device, not according to the invention, for mechanically applying a tension to a thin film in a schematic, partially cutaway top view,

Figure 2 shows this device in a partially cutaway view from below,

Figure 3 shows a section along line III-III of Figure 1 in an enlarged scale,

Figure 4 shows an embodiment variant of a device according to the invention in a schematic, partially cutaway top view,

Figure 5 shows the device according to Figure 4 in a section along line V-V of Figure 4 in an enlarged scale, and

Figure 6 shows a section along line VI-VI of Figure 4 in the region of a web of the thin film in a larger scale.

Ways of Embodying the Invention

Devices according to the invention are usable, for example, as tunable sources for entangled photons, as are considered, for example, for quantum-optical and quantum-communicative applications. This is because these devices presume a tuning of the mechanical tensions within the semiconductor thin film forming quantum points. Of course, the invention is not restricted to such an application, but rather can be applied anywhere specific stress tensors have to be set or changed inside a thin film, as is the case, for example, in microelectronics, nanoelectronics, and optoelectronics for improving the performance of semiconductors.

The device according to the example not according to the invention as shown in Figures 1 to 3 has a substrate 1, which forms piezo elements 2 lying opposite one another in pairs, which protrude radially toward one another. These piezo elements 2 are coated on the top side thereof with a common electrode 3, which covers the substrate 1 and is set to ground, and on the opposite lower side with electrodes 4 restricted to the individual piezo elements 2, and therefore an electrical voltage can be applied to the individual piezo elements as such. A thin film 5, in the exemplary case a semiconductor layer in the form of a GaAs membrane, is applied to the substrate 1 covered by the electrode 3, which thin film forms an application portion 6 provided with quantum points, which results between the individual piezo elements 2 and is indicated by dot-dash lines in Figures 1 and 2.

If an electrical voltage is applied via the electrodes 3, 4 to the piezo elements 2, which are connected to the thin film 5 in a shear-resistant manner, which voltage causes a contraction of the piezo elements 2 in the radial direction, the application portion 6 between the respective piezo elements 2 lying in pairs opposite one another is loaded with tensile stresses extending in the action direction of these piezo elements 2, which are settable in the size thereof and ensure the formation of specific stress tensors inside the application portion 6. Depending on the application to the piezo elements 2 lying in pairs opposite one another, the application portion 6 of the thin film 5 can accordingly be tuned with respect to the stress tensor.

For differentiation from the exemplary device not according to the invention as shown in Figures 1 to 3, according to the exemplary embodiment as shown in Figures 4 to 6, the piezo elements 2 are formed as thin-film elements, which requires the provision of a separate substrate 1 to accommodate the thin film 5. The substrate 1 can be constructed, for example, on the basis of gallium arsenide (GaAs), silicon, copper, lead magnesium niobite-lead titanate (PMN-PT) or the like. Accordingly, the piezo elements 2 are to be arranged on the side of the thin film 5 opposite to the substrate 1, which, corresponding to the exemplary embodiment as shown in Figures 1 to 3, are arranged in pairs with one another while leaving open an application portion 6 of the thin film 5, and therefore upon application of an electrical voltage to the piezo elements 2 via the electrodes 3, 4, the application portion 6 of the thin film 5 can be subjected to a corresponding stress tensor between the pairs of piezo elements 2. It does not have to be particularly emphasized that for this purpose the thin film 5 has to be kept slippery in relation to the substrate 1 in the influence region of the piezo elements 2.

To be able to apply particularly delicate tensile stresses to the application portion 6 via the piezo elements 2, the application portion 6 is connected via radial webs 7 to the rest of the thin film 5, wherein the thin film 5 has openings 8 between the webs 7. These webs 7 correspond in the course thereof to the arrangement of the piezo elements 2 and are connected to these piezo elements 2 in a shear-resistant manner.

PATENTKRAV

1. Indretning til mekanisk påføring af en spænding på en tyndfilm (5), der er tilvejebragt på et substrat (1) og har en applikationssektion (6), hvilken applikationssektion er omgivet af en piezoelektrisk aktuator, der er forbundet med tyndefilmen (5) på en forskydningsbestandig måde, **kendetegnet ved**, at aktuatoren omfatter piezoelementer (2), der parvis ligger modsat hinanden i forhold til applikationssektionen (6), og at elementerne løber radialt i forhold til deres aktive retning i forhold til applikationssektionen (6), og at applikationssektionen (6) af tyndfilmen (5) er forbundet med den øvrige tyndfilm (5) over radiale broer, der er forbundet med piezoelementer (2) i en forskydningsbestandig måde.

