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(54) Title: A SENSING DEVICE, COMPRISING A FIRST ELECTROOPTICAL DEVICE FOR A MOTOR VEHICLE, AS WELL AS AN ARRANGEMENT

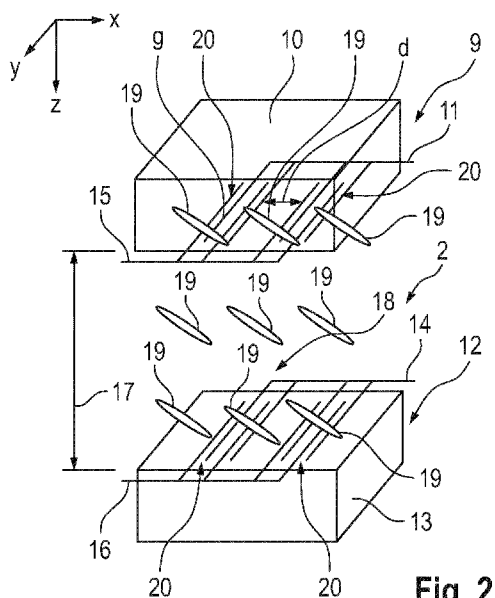


Fig. 2

(57) Abstract: The invention relates to a sensing device (2), comprising a first electrooptical device (9) with at least a first substrate (10) and at least a first electrode (11) on the substrate (10), and comprising a second electrooptical device (12) with at least a second substrate (13) and a second electrode (14) on the substrate (13), wherein a third electrode (15) on the first substrate (10) is provided, wherein the first electrode (11) and the third electrode (15) are non-uniform electrodes, and wherein the first electrode (11) and the third electrode (15) are arranged such, that the first electrode (11) and the third electrode (15) are essentially arranged in parallel to each other on the first substrate (10), wherein a fourth electrode (16) on the second substrate (13) is provided, wherein the second electrode (14) and the fourth electrode (16) are non-uniform electrodes, and wherein the second electrode (14) and the fourth electrode (16) are arranged such, that the second electrode (14) and the fourth electrode (16) are essentially arranged in parallel to each other on the second substrate (13), wherein the first electrooptical device (9) and the second electrooptical device (12) are facing each other, wherein the first electrooptical device (9) and the second electrooptical device (12) are arranged in a predefined distance (17) to each other, and wherein in a free space (18) between the first electrooptical device (9) and the second electrooptical device (12) a voltage sensitive electrooptical material (19) is arranged. Furthermore, the invention relates to an arrangement (23).

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Description

A sensing device, comprising a first electrooptical device for a motor vehicle, as well as an arrangement

The present invention relates to a sensing device, comprising a first electrooptical device with at least a first substrate and at least a first electrode on the substrate, and comprising a second electrooptical device with at least a second substrate and a second electrode on the substrate. Furthermore, the present invention relates to an arrangement comprising at least the sensing device.

Radar sensors are integrated behind plastic covers and motor vehicles, such as the brand emblem or the bumpers. The radar's emitted radiation is reflected at the surface of these parts, relating to an attenuation of the transmitted radiation which causes false detection and a decrease of the achievable maximum range and resolution.

According to the state of the art, automated driving of, for example an SAE level 4 and 5, requires to save an environmental perception. In general, the motor vehicle's environment is detected using different sensor modalities, such as radars, lidars and cameras. Often, the sensor system aims for an 360 degree environmental perception and/or detects all static or dynamic objections around the motor vehicle. Lidars are frequently used for precise distance measurements and can also be used for classification purposes. Current approaches for 360-dimensional perception require either a multitude of single sensors which are combined or larger sensors which provide a 360 degree detection of the environment. Moreover, lidar systems can be prone to adversarial weather conditions such as rain, fog or direct light sources. Radar sensors are well established within the automotive industry and provide reliable and robust environmental data even in poor visual conditions, such as rain, fog, snow and dust.

However, a state of the art radom covering the radar sensors from environmental influences or hiding for design reasons the radar, have huge losses to the transmitted radiation in the order larger 2.5 decibel (db) due to reflection and absorption of the radiation in gigahertz spectral domain.

WO 2022/187949 discloses a simple and cost-effective measurement of polarization components or the complete PSOL (the so-called Stokes parameters), wherein this is achieved without any mechanical movements or deformation by using liquid crystal elements. A transmission of a first polarization of light is greater than a transmission of a second orthogonal polarization of light and transmission of the second polarization is greater than 5%. In another of the different states, the device has different levels of transmission of the first and second polarizations of light. At least two orthogonal polarization component values characterizing the light can be resolved by comparing an intensity of light captured in a plurality of the different states.

