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(54) Method and apparatus for aligning a filter onto a color charge-coupled device imager

(57) A filter is mounted on a surface of the substrate of a charge-coupled device imager (34) by mounting the imager on a chuck (12) of an aligner. The imager (34) is sufficiently thin to be transparent to visible light. The chuck is supported for x-y-θ and vertical movement. Some adhesive is applied to the surface of the imager substrate. The filter which is mounted on a holder (90) is placed on the substrate surface over the adhesive. The chuck is moved vertically upwardly until the filter holder is within a gimbal (40,42) mounted over the chuck, and the filter holder is secured in the gimbal. The chuck is moved vertically upward slightly to cause the adhesive to spread out between the imager substrate and the filter and to cause the filter to become parallel to the imager substrate. A light beam (from 96) is then directed through the imager substrate and the filter from below the imager substrate. The light is viewed through a microscope (56) which is above the filter. While viewing the filter and imager through the microscope, the imager is moved with respect to the filter in the x, y and θ directions until the filter pattern is aligned with the imager array. The adhesive is then cured to secure the filter in proper position on the imager.

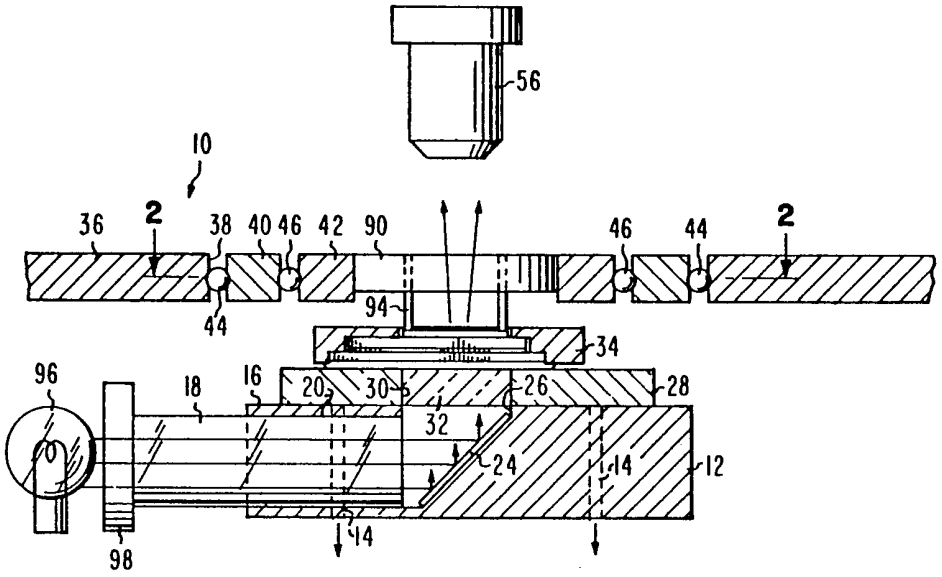

Fig. 1

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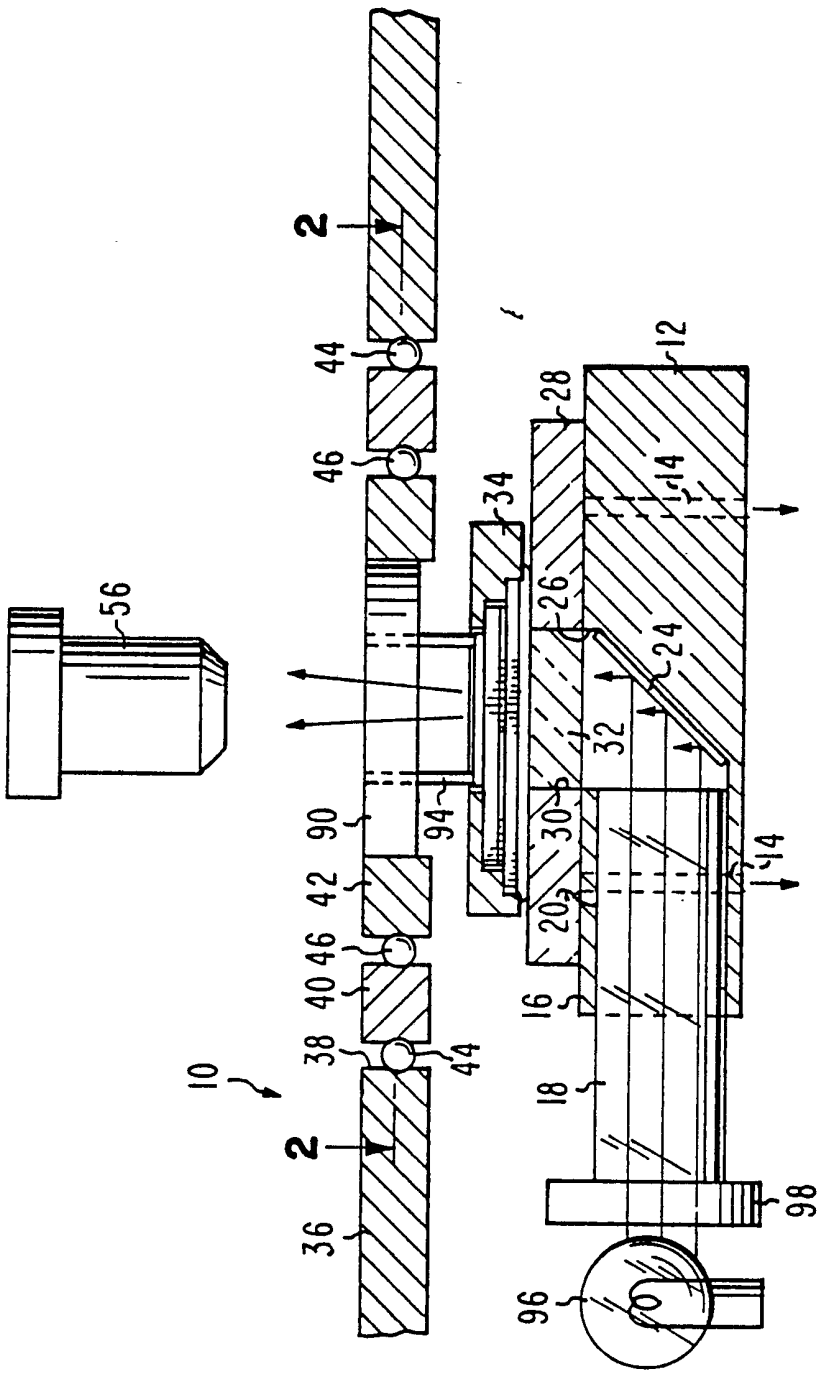
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2
36
98
96

