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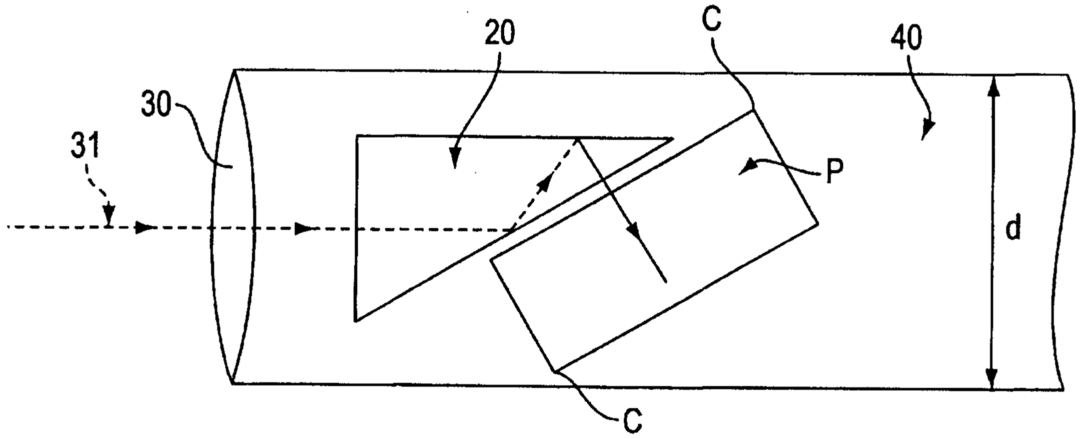

(57) Abstract

A minimized image-sensing device has a housing with an objective lens that collects light from an object and focuses an image of the object toward a Littrow prism having angles of 30, 60 and 90 degrees. A solid state image sensor chip having an array of silicon-based light sensitive pixels is located along the hypotenuse of the prism such that the pixel array receives the focused image transmitted through the prism.

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IMAGING DEVICE HAVING MINIMIZED PACKAGING OF REMOTE SENSORS FOR VIDEO IMAGING AND THE LIKE

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The present invention relates generally to remote imaging, such as used in the medical and other industries, and relates more particularly to the minimization of the package size of the imaging sensors and optics used within imaging devices and more specifically within electronic imaging devices incorporating fiber optic illumination.

2. Description Of The Related Art

The following description of the related art is based on the knowledge of the present inventors, and certain aspects discussed herein are not necessarily prior art to the present invention.

Remote imaging with a small, solid state video camera and a fiber optic illumination system is known in the medical and other industries. These known devices are used, for example, in minimally-invasive diagnostics and surgery and in the industrial inspection of pipelines, airplane engines and the like. One exemplary earlier device is disclosed in U.S. Patent No. 4,074,306 entitled ENDOSCOPE UTILIZING COLOR TELEVISION AND FIBER OPTICS TECHNIQUES, the entire disclosure of which is incorporated herein by reference as background to this invention.

In practice, a video camera for such devices is adapted for use with a charged couple device ("CCD"). However, other silicon-based chips, such as CMOS chips (e.g., NFETs and PFETs combined to form complementary MOS circuits), have been considered as applicable to such electronic video systems. In such remote imaging devices, an electronic imaging chip is mounted at the end of a tubular housing. The housing contains a plurality of illumination fibers and wires. The wires electronically transmit an image signal for digital signal processing and for output to a viewing device such as a monitor.

For minimally-invasive surgery, such remote imaging can be used for electronic scopes that provide the surgeon with visual capabilities inside a patient's body. Minimization of the size of such endoscopes is thus highly beneficial. With reference to FIGS. 1(A) and 1(B), intrinsically, the diameter of such a scope E is limited by the sizes of the imaging chip, the imaging chip package P, and the optics O that direct light to the imaging chip. The inner diameter D of the housing of the imaging device, such as an endoscope, needs to be large enough to contain the sensor package P and the optics O. In this regard, the sensor package P can be mounted inside the housing of the imaging device in a number of ways.

FIGS. 1(A) and 1(B) show a first method wherein the sensor package P and imaging chip are mounted perpendicular to the geometric axis A of the housing H of the imaging device, and FIGS. 2(A)-2(E) show additional methods wherein the sensor package P and the imaging chip are mounted parallel to an axis A of the housing H. FIGS. 2(A)-2(E) show a variety of exemplary schemes for mounting the sensor package P parallel to the housing 40. For these parallel imaging chips, these schemes show that an image can be collected by an objective lens at the input end of the remote imaging device and redirected via various optics O, such as single or multiple prisms or mirrors, to the sensor which lies parallel to the axis A of the housing in the sensor package P. These configurations of prisms or mirrors for redirecting the image are designed to minimize the cross-section of the electronic imaging package. These types of schemes are often complex in design, providing some reduction in the overall cross-sectional area in comparison to an end-mounted (i.e., mounted perpendicular to the axis A of the housing) imaging chip and objective lens like that in FIGS. 1(A) and 1(B). However, the resulting reduced-size package is not necessarily sufficiently minimized to produce the smallest possible package outer diameter.

For providing the smallest possible device (e.g., for use inside a patient's body, for use in an industrial device for optical inspection, or the like), minimizing the size of the image sensor addresses only part of the size-reduction problem. The present inventors have found that minimization in existing imaging devices was not sufficiently performed, especially for small electronic cameras, such as for example those on the order of a few millimeters, because, among other things, such did not achieve a minimum package size independent of other components such as illumination fiber optics. Prior to the present invention, wherein the present inventors have discovered and overcome problems in the art, a desired degree of minimization was not available in the art.

SUMMARY OF THE INVENTION

The present invention improves upon the above-noted and other problems in the related art.