EP 4 012 004 A1 relates to a liquid crystal device comprising at least two opposing transparent substrates, at least one liquid crystal switching layer sandwiched between said opposing substrates, comprising one or more nematogenic compounds, an electrode structure provided on one or both of the opposing substrates, wherein the electrode structure comprises at least one or more electrode layers provided on one or both inner sides of the opposing substrates having a surface roughness ≤ 10 nm RMS (root mean square).

WO 2020/201481 A1 relates to an optical coherence tomography analysis method, comprising: Providing a Swept Source Optical Coherence Tomography system (SS-OCT), the SS-OCT system including: a light source, tunable over a spectral band, that generates a coherent light signal; an optical interferometer for dividing the coherent light signal into a reference arm leading to a reference reflector and a sample arm leading to a sample; an optical element to selectively direct a sample light signal exiting the sample arm to a specific portion of the sample, so that for each selection in the optical element a different specific portion of the sample is illuminated; an optical detector for detecting an interference signal generated by a combination of reference and sample returning signals from the reference arm and from the sample arm, reflected by the reference reflector and the sample, respectively; wherein, for the same selection operated at the optical element level illuminating a specific portion of the sample, the method further comprises: sweeping the light source for a time interval Δt , so that a wavelength of the coherent light signal, leading to the sample light signal illuminating the specific portion of the sample, changes from a minimum wavelength to a maximum wavelength and wherein the wavelength of the coherent light signal reaches the same value between the minimum wavelength to the maximum wavelength at least twice during the sweeping; detecting the interference signal generated by the sweeping, including the interference signal generated by the sample returning signals of the at least two coherent light signals having the same wavelength; elaborating the detected interference signal generated by the sweeping, including the detected interference signal

generated by the sample returning signals of the at least two coherent light signals having the same wavelength, for obtaining an OCT image of the specific portion of the sample.

It is an obstacle of the present invention to provide a sensing device and an arrangement, by which reflection and/or absorption losses may be reduced.

This objection is solved by a sensing device as well as an arrangement according to the independent claims. Advantageous embodiments are presented in the dependent claims.

One aspect of the invention relates to a sensing device, comprising a first electrooptical device with at least a first substrate and at least a first electrode on the first substrate, and comprising a second electrooptical device with at least a second substrate and a second electrode on the second substrate.

According to an embodiment, a third electrode on the first substrate is provided, wherein the first electrode and the third electrode are non-uniform electrodes, and wherein the first electrode and the third electrode are arranged such, that the first electrode and the third electrode are essentially arranged in parallel to each other on the first substrate, wherein a fourth electrode on the second substrate is provided, wherein the second electrode and the fourth electrode are non-uniform electrodes, and wherein the second electrode and the fourth electrode are arranged such, that the second electrode and the fourth electrode are essentially arranged in parallel to each other on the second substrate, wherein the first electrooptical device and the second electrooptical device are facing each other, wherein the first electrooptical device and the second electrooptical device are arranged in a predefined distance to each other, and wherein in a free space between the first electrooptical device and the second electrooptical device a voltage sensitive electrooptical material is arranged.

In particular, the multi orientation and the distance of that electrooptical device are chosen to minimize the radiative loss of the sensing device.

Therefore, the space inside the electrooptical devices may be filled with the electrooptical material. The electrooptical material may comprise molecules aligned in a specific angle, ranging from 0 to 90 degrees with respect to x-axes, typical in the z-x-plane, with respect to substrates and electro fingers. The choice of parameters (sheet resistance R_s (ohmic resistance), d (distance between groups of finger electrodes), D (distance between two substrates, along the z axis), w (width of fingers), and g (gap between finger electrodes), is critical to ensure adequate operation of the device without phase discretization, the space

within the electro fingers on a given substrate must be less than or at the order of the fringing field, which is at the order of electrode separation on two substrates (D). All values here (d , D , w , g ,) must be also selected to reduce the transmission loss at the wavelength of operation.

In particular, therefore, a sensing device structure is provided that can be used for the fabrication of various electro-optic devices, including phase shifters, steering, diffractive gradings, meta structures, and polarization modulators for millimeter range applications, in particular in the gigahertz to terahertz spectrum.

The advantage of the sensing device is that the transmitted radiation through, for example, a radom is increased. Furthermore, less power is needed and no degradation of resolution as well as no degradation of range is provided.

Therefore, significant design freedom for various electrooptical devices, in particular sensing devices, is provided.

According to an embodiment the voltage sensitive electrooptical material is a liquid mixture. For example, the mixture may be liquid crystals. Therefore, an easy way for manipulating the orientation of the liquid crystals is provided, and therefore reflection and/or absorption losses may be reduces.

In another embodiment operating signals for the first electrode and the third electrode are generated with the same voltage and/or operating signals for the second electrode and the fourth electrode are generated with the same voltage (electric potential, different from the first potential). In particular, therefore, the predominant voltage (difference of first and second potentials) and the corresponding electric field may be perpendicular to the substrates (along the z axis), in particular the said axes.