Fig. 1

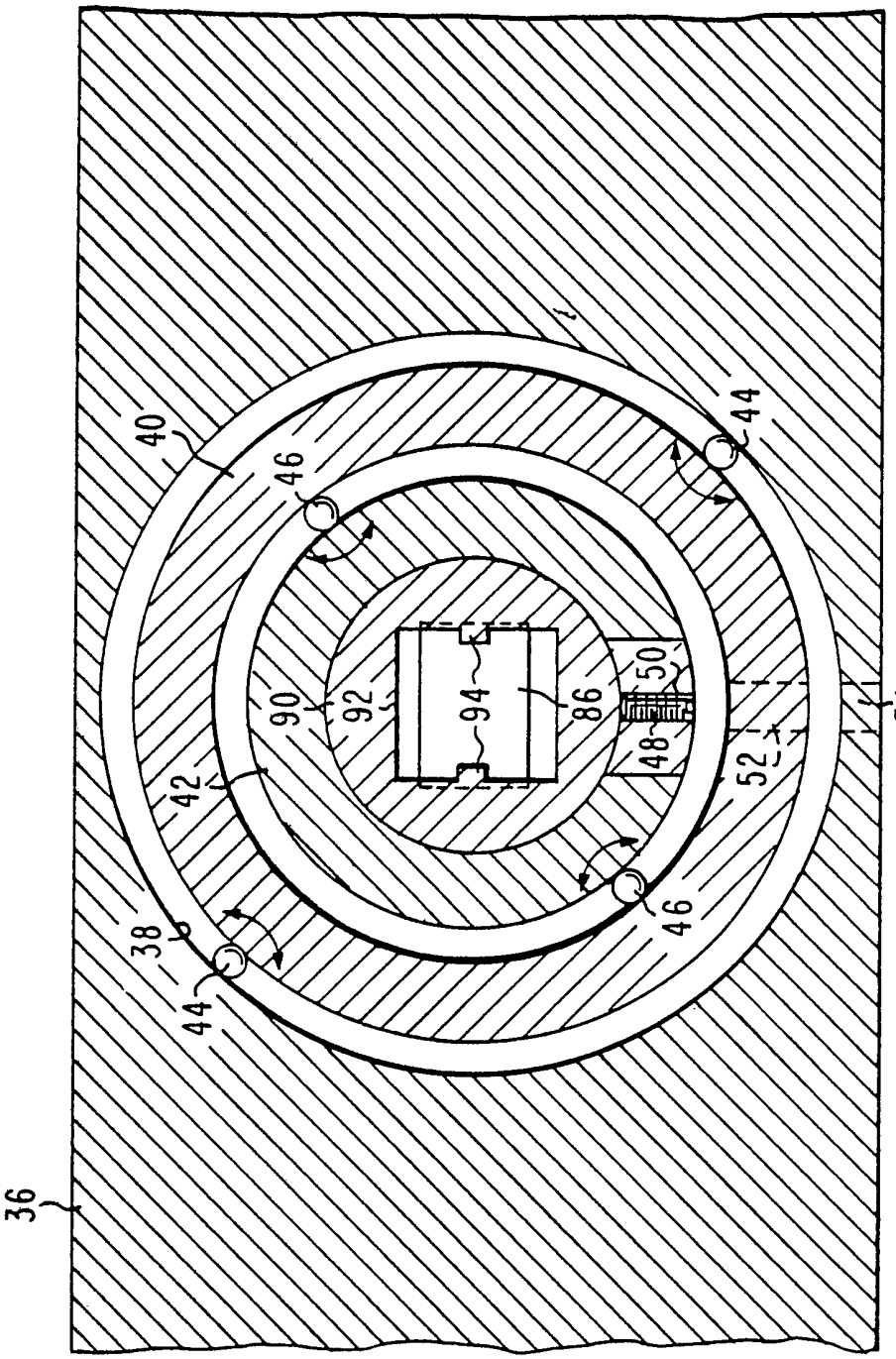

Fig. 2

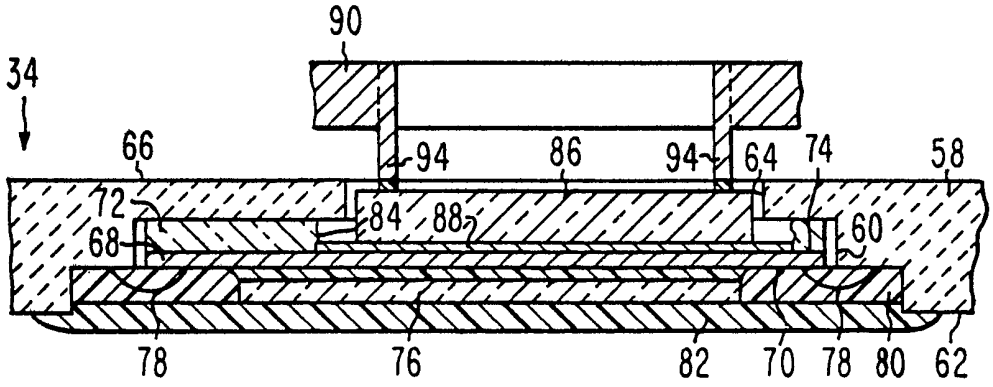
90
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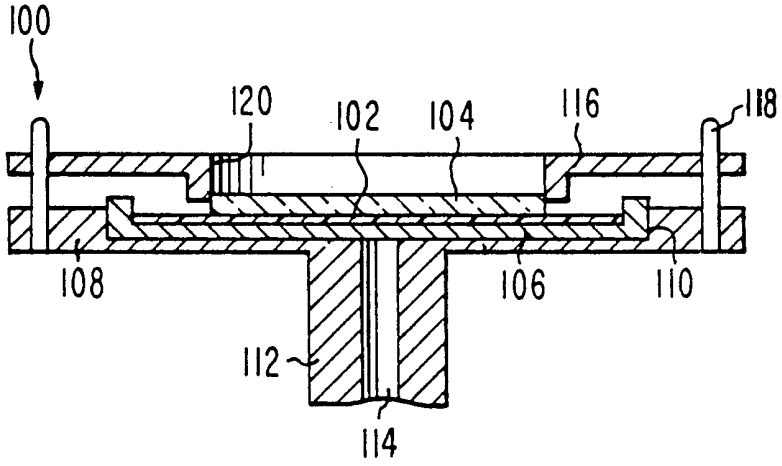
Fig. 3