The preferred embodiments of the present invention can provide a packaging scheme for a remote imaging device with a solid state sensor chip in a manner to minimize the overall inner diameter of such device. The most preferred embodiments can also provide a package for a solid state chip that can be mass-produced with the current chip fabrication processes without major modifications. The most preferred embodiments can also maximize the diameter of the objective lens housed in the smallest possible package.

The most preferred embodiments combine an electronic sensor both with an objective lens and a Littrow prism for deflecting the image to another axis in such a way that the maximum, overall package size is determined by the length of a diagonal of the image sensor plane and is only slightly larger in diameter than the diagonal. The Littrow prism reflects the image twice providing an upright image without electronic correction. In contrast, a single reflection gives an inverted image which requires complex algorithms for converting the images back to upright. The most preferred embodiments also include an angle-cut on the sensor chip package such that it reduces the diameter of the overall camera package.

According to one aspect of the invention, a minimized image-sensing device is provided that includes: a housing having a geometric axis; an objective lens to collect light from an object and focus an image of the object, the objective lens having an optical axis substantially parallel to the geometric axis of the housing; a solid state image sensor chip having an array of silicon-based light sensitive pixels with electronic signal outputs that are connectable to circuitry for signal processing and output to an image viewing device; the solid state image sensor chip having timing and control circuitry to control the electronic signal outputs; a prism having a triangular cross-section delineated by an input side, a parallel side and a hypotenuse side, the input side being at about a 90 degree angle to the parallel side, the hypotenuse side being at about a 60 degree angle to the input side, and the parallel side and the hypotenuse side forming an angle of about 30 degrees; the prism being juxtaposed between the objective lens and the sensor chip, with the input side generally perpendicular to and aligned with the optical axis of the objective lens and the parallel side generally parallel to a wall of the housing, whereby a focused image from the objective lens can be transmitted through the prism; the sensor chip being oriented along the hypotenuse of the prism with the pixel array arranged to receive the focused image transmitted through the prism.

According to another aspect of the invention, the image sensor chip is contained in a package, the package has generally parallel upper and lower surfaces and two sides between the upper and lower surfaces that are at least partially cut at an angle between about 30 degrees and 90 degrees with respect to the upper and lower surfaces of the package.

According to another aspect of the invention, a minimized image-sensing device is provided that includes: a housing having a geometric axis; an objective lens to collect light from an object and focus an image of the object, the objective lens having an optical axis substantially parallel to the geometric axis of the housing; a prism having a triangular cross-section delineated by an input side, a second side and a hypotenuse side, the input side being at a first angle to the second side of between about 80 and 100 degrees, the hypotenuse side being at a second angle to the input side of between about 45 and 75 degrees, and the second side and the hypotenuse side forming a third angle of between about 15 and 45 degrees; the input side of the prism being aligned with the optical axis of the objective lens so that a focused image from the objective lens can be transmitted through the prism; a solid state image sensor chip arranged generally at the hypotenuse of the prism to receive light transmitted through the prism.

According to another aspect of the invention, a minimized image-sensing device is provided that includes: a housing; an objective lens arranged in the housing to collect light from an object and focus an image of the object, the objective lens having an optical axis; a first reflection surface at an angle of about 30 degrees to the optical axis upon which light from the objective lens is received and reflected by total internal reflection; a second reflection surface upon which light from the first reflection surface is received and reflected; and an image sensor chip arranged behind and generally parallel to the first reflective surface upon which light from the second reflection surface is received after passing through the first reflective surface.

According to yet another aspect of the invention, a minimized image-sensing device is provided that includes: a housing; an objective lens arranged in the housing to collect light from an object and focus an image of the object, the objective lens having an optical axis; a first reflection surface at an angle of between about 15 and 45 degrees to the optical axis upon which light from the objective lens is received and reflected by total internal reflection; a second reflection surface having an angle of between about -15 and 15 degrees to the first reflection surface upon which light from the first reflection surface is received; an image sensor chip arranged at an angle of between about 15 and 45 degrees to the optical axis upon which light from the second reflection surface is received.

The above and other advantages, features and aspects of the present invention will be more readily perceived from the following description of the preferred embodiments thereof taken together with the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the accompanying drawings, in which like references indicate like parts, and in which:

FIG. 1(A) is a side view of an exemplary device having an image sensor package mounted vertically within a housing of a imaging device;

FIG. 1(B) is an end view of the device shown in FIG. 1(A);

FIG. 2(A) is a side view of an exemplary device having an image sensor package mounted horizontally, i.e., parallel to an axis of the housing, within the housing of a imaging device;

FIG. 2(B) is an end view of the device shown in FIG. 2(A);

FIG. 2(C) is a side view of a modified optical device and a modified package for a horizontally mounted sensor package like that shown in FIG. 2(A);

FIG. 2(D) is a side view of another modified optical device and a modified package for a horizontally mounted sensor package like that shown in FIG. 2(A);

FIG. 2(E) is a side view of another modified optical device and a modified package for a horizontally mounted sensor package like that shown in FIG. 2(A);

FIG. 3 is a schematic top view of an exemplary image sensor chip;

FIG. 4 is a schematic side view of an objective lens and a Littrow prism used in a preferred embodiment of the invention;

FIG. 5(A) is a cross-sectional side view of a sensor package according to one exemplary embodiment of the invention;

FIG. 5(B) is a cross-sectional side view of a sensor package according to a more preferred embodiment of the invention;

FIG. 6(A) is a side view of one embodiment of the invention using a sensor package like that shown in FIG. 5(A);

FIG. 6(B) is a side view of another embodiment of the invention using a sensor package like that shown in FIG. 5(B);

FIG. 7(A) is a schematic end view of an image sensor chip located within a cylindrical housing, illustrating the relationship between the dimensions of the top surface of the sensor chip and the housing size;

FIG. 7(B) is a schematic side view of an image sensor chip located within a cylindrical housing, illustrating the relationship between the dimensions of the top surface of the sensor chip and the housing size;

FIG. 8(A) is a schematic end view similar to that shown in FIG. 7(A) of the device shown in FIG. 8(B);

FIG. 8(B) is a schematic side view of an image sensor chip located within a cylindrical housing, illustrating the relationship between the thickness of the image sensor chip and the housing size;

FIG. 9 is a side view of a plurality of image sensor chip packages according to another embodiment of the invention, wherein packages are constructed with upper and lower angle cuts.

DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

Reference is first made to FIG. 3 which shows a schematic diagram of a preferred image sensor chip 10.

As shown, the sensor chip 10 can include a two-dimensional array of image sensors creating a photoplane 11, e.g., light sensitive pixels based on silicon such as in a CCD, CID (charge-injection device) or CMOS sensor, which detect the light focused thereon and convert it into electrical signals. Outside this photoplane 11, there can be control and timing circuits 12 and output circuits with bonding pads 13 that read out the pixel-signals, provide limited processing, and send an output signal to additional signal processing devices located away from the image sensor chip.

The space occupied by these circuits 12, 13 can vary widely -- from a minimal portion to a very large portion -- depending on the amount of processing needed to be performed on the chip 10. In the preferred embodiments of this invention, a goal is to achieve as small of a package as possible. Accordingly, the chip 10 is preferably specified to have only the minimum necessary circuits required to output the signal for remote digital signal processing. In one preferred design, the timing and control circuits together with the output circuit with the bonding pad for wiring can be constructed to occupy only about 50% of the total chip area.

In one exemplary embodiment, the sensor chip 10 includes a CMOS sensor with a photoplane 11 that is about 2.52 mm x 1.89 mm and with an overall chip top-face dimension of about 3.42 mm x 2.89 mm. Using a wafer scaled package ("WSP") scheme with a 0.25 mm margin, the package is thus dimensioned about 3.67 mm x 3.14 mm. In this exemplary embodiment, the photoplane 11 preferably contains a 480 x 360 array of pixels 11p.

A few pixels 11p are shown for illustrative purposes in FIG. 3. Here, the packaged chip diagonal is 4.83 mm and the photoplane diagonal is 3.15 mm. As discussed further below, this exemplary embodiment preferably includes a Littrow prism and an angle-cut package to produce a package size with an inner diameter measuring about 3.64 mm, approximately midway between the limits of 3.15 mm and 4.83 mm.

The preferred embodiments of the present invention can also achieve a smaller device through the use of a novel optical arrangement. The optical arrangement most preferably uses a Littrow prism 20, but other optic elements can be used therefor as long as the optical effect is similar.

Reference is now made to FIG. 4 which shows the optical properties of a Littrow prism 20 in combination with a lens 30 having an optical axis 31 that is substantially a) collinear with the axis 21 centered on the face of the side S1 and b) parallel to the side S2 of the Littrow prism 20. This optical configuration can redirect the image focused from the lens to a plane that is offset at an angle from the optical axis of the lens 30 -- most preferably an angle of about 30°.

Among other benefits, there are three notable advantages of using this preferred optical arrangement, which preferably uses a Littrow prism 20:

First, this arrangement has two reflection surfaces. As a result, the output image is upright and not inverted. Advantageously, no extra electronics are thus needed to convert the image.

Second, by mounting the chip 10 at an angle (e.g., preferably about 30°) from the optical axis 31 (and preferably in close proximity to the hypotenuse H of the prism 20), the area for chip placement can be increased (e.g., almost two-fold) as compared to mounting the chip perpendicular to the optical axis 31 for a fixed outer diameter of the housing 40. Moreover, in comparison to mounting the chip 10 parallel to the optical axis 31 and beneath a prism as shown in FIG. 2(A), the outer diameter can be reduced by about the extent of the thickness of the chip 10 from that shown in FIG. 2(A).

Third, this optical arrangement allows the use of the largest diameter objective lens 30 for a given photoplane size and package size.

The end face S1 of the prism 20 can be dimensioned for example about the same as the photoplane 11 in the limit of smallest possible package size. The overall camera diameter can be determined by, for example, a) the amount of space required on the chip 10 for the timing and control electronics of the pixel sensor array and b) the size of the chip package P. The camera size can be minimized if the top surface area of the chip package P is equal to or less than the dimensions of the hypotenuse H of the prism 20. Due to the tilt/angle of the hypotenuse, the increased area along the hypotenuse allows a larger chip top surface area to be mounted without proportionately increasing the camera size -- and thus a reduced overall camera diameter.

Another limit to the size of the camera is the thickness of the packaging of the image sensor.

FIG. 5(A) illustrates a first preferred construction of a package P for the image sensor. As shown, this preferred embodiment includes chip 10 with photoplane 11 on top of the chip. The connections from the chip 10 to the substrate 14 are preferably on the lateral sides (e.g., sides 10L and 10R shown in FIG. 7(A)) of the chip 10 (e.g., from the top to the bottom of the chip). The chip 10 is then soldered to the substrate 14 which has matching contacts that connect to the chip 10. These contacts are then connected to the backside of the substrate for connection to other devices. On top of the chip 10, a clear optical epoxy 15 is preferably used to attach a glass cover 16 to the chip. All of the above-mentioned construction-process steps thus far are done at the wafer scale. The whole assembled package is then preferably saw-cut (preferably not along the lateral sides having the connections from the chip 10 to the substrate 14) into individual devices with contacts on the back of the substrate 14 for connection to the external devices. The thickness of the package is typically about 1.5 mm, but the thickness can vary depending on circumstances. For example, a thinner package can be made, such as for example less than 1.0 mm, or even down to about 0.6 mm, or less.