2. Indretning ifølge krav 1, **kendetegnet ved**, at substratet (1) danner piezoelementerne (2) der parvis ligger modsat hinanden.

3. Indretning ifølge krav 1 eller 2, **kendetegnet ved**, at tre par af piezoelementer (2) der parvis ligger modsat hinanden er tilvejebragt hver forskudt om ca. 60° mod hinanden.

FIG.1

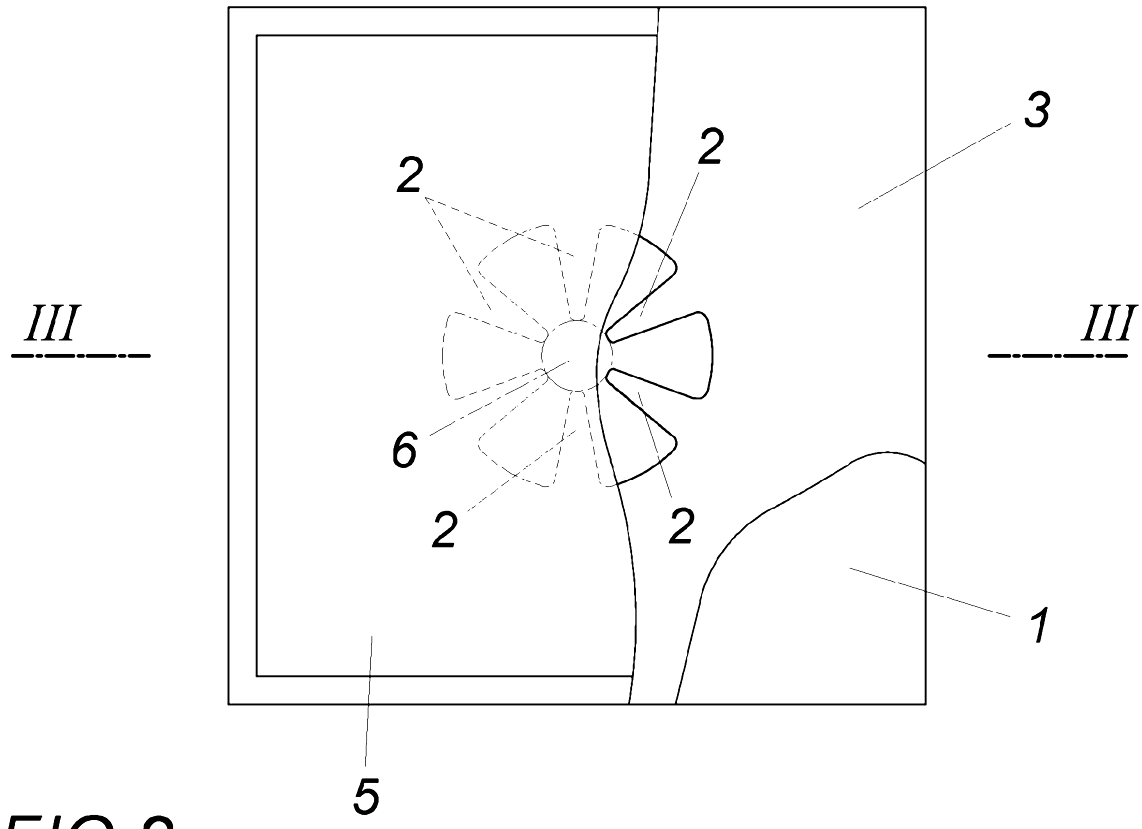
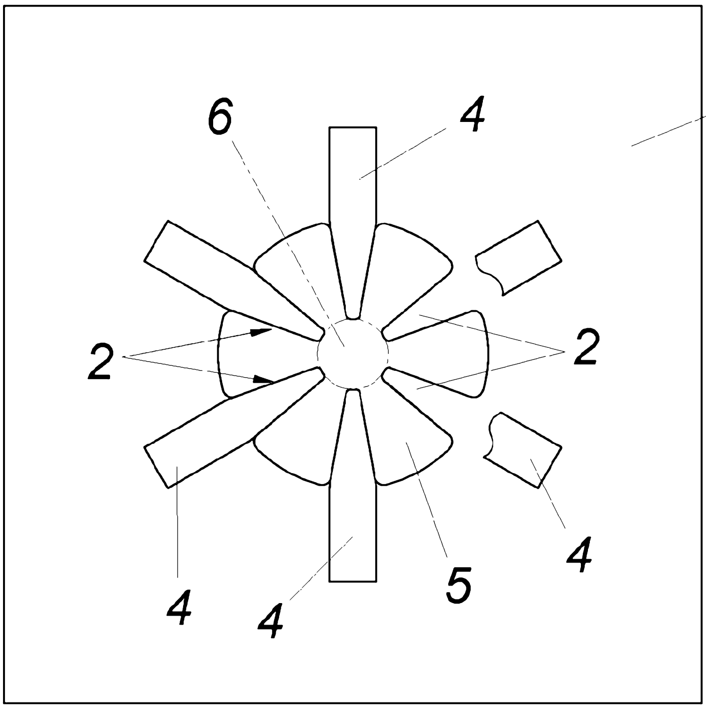