100
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114

Fig. 4

SPECIFICATION

Method and apparatus for aligning a filter onto a color charge-coupled device imager

The present invention relates to a method and apparatus for use in fabrication of a single chip color charge-coupled device (CCD) imager. More particularly, the present invention relates to a method and apparatus for aligning a color filter on a CCD imager.

A CCD imager in general comprises a substrate of single crystalline silicon having therein three sections: a photosensing array, known as the A-register; a temporary storage array, known as the B-register; and an output register, known as the C-register.

The CCD imager is generally mounted in a housing having an opening or window therein. The imager substrate is mounted in the housing so that the A-register is aligned with the window and is exposed to the area to be detected, and so that the E-register and the C-register are covered by the housing. This imager produces an image in black and white.

To provide an image in color, initially three CCD imagers were used. The imagers were mounted on a prism which divided the incoming image into three primary colors with each color being detected by a separate imager. The output signals from each of the imagers were combined electrically to reproduce the original image in color. Such a device is shown in U.S. Patent No. 4,323,918 to Sidney L. Bendall, entitled "Optical Assembly For Color Television", issued April 6, 1982. However, such devices are complex and difficult to manufacture since they require an exact alignment of the three imagers with the incoming image to insure a proper output.

A more recent technique for achieving a color image is to mount a three color filter directly on the CCD imager over the A-register. The filter is generally a flat glass substrate having thereon a stripe or mosaic pattern of filter materials for the three primary colors. The filter substrate is bonded to the substrate of the CCD imager with a suitable cement.

One type of CCD imager requires the radiation being detected to pass through the silicon substrate to the CCD array. To allow the radiation to pass more easily through the substrate, the substrate is made very thin by removing portions of the substrate from its surface opposite to the surface on which the CCD array is formed, i.e. the back surface after forming the CCD array. In order to provide support for such a thin substrate a glass plate is bonded to the back surface of the thinned substrate. An imager which includes a thinned silicon substrate and a glass support plate is shown in U.S. Patent-No. 4,266,334 to T. W. Edwards et al., issued May 12, 1981 entitled, "Manufacture of Thinned Substrate Imagers". To make a color imager with this type of CCD imager, the portion of the glass support plate over the A-register is removed and the filter is bonded directly to the exposed back surface of the CCD substrate. A problem in mounting the filter on the substrate of the CCD imager is to achieve good alignment of the filter pattern with the pattern of the CCD array and, once such alignment is achieved, to secure the filter to the imager substrate. However, since the substrate of the CCD imager is so thin, this mounting must be achieved without breaking or otherwise damaging the thin silicon substrate of the CCD imager.