As shown in FIG. 6(A), when the package P shown in FIG. 5(A) is attached to the Littrow prism 20 and placed into a housing that is a cylindrical tube 40, the minimum tube diameter D is for example about 4.44 mm for a 1.5 mm thick package P. This is due to the corners C of the package P because the package P is tilted with respect to the axis 31 so as to abut the housing wall of the camera.

FIG. 5(B) illustrates a second modified embodiment that is able to create a smaller cylindrical camera with the same chip 10 (such as, for example, having an inner diameter of 3.64 mm). According to the embodiment shown in FIG. 5(B), the assembled substrate package P' is saw-cut at an angle θ at opposite sides so that the sides of the package P' conform to the angle of tilt (preferably, e.g., 30°) from the optical axis 31, enabling the chip 10 to be packaged within a cylinder 40 of smaller diameter as shown in FIG. 6(B). In practice, such a saw-cut package P' can be very thick and the angle of the package P' to a plane perpendicular to the axis 31 can be optimized to be less than 60° depending on the size and thickness of the package P', as discussed below. In addition, the WSP sensor package can be soldered on to a flexible circuit board for the transmission of the video signal from the sensor to the processing electronics. The flexible circuit board acts as intermediate connections between the sensor and the wiring harness.

FIG. 7(A) shows a front view and FIG. 7(B) shows a side view of the packaged chip 10 (the top surface alone is shown for illustrative purposes) placed at an angle θ2 of 30° to the optical axis 31 and having a width W and a length L. All four corners C of the chip package P' contact the inside wall 41 of the housing 40. For a given width W and length L, the radius R can be calculated as follows:

(i) referring to FIG. 7(B), d is given by $d = L/2 \sin(30°)$; and

(ii) referring to FIG. 7(A), R is given by $R = \sqrt{(d^2 + (W/2)^2)}$.

For example, in one preferred embodiment, where W = 3.14 mm and L = 3.67 mm: d = 3.67/2 sin(30°) = 0.9175 mm; and $R=\sqrt{(0.91752+(3.14/2)^2)}$ = 1.818 mm. The resulting inner diameter of the cylinder is thus 2 x 1.818 mm = 3.64 mm.

For a package with a finite thickness 't', as shown in FIG. 8, the above equations become as follows:

$t = b \cos\theta 4 \Rightarrow b = t/\cos\theta 4;$

$b/\sin 30° = a/\sin(60°-\theta 4) \Rightarrow$

$a = b \sin(60°-\theta 4)/\sin 30°$

$= t \sin(60°-\theta 4)/(\cos\theta 4 \sin 30°);$

$d = (L+a)\sin 30°/2;$

$$R = \sqrt{\left(\frac{\left(L + \frac{2t \sin(60° - \theta_4)}{\cos\theta_4 \sin 30°}\right)\sin 30°}{4}\right)^2 + (w/2)^2}$$

Table 1 below, which is based on the above equation, illustrates required angles θ4 for certain package thicknesses t in order to achieve a desired inner housing diameter D.

Table 1: Angle Cut Scenarios

Angle (degrees)	Thickness (mm) 0	0.5	1	1.5	2
0	3.64	3.87	4.14	4.44	4.75
10	3.64	3.85	4.08	4.34	4.62
20	3.64	3.82	4.03	4.25	4.48
30	3.64	3.79	3.96	4.14	4.34
40	3.64	3.75	3.88	4.02	4.16
50	3.64	3.71	3.78	3.86	3.94
60	3.64	3.64	3.64	3.64	3.64

Inner diameter of housing required for certain angle cuts and thicknesses. Wherein width (W)=3.14 mm and length (L)=3.67 mm.

As shown in the above table, as one illustrative example, for a package having a housing (e.g., cylinder) 40 with an inner diameter 3.79 mm and a package thickness t of 0.5 mm, the angle cut required is only about 30° instead of 60°. For a 1.5 mm package, angle cutting at 60° reduces the inner diameter from 4.44 mm to 3.64 mm. Notably, for a package having a thickness t of zero, or for an angle cut of 60°, the inner diameter remains at the minimum of 3.64 mm.

In order to further reduce the size of the device, the dimensions of the various components can be scaled accordingly. This includes the lens size, the prism size, the pixel size, the photoplane size, and the chip size. However, one parameter that can not be scaled as easily is the thickness t of the package. As a result, the thickness t presents a significant obstacle and is an ultimately limiting factor. The angle saw-cut of the preferred embodiments, however, can relax the scaling requirement of the package P and allow an even smaller camera to be made as the photoplane 11 gets smaller.

Although, as shown in FIG. 5(B), the preferred embodiment of the package is cut at the same angle from the top to the bottom surface, in practice, this can be varied as desired since the limiting size is the semiconductor chip itself that is contained in the package. In this regard, FIG. 9 illustrates another exemplary embodiment having a package P" with a different cutting configuration. The configuration shown in FIG. 9 does not require cutting to be done at 60° from the top to the bottom, which could potentially create problems in the mounting of the wafer on the saw table, but rather, the front and bottom are cut separately. That is, instead of using one angle cut from the top to the bottom, upper and lower chamfer cuts CL and CR are made at each end. The chamfer cuts preferably meet proximate the center as shown so that the cuts together separate the individual sensor packages P". Depending on the specific saw requirements, other cutting schemes can be developed to produce an appropriate angle cut package to fit into a particular package housing.