According to another embodiment, operating signals for the first electrode and the third electrode are generated with, in particular different electric potentials, generating thus a first voltage and operating signals for the second electrode and the fourth electrode are generated with different electric potentials, generating thus a second voltage, wherein the second voltage in general is different from the first voltage. Therefore, a predominant electric field can be generated, which is parallel to the substrates, in particular along the x -axis (electro fingers being parallel to y axis).

In another embodiment, additionally at least two side electrodes facing the voltage sensitive electrooptical material are arranged on the sensing device, in particular along the x axis. These electrodes may be added to the electrooptical device for an even better manipulation. However, they must be out of the working zone to avoid the attenuation of radiation since these electrodes will be parallel to its field. In particular, also more than two side electrodes may be provided. These electrodes may be also segmented to further enhance the spatial resolution of the electrooptic control.

According to another embodiment, the first electrooptical device is arranged tilted relatively to the second electrooptical device. In particular, the electrooptical devices may be tilted with respect to each other. This may create an electrically tunable wedge-type device, introducing different phase delays depending upon the position, in particular the thickness of the electrooptical devices. If the tilt must be permanent, then the use of electrodes or liquid crystal material may not be necessary. One can mold such structures per need and use them as lamination substrates for radar, camera, lidar or other devices.

In another embodiment, each of the electrodes comprises fingers of the electrodes, wherein each finger of the electrodes on each electrooptical device is arranged interlocked. Therefore, a grid-like structure is provided, wherein the fingers are arranged such, that fingers from each electrode are interlocking each other. In particular, a special distribution pattern is provided which may reduce a transmission loss through the substrate.

In another embodiment, the substrate is a transparent substrate. For example, the transparent substrate may be glass, plastic or a composite substrate. Therefore, different types of substrates may be provided, wherein the electrooptical device/sensing device is high flexible to be arranged or used.

In another embodiment, at least the first electrode and/or the second electrode are comprising a layer of Indium Tin Oxide (ITO) and/or copper and/or gold and/or silver and/or carbon nano tubes and/or silver nano wires and/or a conductive polymer. These examples are not exhaustive. In particular, one of the frequently used electrode materials for visible electrooptic applications is a thin film of ITO. With appropriate choice of the deposition conditions and the physical parameters of the film, it can provide rather low values of R_s , for example, as low as 10 Ohm/Square. On the other hand, with appropriate index matching layers, ITO films, in particular, deposited on the substrate, can also provide very low optical or radiative losses, mostly to the absorption and reflection, for example at the order of 0.2 % in the visible spectral range.

According to an advantageous form of configuration, it may be used at the gigahertz or terahertz frequency spectrum, but unfortunately, their absorption may be very high, such as the order of 10 db. The losses can be dramatically reduced with a specific choice of the ITO material, in particular the range of the Rs, and its special distribution pattern. In particular, the ITO shows excellent transmission when its lines/fingers are along y-axis, that is perpendicular to the polarization of the radiation, in particular along x-axes. The loss, in particular introduced by the ITO pattern, is at the order of a fraction of 1 db. Therefore, this gives a significant design freedom for various electrooptic applications and/or various sensing devices.

In another embodiment, at least four electrodes are arranged on each substrate of each electrooptical device allowing the generation of additional electric field with essential component that is parallel to the substrates (except in the close vicinity of electrodes) and to the electric field of transmitted radiation. In particular, a structure range is provided with two different, interlocking electrode structures. In particular, more electrodes are fabricated on the same substrate, for the total of N, with the same orientation, for example, along a y-axis, but with possible different spacings and with individual controls. According to an embodiment, such a substrate may be assembled with another similar electrode that may allow generating refractive index modulations with a grating wave vector that is parallel with the x-axes.

A further aspect of the invention relates to an arrangement for a sensing device comprising at least a sensing device according to any of the preceding aspects and at least one electrical field generating device and/or an electrical field receiving device. Therefore, the arrangement may be configured as sensing device and/or receiving device, for example, for a radar sensor.

According to another embodiment, the electrodes are arranged essentially perpendicular to the generated and/or received electrical field. In particular, according to an embodiment, the transmission loss is reduced dramatically.

According to another embodiment, the arrangement is configured for generating and/or receiving an electrical field in at least a GHz-Spectrum or higher. Therefore, the arrangement can be used, for example, for radars in order to capture surroundings of, for example, a motor vehicle.

In another embodiment, the arrangement is configured as a radar emitter for communication purposes to dynamically adjust or re-rout information.

In another embodiment, the arrangement is configured as a radar sensor.

A still further aspect of the invention relates to a motor vehicle comprising at least the sensing device and/or the arrangement according to the preceding aspects. Advantageous forms of the sensing device are to be regarded as advantageous forms of the arrangements as well as of the motor vehicle.

In particular, an electronic computing device/computing unit may be provided, for example, for generating the operating signals.