In accordance with one aspect of the present invention a filter which includes a transparent substrate having a pattern of color filters on a surface thereof is mounted on a charge-coupled device imager which includes a substrate of single crystalline silicon which is sufficiently thin to be transparent to radiation from an image and having a pair of opposed major surfaces with the charge-coupled device array being on one of the major surfaces by supporting the imager with the other major surface of the imager substrate being exposed and placing a bonding material on the other major surface. The filter substrate is then placed on the bonding material. A beam of light is directed through the substrate from the one major surface of the imager substrate. The substrates are then moved with respect to each other while viewing them from the filter surface until the filter pattern is aligned with the charge-coupled device array. The bonding material is then cured to secure the filter to the imager device.

An apparatus for use in mounting the filter substrate on the imager substrate includes chuck means adapted to be mounted on a table having x-y-θ and vertical movement. The chuck means includes an opening in its upper surface and means for directing a beam of light through the opening. An imager holder having a window therein through which light can pass is adapted to be mounted on the chuck means. Above the imager holder is means for supporting a filter in vertical fixed position. Above the filter support means is means for viewing the light directed upwardly from the chuck means.

In the accompanying drawings:

FIGURE 1 is a schematic view of a portion of an aligner which incorporates the present invention for carrying out the method of the present invention.

FIGURE 2 is a sectional view taken along line 2-2 of FIGURE 1.

FIGURE 3 is a sectional view of a CCD imager assembly having a filter mounted thereon in accordance with the present invention.

FIGURE 4 is a schematic view of another apparatus which is used in addition to the aligner shown in FIGURES 1 and 2 to carry out a modification of the method of the pre-

sent invention.

Referring to FIGURES 1 and 2, there is shown a portion of an aligner, generally designated as 10, which can be used to carry out the method of the present invention. The aligner 10 includes a vacuum chuck 12 having passages 14 therethrough to the upper surface 16 through which a vacuum can be drawn to hold an article on the surface 16. The vacuum chuck 12 is mounted on an x-y-θ table of a standard aligner. The x-y-θ table of the aligner allows the chuck to be moved in the x direction, y direction and to be rotated. The aligner table is also capable of being moved vertically upwardly and downwardly. A light pipe 18 extends through a horizontal passage 20 in the vacuum chuck 12 to an angled mirror 24 at the center of the vacuum chuck 12. The mirror 24 reflects light passing through the light pipe 18 vertically upwardly through an opening 26 in the upper surface 16 of the vacuum chuck 12.

A CCD holder 28 is mounted on the top surface 16 of the vacuum chuck 12 and is secured to the vacuum chuck 12 by the vacuum drawn through the openings 14. The CCD holder 28 is a metal plate having a central opening 30 therethrough and a glass window 32 secured in the opening 30. The CCD holder 28 is mounted on the chuck 12 with the glass window 32 being directly over the opening 26 so that the light from the light pipe 18 is reflected by the mirror 24 through the window 32. A CCD imager assembly 34, which will be described in detail later, is mounted on the holder 28.

A support plate 36 extends horizontally over the vacuum chuck 12 and is securely mounted on the aligner. The support plate 36 has a circular opening 38 therethrough over the chuck 12. A gimbal is mounted within the opening 36. The gimbal includes a pair of concentric rings 40 and 42 within the opening 38. The outer ring 40 is supported in the opening 38 by a pair of diametrically opposed ball bearings 44 which are between the outer surface of the outer ring 40 and the surface of the opening 38. This allows for pivotation of the outer ring 40 with respect to the plate 36 about an axis which extends along the diameter passing through the bearings 44. The inner ring 42 is supported in the outer ring 40 by a pair of diametrically opposed ball bearings 46 which are between the outer surface of the inner ring 42 and the inner surface of the outer ring 40. Thus, the inner ring 42 is pivotable along an axis which extends along the diameter which extends through the ball bearings 46. The ball bearings 46 extend along a diameter which is perpendicular to the diameter which extends through the ball bearings 44 so that the gimbal provides motion along two different axes. As shown in FIGURE 2, a set screw 48 is threaded through an opening 50 in the inner ring 42. The outer ring 40 and the plate 36 have aligned openings 52 and 54 therethrough to allow access to the set screw 48. A microscope, the objective 56 of which is shown in FIGURE 1, is mounted over the vacuum chuck 12 with the objective 56 being aligned with the opening through the inner ring 42 of the gimbal.