The pixel sizes that are used in general are preferably above 4 microns because due to limitations of the lens design and the optical resolution in the diffraction limit the image quality will degrade as the pixel size gets smaller than about 4 microns. Smaller pixels can be used to improve the performance of aliasing without improvement of resolution which would be limited by the lens. Even though semiconductor technology is capable, in principle, of fabricating even smaller pixels, fabrication of smaller lenses to accommodate such smaller pixels will not really enable even smaller imaging sensing devices to be built because of degradation in optical image quality and resolution. Therefore, the ultimate miniaturization of the package size for the smallest image sensors will be essentially determined by the objective lens 30 of the small camera itself and the configuration of the chip 10 relative to the lens. As a result, the smallest possible package size requires orienting the chip 10 to maximize the advantage of its positioning within the housing 40 to minimize the overall inner diameter of the housing. And, the angle-cut of the package 40 further minimizes the package size of the camera in view of the relative size constraints between the photoplane 11 and the objective lens 30.

Although the most preferred embodiments use a prism 20, as shown in FIG. 4, having a first angle $\theta 1$ of 60°, a second angle $\theta 2$ of 30°, and a third angle $\theta 3$ of 90°, thereby providing an optimal performance, these angles may be varied under certain circumstances. While such variations may provide a less than optimal performance, depending on circumstances, such variation might still provide a desirable solution. For example, the incident angle at the face S1 may not necessarily be perpendicular in some cases due to mechanical constraints, for example, so that the effect would be the introduction of chromatic dispersion. In addition, the angle of incidence upon the hypotenuse H may not need to be 60° (here = $\theta 1$), depending on the refractive index of the material used. The critical angle for total internal reflection can range for example from 30° for sapphire with a refractive index of 2, to 41° for glass with a refractive index of 1.5, and to 50° for certain plastics with refractive indexes of 1.3. As a result, depending on other constraints and acceptable image quality, the angle $\theta 1$ can vary between about 45 to 75 degrees, while a more preferred range is between about 45 to 70 degrees, and an even more preferred range is between about 55 to 65 degrees -- and is most preferably 60 degrees. The side S2 is also preferably coated with a reflective coating.

While the present invention has been shown and described with reference to preferred embodiments presently contemplated as best modes for carrying out the invention, it is to be understood that various changes may be made in adapting the invention to different embodiments without departing from the broader inventive concepts disclosed herein and comprehended by the claims which follow.

CLAIMS

What is claimed is:

1. A minimized image-sensing device, comprising:

a housing having a geometric axis;

an objective lens to collect light from an object and focus an image of said object, said objective lens having an optical axis substantially parallel to said geometric axis of said housing;

a solid state image sensor chip having an array of light sensitive pixels with electronic signal outputs that are connectable to circuitry for signal processing and output to an image viewing device;

said solid state image sensor chip having timing and control circuitry to control said electronic signal outputs;

a prism having a triangular cross-section delineated by an input side, a parallel side and a hypotenuse side, said input side being at about a 90 degree angle to said parallel side, said hypotenuse side being at about a 60 degree angle to said input side, and said parallel side and said hypotenuse side forming an angle of about 30 degrees;

said prism being juxtaposed between said objective lens and said sensor chip, with said input side generally perpendicular to and aligned with said optical axis of said objective lens and said parallel side generally parallel to a wall of said housing, whereby a focused image from said objective lens can be transmitted through said prism;

said sensor chip being oriented along said hypotenuse of said prism with said pixel array arranged to receive said focused image transmitted through said prism.

2. The device of claim 1, wherein said array of light sensitive pixels includes silicon based sensors.

3. The device of claim 1, wherein said silicon based sensors include at least one of CMOS, CCD or CID sensors.

4. The device of claim 1, wherein said housing is generally cylindrical.

5. The device of claim 1, wherein said parallel side of said prism has a coating to reflect light.

6. The device of claim 1, wherein said image sensor chip is contained in a package, said package has generally parallel upper and lower surfaces and two sides between said upper and lower surfaces that are at least partially cut at an angle between about 30 degrees and 90 degrees with respect to said upper and lower surfaces of said package.

7. The device of claim 1, wherein said parallel side has dimensions greater than or equal to the dimensions of said pixel array.

8. The device of claim 1, wherein said hypotenuse side has dimensions greater than the dimensions of a photoplane of said sensor chip.

9. The device of claim 1, wherein an inner diameter of said housing is equal to about the diameter of the objective lens.

10. A minimized image-sensing device, comprising:

a housing having a geometric axis;

an objective lens to collect light from an object and focus an image of said object, said objective lens having an optical axis substantially parallel to said geometric axis of said housing;

a prism having a triangular cross-section delineated by an input side, a second side and a hypotenuse side, said input side being at a first angle to said second side of between about 80 and 100 degrees, said hypotenuse side being at a second angle to said input side of between about 45 and 75 degrees, and said second side and said hypotenuse side forming a third angle of between about 15 and 45 degrees;

said input side of said prism being aligned with said optical axis of said objective lens so that a focused image from said objective lens can be transmitted through said prism;

a solid state image sensor chip arranged generally at said hypotenuse of said prism to receive light transmitted through said prism.

11. The device of claim 10, wherein said housing is generally cylindrical.

12. The device of claim 10, wherein said second side of said prism has a coating to reflect light.

13. The device of claim 10, wherein said image sensor chip is contained in a package, said package has generally parallel upper and lower surfaces and two sides between said upper and lower surfaces that are at least partially cut at an angle between about 30 degrees and 90 degrees with respect to said upper and lower surfaces of said package.

14. The device of claim 13, wherein said package is a wafer scale package.

15. The device of claim 14, wherein said wafer scale package is further connected to a flexible circuit board to facilitate the transmission of video signals out of the package.

16. The device of claim 10, wherein said second side has dimensions greater than or equal to the dimensions of a planar pixel array in said image sensor chip.

17. The device of claim 10, wherein said hypotenuse side has dimensions greater than the dimensions of a photoplane of said image sensor chip.