In particular an electronic computing device/computing unit may be provided, for example for receiving the operation signals.

A computing unit may in particular be understood as a data processing device, which comprises processing circuitry. The computing unit can therefore in particular process data to perform computing operations. This may also include operations to perform indexed accesses to a data structure, for example a look-up table, LUT. This may also include data generated by other (for example, temperature) sensors, used to optimize the operation of the main device.

In particular, the computing unit may include one or more computers, one or more microcontrollers, and/or one or more integrated circuits, for example, one or more application-specific integrated circuits, ASIC, one or more field-programmable gate arrays, FPGA, and/or one or more systems on a chip, SoC. The computing unit may also include one or more processors, for example one or more microprocessors, one or more central processing units, CPU, one or more graphics processing units, GPU, and/or one or more signal processors, in particular one or more digital signal processors, DSP. The computing unit may also include a physical or a virtual cluster of computers or other of said units.

In various embodiments, the computing unit includes one or more hardware and/or software interfaces and/or one or more memory units.

A memory unit may be implemented as a volatile data memory, for example a dynamic random access memory, DRAM, or a static random access memory, SRAM, or as a non-

volatile data memory, for example a read-only memory, ROM, a programmable read-only memory, PROM, an erasable programmable read-only memory, EPROM, an electrically erasable programmable read-only memory, EEPROM, a flash memory or flash EEPROM, a ferroelectric random access memory, FRAM, a magnetoresistive random access memory, MRAM, or a phase-change random access memory, PCRAM.

The sensing device may be used in an electronic vehicle guidance system. An electronic vehicle guidance system may be understood as an electronic system, configured to guide a vehicle in a fully automated or a fully autonomous manner and, in particular, without a manual intervention or control by a driver or user of the vehicle being necessary. The vehicle carries out all required functions, such as steering maneuvers, deceleration maneuvers and/or acceleration maneuvers as well as monitoring and recording the road traffic and corresponding reactions automatically. In particular, the electronic vehicle guidance system may implement a fully automatic or fully autonomous driving mode according to level 5 of the SAE J3016 classification. An electronic vehicle guidance system may also be implemented as an advanced driver assistance system, ADAS, assisting a driver for partially automatic or partially autonomous driving. In particular, the electronic vehicle guidance system may implement a partly automatic or partly autonomous driving mode according to levels 1 to 4 of the SAE J3016 classification. Here and in the following, SAE J3016 refers to the respective standard dated April 2021.

Guiding the vehicle at least in part automatically may therefore comprise guiding the vehicle according to a fully automatic or fully autonomous driving mode according to level 5 of the SAE J3016 classification. Guiding the vehicle at least in part automatically may also comprise guiding the vehicle according to a partly automatic or partly autonomous driving mode according to levels 1 to 4 of the SAE J3016 classification.

The sensing device may be configured as environmental sensing system. For example, an environmental sensor system can be understood as a sensor system, which is able to generate sensor data or sensor signals, which depict, represent or image an environment of the environmental sensor system. In particular, the ability to capture or detect electromagnetic or other signals from the environment, cannot be considered a sufficient condition for qualifying a sensor system as an environmental sensor system. For example, cameras, lidar systems, radar systems or ultrasonic sensor systems may be considered as environmental sensor systems.

Further features of the invention are apparent from the claims, the figures and the figure description. The features and combinations of features mentioned above in the description as well as the features and combinations of features mentioned below in the description of figures and/or shown in the figures may be comprised by the invention not only in the respective combination stated, but also in other combinations. In particular, embodiments and combinations of features, which do not have all the features of an originally formulated claim, may also be comprised by the invention. Moreover, embodiments and combinations of features, which go beyond or deviate from the combinations of features set forth in the recitations of the claims may be comprised by the invention.

In the following, the invention will be explained in detail with reference to specific exemplary implementations and respective schematic drawings. In the drawings, identical or functionally identical elements may be denoted by the same reference signs. The description of identical or functionally identical elements is not necessarily repeated with respect to different figures.

Therefore, the drawings show in:

Fig. 1 a schematic top view according to an embodiment of a motor vehicle comprising an embodiment of a sensing device;

Fig. 2 a schematic perspective view according to an embodiment of a sensing device;

Fig. 3 another schematic view according to another embodiment of a sensing device; and

Fig. 4 a schematic side view according to an embodiment of a sensing device.

In the figures, elements having the same function are indicated by the same reference signs.

Fig. 1 shows a schematic top view according to an embodiment of a motor vehicle 1. The motor vehicle 1 may be configured as an at least in part assisted motor vehicle 1 or a fully assisted motor vehicle 1. For that purpose, the motor vehicle 1 comprises at least one sensing device 2. The sensing device 2 may be configured as, for example, a radar sensor. Therefore, the sensing device 2 may be configured as a sending device 3 and/or a receiving device 5. In particular, the sending device 3 may be configured for sending a signal into the surroundings 4 of the motor vehicle 1. The receiving device 5 may be configured for receiving signals from the surroundings 4. Furthermore, the sensing device 2 may comprise

one electrical field generating device 6 and/or one electrical field receiving device 7. Furthermore, the sensing device 2 may comprise an electronic computing device 8.