FIG.2



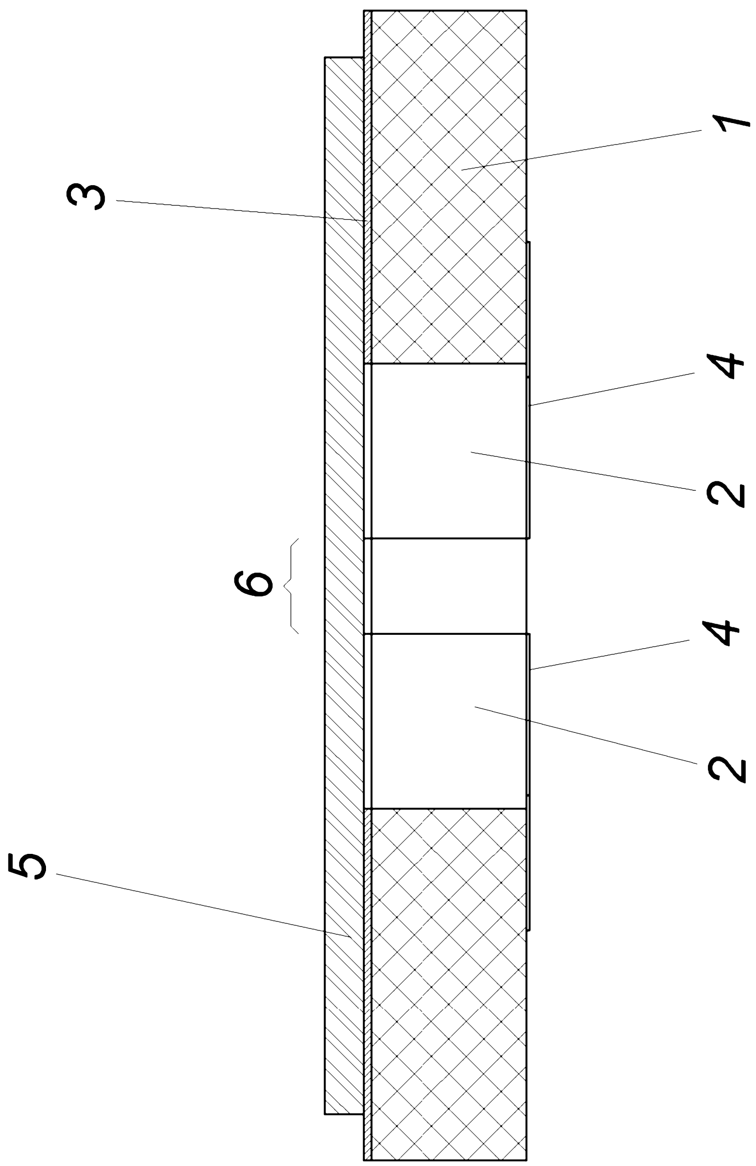


FIG.3

FIG.4