18. The device of claim 1, wherein an inner diameter of said housing is equal to about the diameter of said objective lens.

19. A minimized image-sensing device, comprising:

a housing;

an objective lens arranged in said housing to collect light from an object and focus an image of said object, said objective lens having an optical axis;

a first reflection surface at an angle of about 30 degrees to said optical axis upon which light from said objective lens is received and reflected;

a second reflection surface upon which light from said first reflection surface is received and reflected; and

an image sensor chip arranged behind and generally parallel to said first reflective surface upon which light from said second reflection surface is received after passing through said first reflective surface.

20. The device of claim 19, wherein said first and second reflection surfaces are surfaces of a prism.

21. The device of claim 20, wherein said prism is a Littrow prism.

22. A minimized image-sensing device, comprising:

a housing;

an objective lens arranged in said housing to collect light from an object and focus an image of said object, said objective lens having an optical axis;

a first reflection surface at an angle of between about 15 and 45 degrees to said optical axis upon which light from said objective lens is received;

a second reflection surface having an angle of between about -15 and 15 degrees to said first reflection surface upon which light from said first reflection surface is received;

an image sensor chip arranged at an angle of between about 15 and 45 degrees to said optical axis upon which light from said second reflection surface is received.

23. The device of claim 22, wherein said first and second reflection surfaces are surfaces of a prism.

24. The device of claim 23, wherein said prism is a Littrow prism.

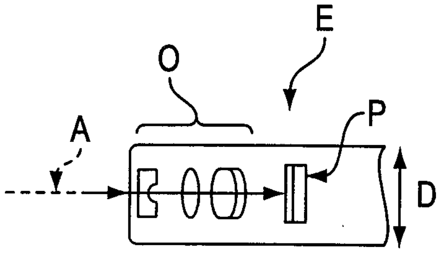


FIG. 1A

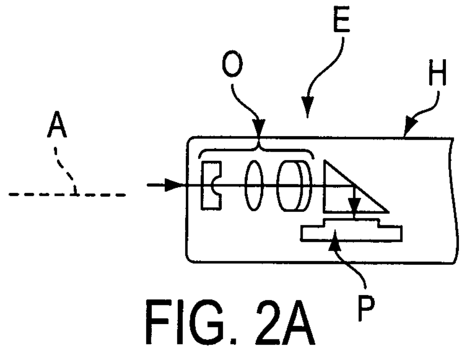


FIG. 2A

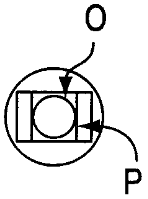


FIG. 1B

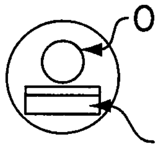


FIG. 2B

FIG. 2C

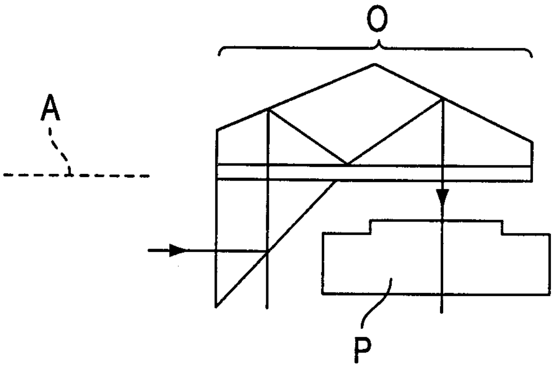


FIG. 2D

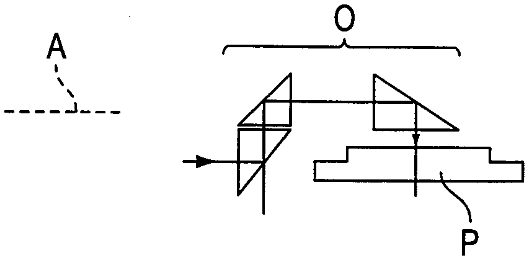
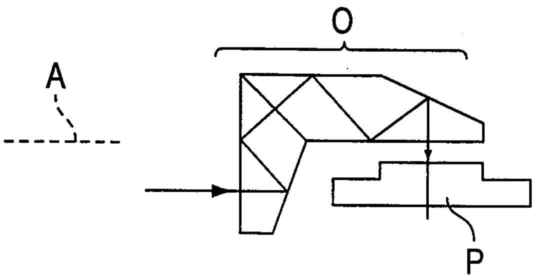