Fig. 2 shows a schematic view according to an embodiment of the sensing device 2. In particular, the sensing device 2 may comprise a first electrooptical device 9 with at least a first substrate 10 and at least a first electrode 11 extending on the first substrate 10 finger type conductive lines. Furthermore, the sensing device 2 comprises a second electrooptical device 12 with at least a second substrate 13 and a second electrode 14 extending on the second substrate 13 finger type conductive lines.

According to an embodiment, a third electrode 15, extending on the first substrate 10 finger type conductive lines, is provided, wherein the first electrode 11 and the third electrode 15 are non-uniform electrodes, and wherein the first electrode 11 and the third electrode 15 are arranged such, that the first electrode 11 and the third electrode 15 are essentially arranged in parallel to each other on the first substrate 10, wherein a fourth electrode 16 is provided (extending on the substrate 13 finger type electrode lines), wherein the second electrode 14 and the fourth electrode 16 are arranged such that the second electrode 14 and the fourth electrode 16 are essentially arranged parallel to each other on the second substrate 13, wherein the first electrooptical device 9 and the second electrooptical device 12 are facing each other, wherein the first electrooptical device 9 and the second electrooptical device 12 are arranged in a predefined distance 17 to each other, and wherein in a free space 18 between the first electrooptical device 9 and the second electrooptical device 12 a voltage sensitive electrooptical material 19 is arranged.

In particular, the voltage sensitive electrooptical material 19 is a liquid crystalline mixture.

In particular, Fig. 2 shows that the free space 18 of the sensing device 2 may be filled with an electrooptical material 19 such as a liquid crystal (LC) with molecules aligned in a specific angle α , ranging from 0 to 90 degrees with respect to the x-axes, typical in the z-x-plane, with respect to the substrates 10, 13 and electro fingers. The choice of parameters (R_s , D , d , w , and g) is critical to ensure adequate operation of the device without phase discretization and with highest possible efficiency, the space d within the electro fingers on a given substrate 10, 13 must be less than or comparable with the fringing field, which is at the order of the substrate separation D .

According to an embodiment, operating signals for the first electrode 11 and the third electrode 15 are generated with the same first electrical potential (voltage) and/or operating

signals for the second electrode 14 and the fourth electrode 16 are generated with the same second electrical potential (voltage), different from the first electrical potential. Therefore, the generated predominant field may be perpendicular to the substrates 10, 13, except in the close vicinity of finger electrodes. In this way, the LC molecules may be manipulated easily, particularly with respect to the normal of substrates. In contrast, when electric potentials of the first electrode 11 and the third electrode 15 are not equal and electric potentials of the second electrode 14 and the fourth electrode 16 are not equal, but half of the voltages of the first electrode 11 and the third electrode 15 are equal to half of the voltages of the second electrode 14 and the fourth electrode 16, then the dominant field may be parallel to the substrate 10, 13 along the x-axis (except in the close vicinity of finger electrodes), and perpendicular to the fingers, which are parallel to the y-axis. In this way, the LC molecules may be manipulated easily, particularly in the plan of substrates.

Fig. 3 shows another schematic view according to a sensing device 2. According to the shown embodiment, two or more side electrodes 21, 22 may be added to the sensing device 2 for an even better manipulation. However, they must be out of the working zone to avoid the attenuation of the radiation since these side electrodes 21, 22 may be parallel to its field. In a different embodiment, multiple segments of such structures may be built on the same substrates 10, 13 and used with individual segment control, for example, for rate application. Therefore, additional side electrodes 21, 22 are arranged outside the area of radiation transmission to complement the electrical field generated by the first electrooptical device 9 and the second electrooptical device 12.

Fig. 4 shows another schematic side (cross-sectional) view according to an embodiment of a sensing device 2. According to the shown embodiment, the first electrooptical device 9 is arranged tilted relatively to the second electrooptical device 12. In particular, the two substrates 10, 13 of the electrooptical devices 9, 12 may be tilted with respect to each other. This may create an electrically tunable wedge-type device, introducing different (dynamically controllable) phase delays depending upon the position, in particular the thickness of the cell. This may allow a dynamic steering of radiation. If the tilt must be permanent, then the use of electrodes or liquid crystal material may not be necessary. One can mold such structures per need and use them as lamination substrates for radar, lidar, camera or other devices.