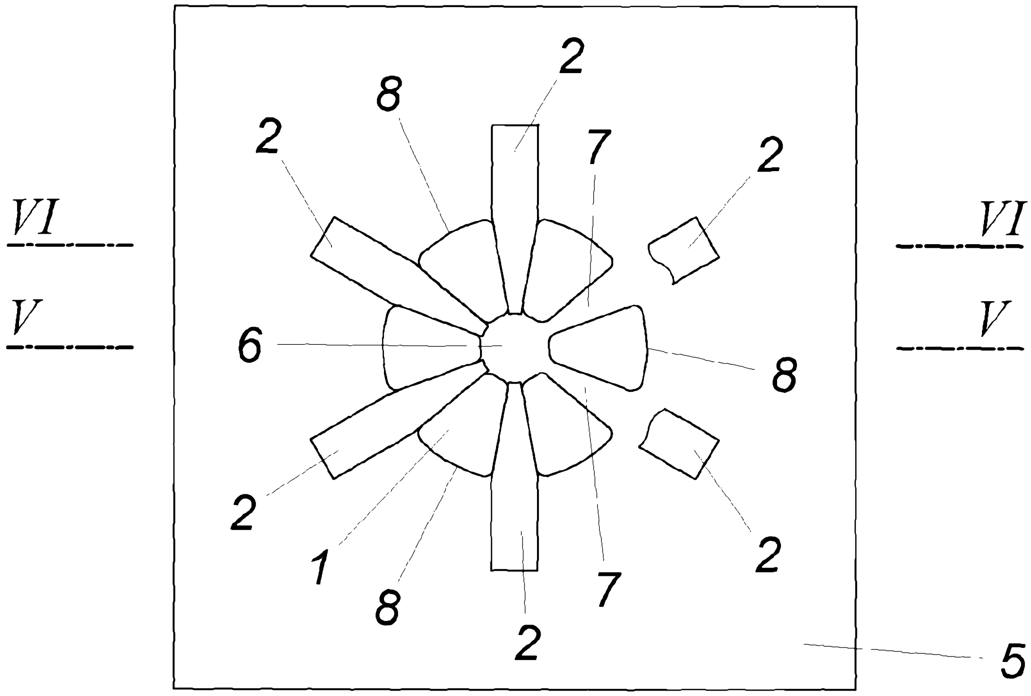


FIG.5

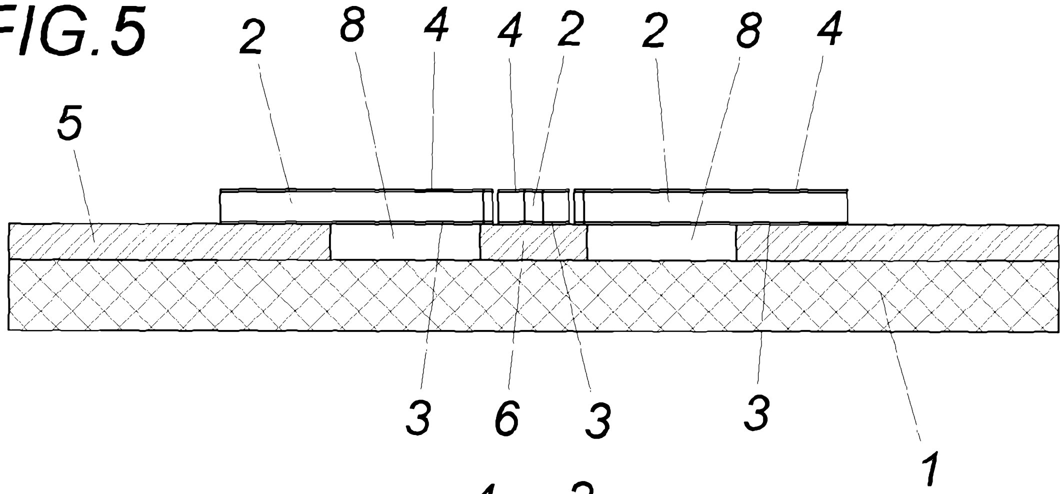


FIG.6