FIG. 2E



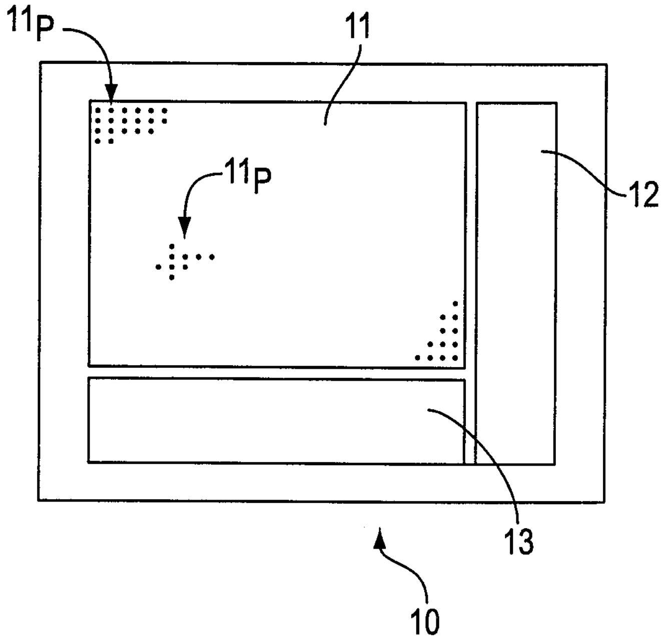


FIG. 3

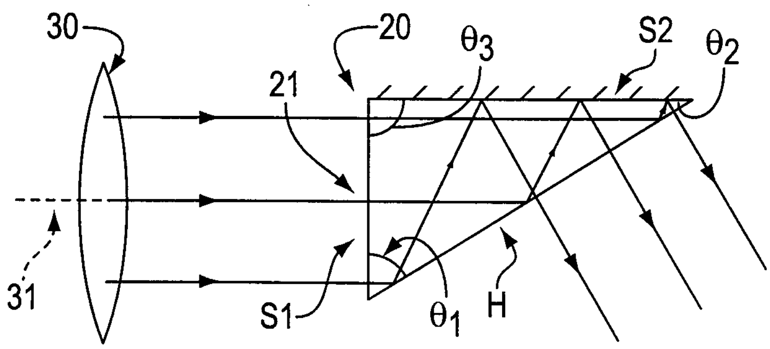


FIG. 4

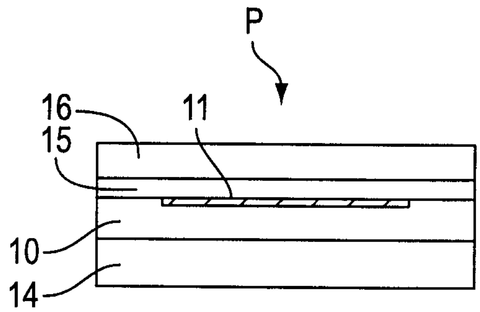


FIG. 5A

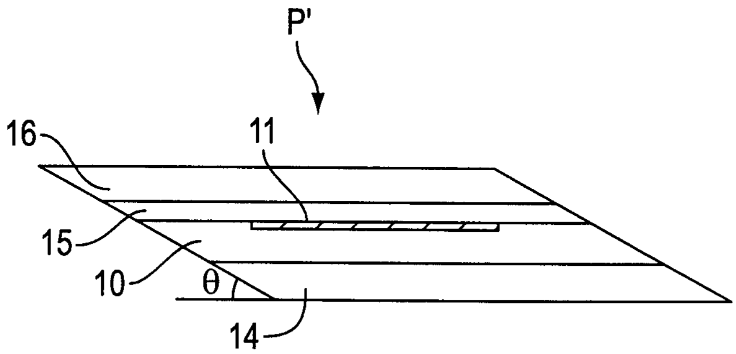


FIG. 5B

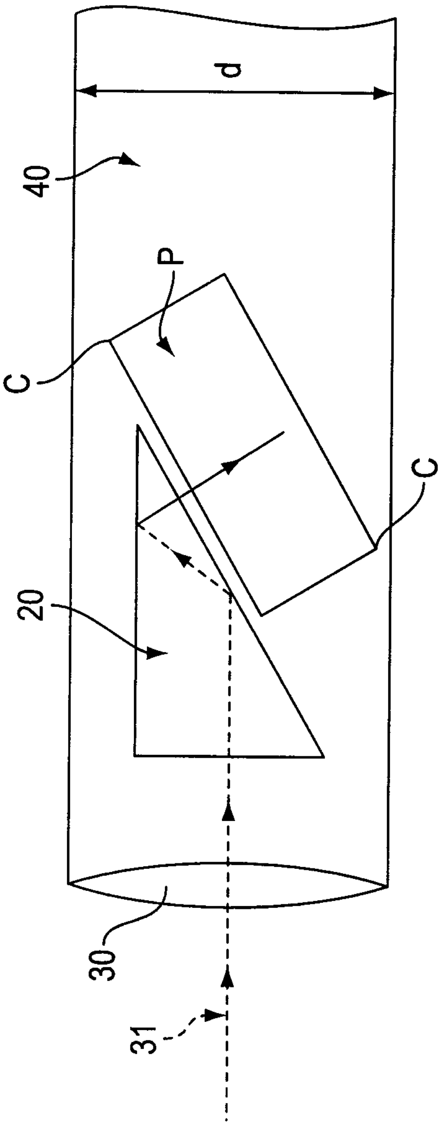


FIG. 6A

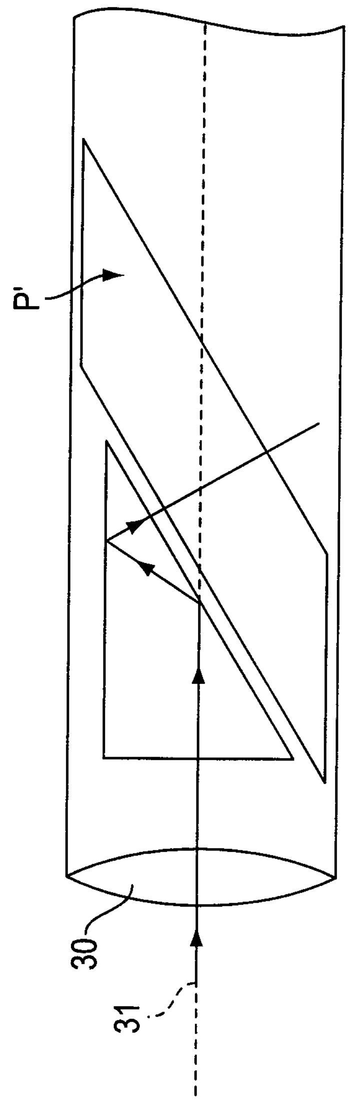


FIG. 6B

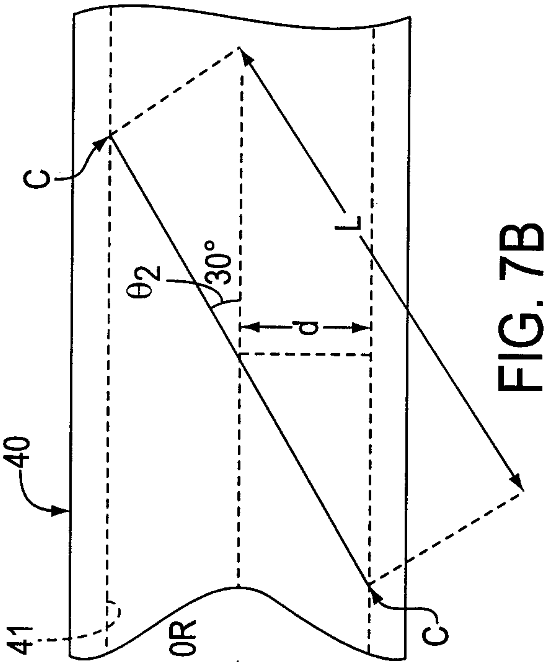


FIG. 7B

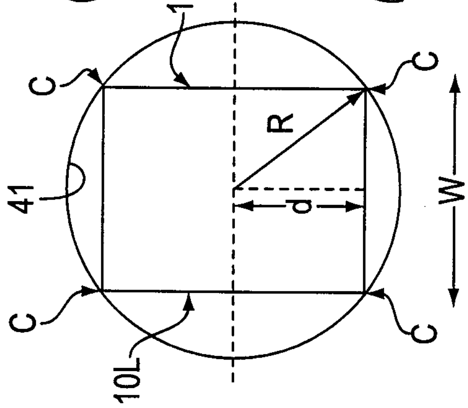


FIG. 7A

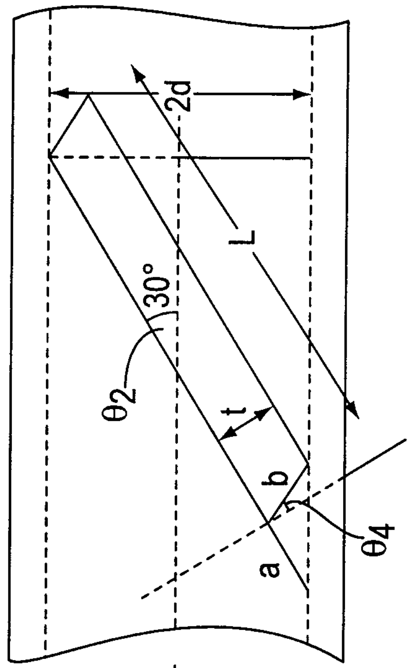


FIG. 8B

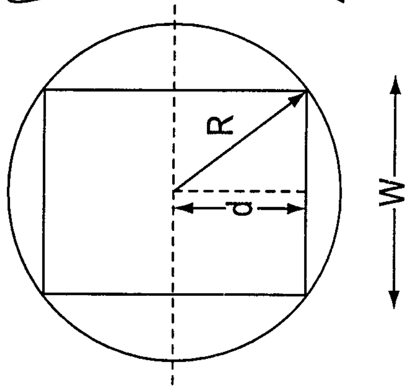


FIG. 8A

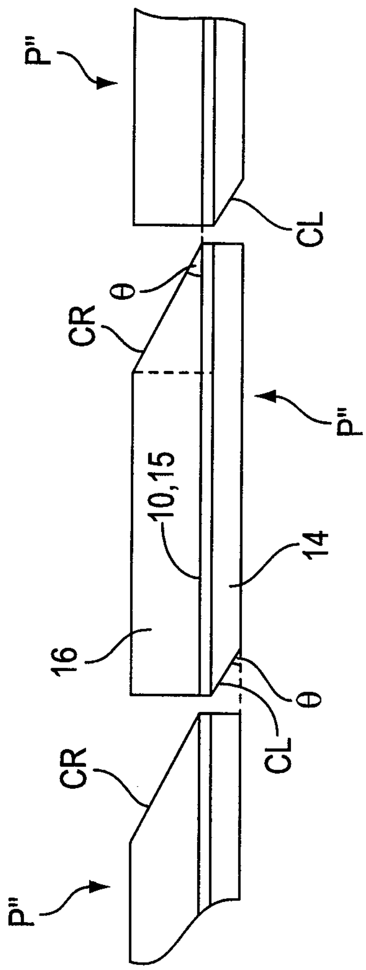


FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/01711

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B23/24

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)
IPC 7 G02B

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 097 352 A (MIYANAGA HIROFUMI ET AL) 17 March 1992 (1992-03-17) column 5, line 62 -column 6, line 28; figure 8	1-13, 16-24
X	US 4 746 203 A (NISHIOKA KIMIHIKO ET AL) 24 May 1988 (1988-05-24) column 2, line 18 - line 34 column 5, line 57 -column 6, line 48; figure 18	1-13, 16-20, 22,23
X	US 5 612 816 A (SANDER ULRICH ET AL) 18 March 1997 (1997-03-18) column 5, line 24 - line 33; figures 2A,2B	19,20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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	Date of mailing of the international search report
16 May 2000	23/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Mollenhauer, R

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/01711

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 919 114 A (MIYAZAKI ATSUSHI) 24 April 1990 (1990-04-24)	22
A	column 9, line 46 -column 10, line 42; figure 11	1-15

A	JP 06 030420 A (OLYMPUS OPTICAL CO LTD) 4 February 1994 (1994-02-04) figures 1,15	1-24
P,A	-& US 5 995 136 A (HASEGAWA AKIRA ET AL) 30 November 1999 (1999-11-30) column 3, line 63 -column 4, line 9 column 8, line 63 -column 10, line 5; figures 1,13-18	1-24

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/01711

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