In particular, the shown embodiment may be used for an arrangement 23 (Fig. 1), wherein the arrangement 23 comprises at least the sensing device 2 and the electrical field generating device 6 and/or the electrical field receiving device 7. In particular, the electrode 11, 14, 15, 16 may be arranged essentially perpendicular to the generated and/or received

electrical field. Furthermore, the arrangement 23 is configured for generating and/or receiving an electrical field in at least a GHz-Spectrum or higher. Furthermore, the arrangement 23 is configured as a radar sensor.

Furthermore, Fig. 2 and Fig. 3 show that at least the first electrode 11 and/or the second electrode 14 are comprising a layer of Indium Tin Oxide (ITO) and/or copper and/or gold and/or silver and/or carbon nano tubes and/or silver nano wires and/or a conductive polymer. Furthermore, it is shown that the at least four electrodes 11, 14, 15, 16 are arranged on each substrate 10, 13 for each electrooptical device 9, 12 allowing the generation of additional electric field with essential component that is parallel to substrate 10, 13 and the electrical field of transmitted radiation.

In particular, the substrate 10, 13 is a transparent substrate 10, 13. Furthermore, it is shown that each of the electrodes 11, 14, 15, 16 comprises fingers of electrodes, wherein each finger of the electrodes 11, 14, 15, 16 on each electrooptical device 9, 12 is arranged interlocked.

Reference signs

1	motor vehicle
2	sensing device
3	sending device
4	surroundings
5	receiving device
6	electrical field generating device
7	electrical field receiving device
8	electronic computing device
9	first electrooptical device
10	first substrate
11	first electrode
12	second electrooptical device
13	second substrate
14	second electrode
15	third electrode
16	fourth electrode
17	distance
18	free space
19	voltage sensitive electrooptical material
20	fingers
21	first side electrode
22	second side electrode
23	arrangement
x	x-axis
y	y-axis
z	z-axis
α	angle

Claims

1. A sensing device (2), comprising a first electrooptical device (9) with at least a first substrate (10) and at least a first electrode (11) on the first substrate (10), and comprising a second electrooptical device (12) with at least a second substrate (13) and a second electrode (14) on the second substrate (13), characterized in that,
a third electrode (15) on the first substrate (10) is provided, wherein the first electrode (11) and the third electrode (15) are non-uniform electrodes, and wherein the first electrode (11) and the third electrode (15) are arranged such, that the first electrode (11) and the third electrode (15) are essentially arranged in parallel to each other on the first substrate (10), wherein a fourth electrode (16) on the second substrate (13) is provided, wherein the second electrode (14) and the fourth electrode (16) are non-uniform electrodes, and wherein the second electrode (14) and the fourth electrode (16) are arranged such, that the second electrode (14) and the fourth electrode (16) are essentially arranged in parallel to each other on the second substrate (13), wherein the first electrooptical device (9) and the second electrooptical device (12) are facing each other, wherein the first electrooptical device (9) and the second electrooptical device (12) are arranged in a predefined distance (17) to each other, and wherein in a free space (18) between the first electrooptical device (9) and the second electrooptical device (12) a voltage sensitive electrooptical material (19) is arranged.
2. A sensing device (2) according to claim 1, characterized in that
the voltage sensitive electrooptical material (19) is a liquid crystalline mixture.
3. A sensing device (2) according to claim 1 or 2, characterized in that
operating signals for the first electrode (11) and the third electrode (15) are generated with the same voltage and/or operating signals for the second electrode (14) and the fourth electrode (16) are generated with the same voltage.
4. A sensing device (2) according to claim 3,

characterized in that

operating signals for the first electrode (11) and the third electrode (16) are generated with a first voltage and operating signals for the second electrode (14) and the fourth electrode (16) are generated with a second voltage, wherein the second voltage is different to the first voltage.

5. A sensing device (2) according to any one of claims 1 to 4, characterized in that additionally at least two side electrodes (21, 22) facing the voltage sensitive electrooptical material (19) are arranged on the sensing device (2).
6. A sensing device (2) according to claim 5, characterized in that additional side electrodes (21, 22) are arranged outside the area of radiation transmission to complement the electrical field generated by the first electrooptical device (9) and the second electrooptical device (12).
7. A sensing device (2) according to any one of claims 1 to 6, characterized in that the first electrooptical device (9) is arranged tilted relatively to the second electrooptical device (12).
8. A sensing device (2) according to any one of claims 1 to 7, characterized in that each of the electrodes (11, 14, 15, 16) comprise fingers (20) of the electrodes (11, 14, 15, 16), wherein each finger (20) of the electrodes (11, 14, 15, 16) on each electrooptical device (9, 12) are arranged interlocked.
9. A sensing device (2) according to any of claims 1 to 8, characterized in that the substrate (10, 13) is a transparent substrate.
10. A sensing device (2) according to any of claims 1 to 9, characterized in that at least the first electrode (11) and/or the second electrode (14) are comprising a layer of Indium Tin Oxide and/or copper and/or gold and/or silver and/or carbon nano tubes and/or silver nano wires and/or a conductive polymer.