Referring to FIGURE 3, the CCD imager assembly 34 includes a housing 58 of a ceramic material having a stepped recess 60 in one surface 62 thereof and a window opening 64 through the bottom of the recess 60 to the other surface 66 of the housing 58. Within the recess 60 is the CCD imager which includes a thin substrate 68 of single crystalline silicon having the registers of the imager along the front surface 70 thereof. A glass support plate 72 is secured to the back surface 74 of the substrate 68. A glass cover plate 76 extends across and is secured to a portion of the front surface 70 of the substrate 68. The CCD imager is seated in the recess 60 with the support plate 72 being on the bottom of the recess 60. Connecting wires 78 extend between and are bonded to terminal pads on the front surface 70 of the substrate 68 and terminal pins (not shown) on the housing 58. A plastic encapsulant 80 fills the recess 60 around the CCD imager and encompasses the wire 78. A cover layer 82 of a plastic material extends across the opened end of the recess 60 to seal the CCD imager within the recess 60. The support plate 72 has an opening 84 therethrough in alignment with the window opening 64 in the housing 58 and over the A-register of the CCD imager.

A filter 86 extends through the window opening 64 and the opening 84 in the support plate 72 and is secured to the back surface 74 of the substrate 68 by a thin layer 88 of a suitable adhesive. The adhesive layer 88 should be thin and of substantially uniform thickness to allow radiation to pass therethrough easily and to have the filter pattern as close as possible to the CCD array. However, the adhesive layer 88 must be thick enough to obtain a good bond between the filter 86 and the substrate 68. The filter 86 is a glass plate having on a surface thereof layers of a filter material which are arranged in a pattern corresponding to the pattern of the CCD photosensing array in the A-register of the imager.

To mount the filter 86 on the imager and align the filter with the A-register of the imager in accordance with the method of the present invention, the CCD imager assembly 34, without the filter 86 thereon, is mounted on the CCD holder 28 with the cover layer 82 being seated on the window 32 and the housing window opening 64 facing upwardly. The terminal pins of the imager assembly 34 are inserted in openings in the top surface of the CCD holder 28 to position the imager assembly 34 with the A-register of the imager and the window opening 64 being over and

aligned with the glass window 32 of the holder 28.

The filter 86 is mounted on a filter holder 90. The filter holder 90 is a circular plate having a rectangular opening 92 through the center thereof and a pair of fingers 94 extending downwardly from two opposed sides of the opening 92. The filter 86 is secured to the ends of the fingers 92, such as with a suitable adhesive preferably a UV-curable adhesive having a low viscosity (about 300-500 centipoise). Suitable adhesives include Norland 61 made by Norland Products, Inc., North Brunswick, New Jersey and Vitralit DAL, made by 3M Company, St. Paul, Minnesota. A few drops of the adhesive are applied to the back surface 74 of the substrate 68 which is exposed through the housing window 64 and opening 84 in the support plate 72. The filter 86 is inserted through the housing window 64 and seated on the substrate 68. The pressure of the filter 86 on the drops of adhesive cause the adhesive to spread out over the interface between the substrate 68 and the filter 86 to form a thin, less than 5 microns in thickness, layer of the adhesive layer 88. The table on which the vacuum chuck 12 is mounted is then lifted vertically upwardly until the filter holder 90 fits within the inner ring 42 of the gimbal. The filter holder 90 is then locked into the gimbal by the set screw 48. A slight pressure can be applied to the filter 86 by raising the table slightly. The gimbal mount enables the filter 86 to adjust itself to be parallel to the back surface 74 of the substrate 68 without exerting undue localized pressure on the mechanically weak thinned substrate 68. This also causes the adhesive to spread out between the filter 86 and the substrate 68 to achieve the desired thin layer of substantially uniform thickness.