11. A sensing device (2) according to any of claims 1 to 10, characterized in that
at least four electrodes (11, 14, 15, 16) are arranged on each substrate (10, 13) of each electrooptical device (9, 12) allowing the generation of additional electric field with essential component that is parallel to the substrates (10, 13) and to the electric field of transmitted radiation.
12. An arrangement (23) for a sensing device (2) comprising at least a sensing device (2) according to any of claims the 1 to 11 and at least one electrical field generating device (6) and/or an electrical field receiving device (7).
13. An arrangement (23) according to claim 13, characterized in that
the electrodes (11, 14, 15, 16) are arranged essentially perpendicular to the generated and/or received electrical field.
14. An arrangement (23) according to claim 13 or 14, characterized in that
the arrangement (23) is configured for generating and/or receiving an electrical field in at least a GHz-Spectrum or higher.
15. An arrangement (23) according to claim 15, characterized in that
the arrangement (23) is configured as a radar sensor.

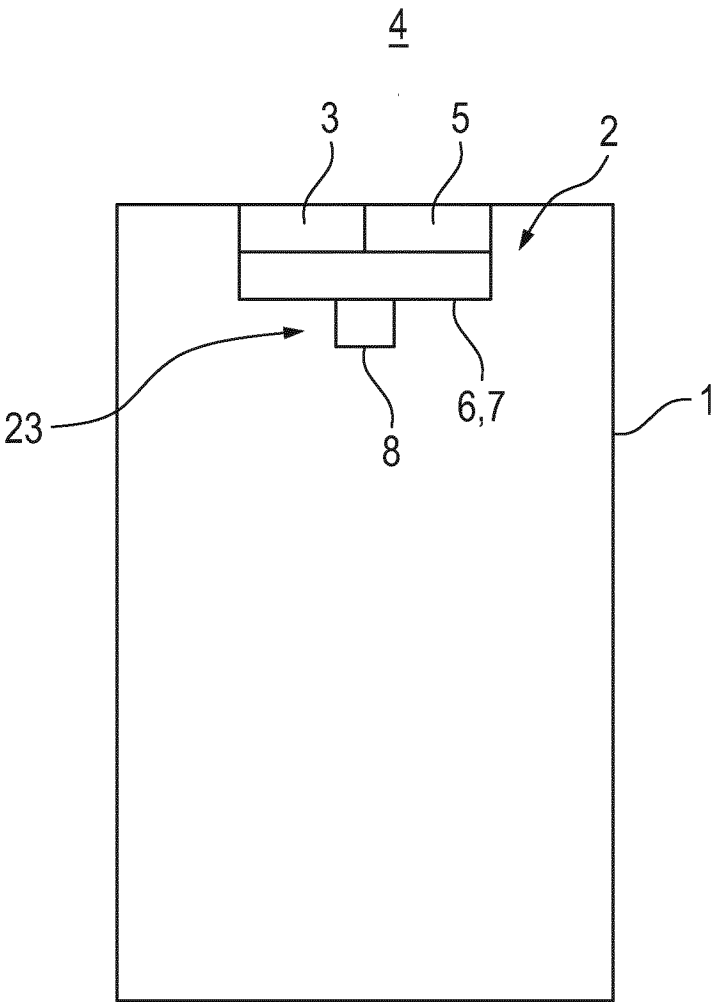


Fig. 1

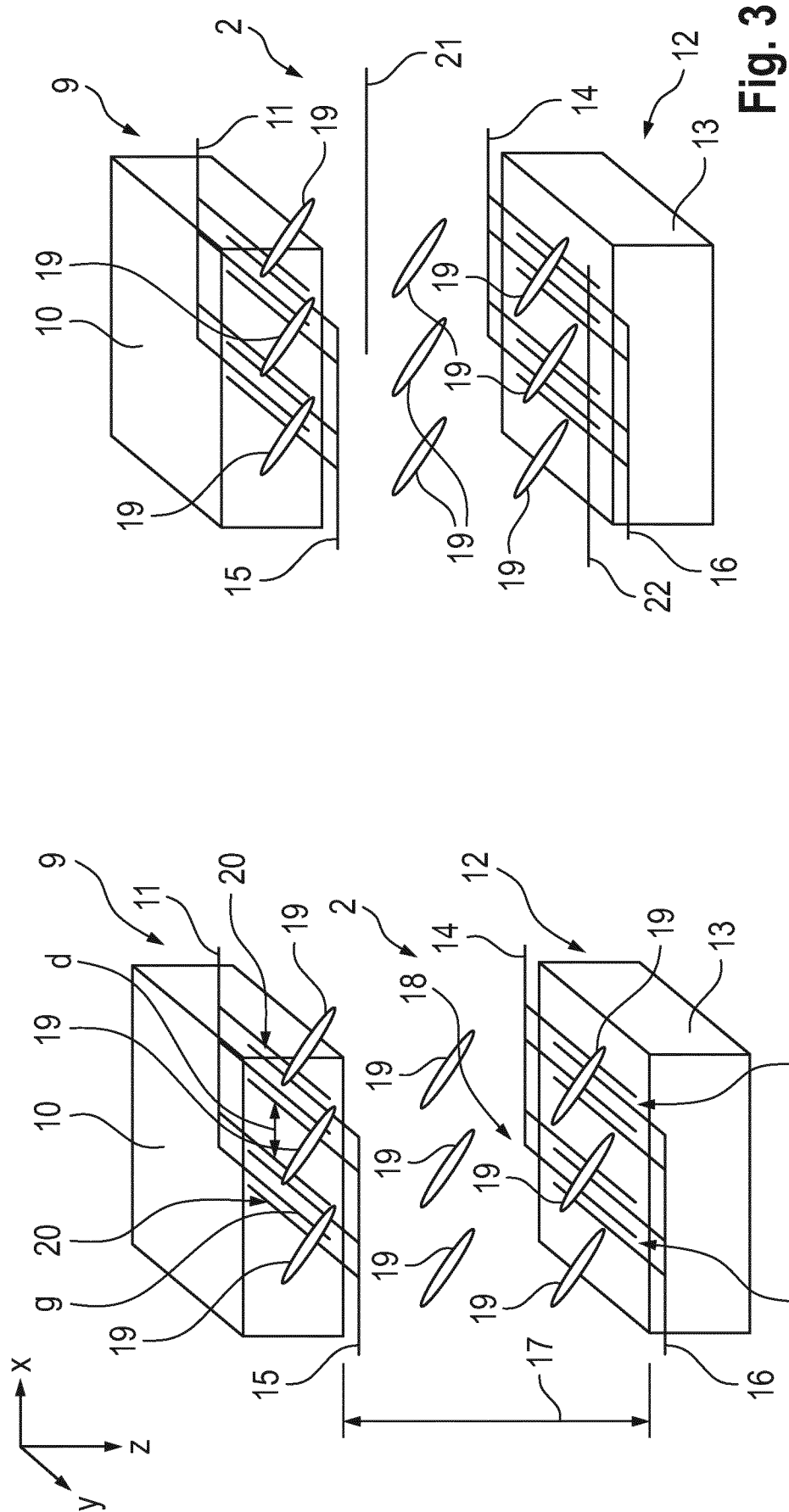


Fig. 2

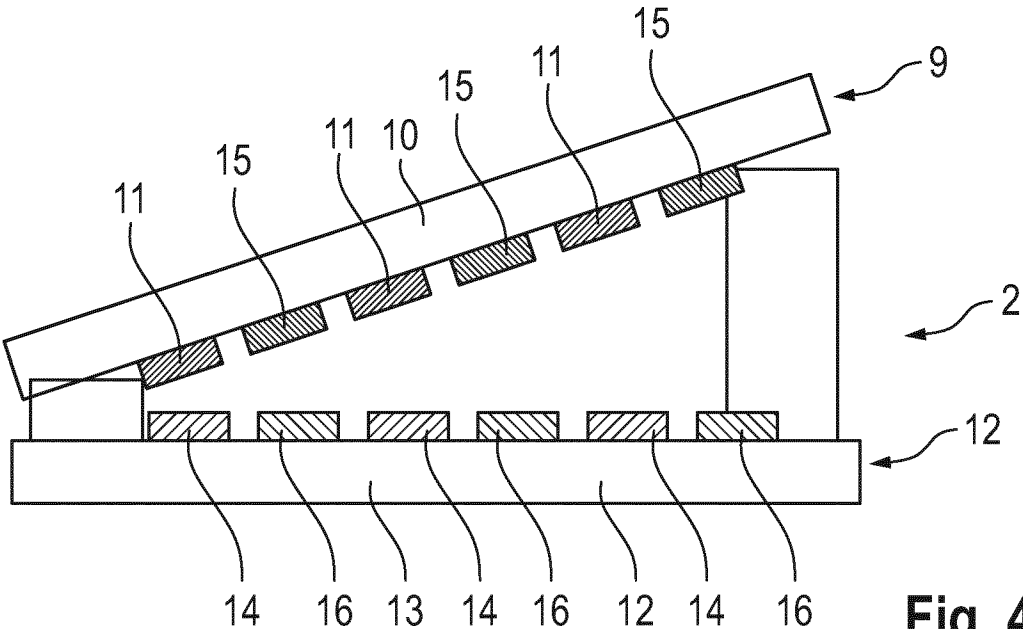


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/073412

A. CLASSIFICATION OF SUBJECT MATTER INV. G02F1/29 G01S17/88 G06F3/044 ADD.		
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) G02F G01S G06F		
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		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 18 March 2024		Date of mailing of the international search report 25/03/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Votini, Stefano

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