The light source 96 is then turned on to direct a beam of light through a yellow filter 98 into an end along the light pipe 18. The light is then reflected by the mirror 24 through the substrate 66 and filter 86 to the objective 56 of the microscope. Since the silicon substrate 68 and the glass filter plate are transparent and the structure forming the CCD photosensing array and the filters are at least partially opaque, the patterns of the filters and the CCD array can be viewed through the microscope. By using the x-y-θ table on which the vacuum chuck 12 is mounted, the CCD imager substrate 68 can be moved with respect to the filter 86 until the filter pattern is aligned with the CCD photosensing pattern.

Once alignment is achieved, the adhesive layer 88 is cured. By using a UV-curable adhesive, the adhesive layer 88 can be quickly cured by exposing the assembly to UV radiation. The CCD image assembly 34 and the filter holder 90 are then removed from the aligner 10 and the filter holder 90 is removed from the CCD imager assembly 34 using heat or a suitable solvent or the adhesive used to hold the filter 86 to the filter holder 90. Thus, the method and apparatus of the present invention provide for mounting the filter on the CCD imager and aligning the filter pattern with the photosensing array pattern accurately and without causing damage to the very thin substrate 68 of the imager.

The CCD imager is made by forming a plurality of the imagers on a relatively large, thick wafer of single crystalline silicon. After the imagers are formed along one surface of the wafer, the wafer is thinned from the other surface a glass plate is mounted on the back surface of the thinned substrate and the substrate and glass laminate is then cut into the individual CCD imagers as described in the Edwards et al. Patent No. 4,266,334. Although the method of the present invention has been described with regard to mounting and aligning a single filter on a single CCD imager, the method of the present invention can also be used for mounting a large glass plate having a plurality of filter arrays thereon onto a wafer having a plurality of CCD imagers formed thereon. The adhesive layer 88 between the filter 86 and the CCD imager substrate 68 should be relatively thin and of uniform thickness.

FIGURE 4 shows an apparatus 100 which is suitable for achieving a thin adhesive film 102 of uniform thickness between a large glass plate 104 having the filter patterns thereon and a large wafer 106 containing the CCD arrays. The apparatus 100 includes a chuck plate 108 having a recess 110 in its upper surface. The recess 110 is of a size and shape to receive the wafer 106. The chuck plate 108 is mounted on the end of a shaft 112 whose axis is perpendicular to the chuck plate 108 and extends to the center of the chuck plate. The shaft 112 has a passage 114 extending longitudinally therethrough to the bottom of the recess 110. A filter holder plate 116 is mounted on guide pins 118 projecting from the top surface of the chuck plate 108. The filter holder plate 116 has a rectangular opening 120 in the center thereof which is adapted to receive the filter 104.

To mount the filter 104 on the wafer 106, the wafer 106 is seated in the recess 110 and a vacuum is pulled through the passage 114 to hold the wafer 106 in the recess 110. Some adhesive, which is preferably a UV-curable adhesive, is applied to the substrate 106 and the filter 104 is placed on the adhesive and is held in position on the wafer 106 by the filter holder plate 116. The filter 104 is positioned on the wafer 106 by the filter holder plate 116 so that the filter pattern is substantially aligned with the CCD arrays on the wafer 106. The shaft 112 is then rotated about its longitudinal axis to spin the wafer 106, adhesive, and the filter 104. This spinning action causes the adhesive to spread ra-

dially outwardly between the filter 104 and the wafer 106 to form a thin layer 102 of the adhesive which is of uniform thickness along the entire area of the filter 104. Any excess adhesive builds up around the outer periphery of the substrate 106 outside the edge of the filter 104. The final thickness of the adhesive layer 102 will be determined by the speed and duration of the rotation. The assembly of the filter 104 and the wafer 106 is then removed from the apparatus 100 and placed in an aligner of the type shown in FIGURE 1.

Using the method previously described, the wafer 106 is then moved with respect to the filter 104 until the filter pattern is completely aligned with the CCD array. The adhesive layer 102 is then hardened, such as by subjecting it to UV radiation, to complete the assembly. The wafer-filter assembly can then be cut apart into the individual imager devices having a filter thereon for packaging in a desired housing.

It is to be noted that in FIGURE 1 the gimbal bearings 44 and 46 have been shown in peripherally displaced positions relatively to the rings 40 and 46 for illustrative purposes.

CLAIMS

1. A method of mounting a filter which includes a transparent substrate having a pattern of color filters on a surface thereof onto a charge-coupled device imager which includes a substrate of single crystalline silicon sufficiently thin to be transparent to radiation from an imager having a pair of opposed major surfaces with the charge-coupled device array being at one of the major surfaces, comprising the steps of

(a) supporting the imager with at least a portion of the other major surface of the imager substrate being exposed,

(b) placing a bonding material on the other major surface of the imager substrate,

(c) placing the filter substrate on the bonding material,

(d) directing a light beam through the substrate from the one major surface of the imager substrate,

(e) while viewing the substrate from the filter side moving the substrate with respect to each other until the filter pattern is aligned with the charge-coupled device array, and then

(f) curing the bonding material.

2. A method in accordance with Claim 1 including pressing the imager substrate against the filter substrate to spread the bonding material along the opposed surfaces of the substrates.

3. A method in accordance with Claim 2 in which the filter substrate is supported in a gimbal device when the imager substrate is pressed against the filter substrate so that the filter substrate adjust to a position parallel with the other major surface of the imager substrate.

4. A method in accordance with Claim 1 in which after the filter is placed on the bonding material the substrates are rotated about an axis perpendicular to the said surfaces of the substrates to spread the bonding material across the opposed surfaces of the substrates.

5. A method in accordance with any preceding claim in which the bonding material is a UV-curable adhesive and after the two substrates are aligned the device is subjected to UV radiation to cure the adhesive.

6. Apparatus for mounting a filter which includes a substrate having a pattern of color filters on a charge-coupled device imager comprising

(a) chuck means adapted to be mounted on a table having x-y-θ and vertical movement, said chuck means including an opening in its upper surface and means for directing a light beam through said opening,

(b) an imager holder adapted to be mounted on said chuck means and having a window therein through which the light beam from the chuck can pass,

(c) means above the imager holder for supporting a filter in a vertical fixed position, and

(d) means above the filter support means for viewing the light directed upwardly from its chuck means.

7. Apparatus in accordance with Claim 6 in which the means above the imager holder includes a support plate having an opening therethrough and a gimbal mounted in the opening and adapted to support the filter and allow pivotation of the filter along two separate axes which are perpendicular to each other.

8. Apparatus in accordance with Claim 7 in which the gimbal includes two concentric rings mounted in the opening in the support plate, a first pair of diametrically opposed ball bearings between the outer ring and the wall of the opening in the support plate to support the outer ring in the support plate for pivotation about an axes passing through the first ball bearings, and a second pair of diametrically opposed ball bearings between the inner ring and the outer ring to support the inner ring for pivotation about an axis passing through the second ball bearings, the axis passing through the second ball bearings being perpendicular to the axis passing through the first ball bearings.

CLAIMS

Amendments to the claims have been filed, and have the following effect:

New or textually amended claims have been filed as follows:9. Apparatus in accordance with Claim 8 including a filter holder adapted to be secured to a filter and mounted in the gimbal, said filter holder comprising a plate having an opening therethrough and fingers extending from the edges of the opening.

10. Apparatus in accordance with Claim 6 in

which the means for directing a light beam through the opening in the chuck includes a light pipe extending through the chuck to a position beneath the opening and a mirror at the end of the light pipe and adapted to reflect light from the light pipe through the opening in the chuck.

11. Apparatus in accordance with Claim 9 in which the chuck is a vacuum chuck and has passages therethrough to its upper surface through which a vacuum can be drawn to hold the imager holder on the chuck.

12. A method of mounting a filter substantially as hereinbefore described.

13. Apparatus for mounting a filter substantially as hereinbefore described and shown with reference to Figs. 1 to 4 of the accompanying drawings.

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