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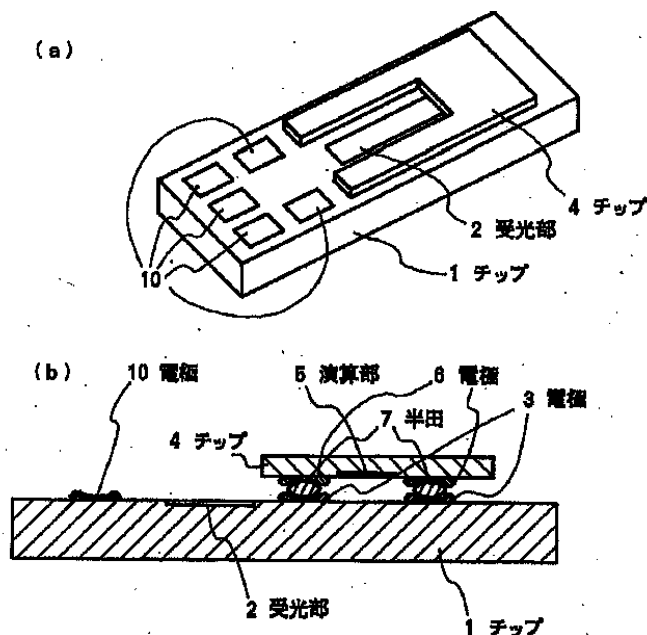
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**(54) [TITLE OF THE INVENTION] PHOTODIODE WITH
COMPUTING FUNCTION****(57) [ABSTRACT]**

[PURPOSE] It is possible to realize a photodiode with a computing function that has the merits that it is compact and resistant to electrical noise, and furthermore which has a low cost of changes to the shape of its light-receiving part.

[CONFIGURATION] A chip 1 having a light-receiving part 2 and a chip 4 having a computing part 5 have electrodes 3 of the chip 1 and electrodes 6 of the chip 4 facing each other and fixed together with solder 7. An optical signal picked up by the light-receiving part 2 of the chip 1 is converted into an electrical signal and passes through the solder 7, is operated upon by the computing part 5 of the chip 4, passes through the solder 7 again and returns to the chip 1. Because the electrodes 3 of the chip 1 and the electrodes 6 of the chip 4 are fixed to each other directly with the solder 7, the device is compact, and because the transmission distances are short there is no danger of noise entering the electrical signal. And when the shape of the light-receiving part 2 of the chip 1 is to be changed, it can be changed cheaply by a chip having the same disposition of electrodes as the electrodes 3 of the chip 1 and having a light-receiving part of the desired shape being connected to the chip 4 by the same method as when the chip 1 was connected.



[Scope of Patent Claims]

[Claim 1] In a photodiode with a computing function that converts an optical signal picked up by a light-receiving part into an electrical signal and operates upon the electrical signal in a computing part, a photodiode with a computing function characterized in that a light-receiving part for converting an optical signal into an electrical signal and a computing part for operating upon the electrical signal are formed on different semiconductor chips; on the semiconductor chip on which the computing part is formed there are provided electrodes in the same disposition as a number of electrodes of the semiconductor chip on which the light-receiving part is formed; and these chips have their electrodes connected together with a conductor so as not to cover the light-receiving part.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Use] This invention relates to an opto-electric integrated circuit and particularly to a device having a function for converting an optical signal into an electrical signal and a function for operating upon the electrical signal.

[Prior Art] An example of a photodiode with a computing function of prior art is the PDIC mentioned in the Nikkei Electronics (1991.8.19, no. 534, pp. 100, 101) article, 'Thin Optical Pickup with Optical Train Including Semiconductor Laser Mounted on an Actuator'. It is shown in perspective view in Fig. 2. The PDIC converts an optical signal picked up by a light-receiving part 8 into an electrical signal and operates upon this electrical signal in a computing part 9. And it is connected to another circuit by electrodes 11. Because the light-receiving part 8 and the computing part 9 are formed on the same substrate, it has the merits that it is resistant to noise and is also compact.

[0003]

[Problem to be Solved by the Invention] Although optical pickups frequently undergo model changes, as described above a photodiode with a computing function of the prior art has the light-receiving part 8 and the computing part 9 formed on the same substrate, and consequently, when the shape of the light-receiving part 8 is to be changed, the computing part 9 also has to be changed, and there has been the problem that design changes are very expensive.

[0004] The purpose of this invention is to provide a photodiode with a computing function having the merits of being compact and resistant to noise, which are characteristic of photodiodes with a computing function of the prior art, with which furthermore the cost of changing the shape of the light-receiving part is low.

[0005]

[Means for Solving the Problem] A photodiode with a computing function of the invention, to solve the problem described above, is a construction, in a photodiode with a computing function that converts an optical signal picked up by a light-receiving part into an electrical signal and operates upon the electrical signal in a computing part, characterized in that a light-receiving part for converting an optical signal into an electrical signal and a computing part for operating upon the electrical signal are formed on different semiconductor chips; on the semiconductor chip on which the computing part is formed there are provided electrodes in the same disposition as a number of electrodes of the semiconductor chip on which the light-receiving part is formed; and these chips have their electrodes connected together with a conductor so as not to cover the light-receiving part.

[0006]

[Operation] With a photodiode with a computing function of the invention, because the electrodes of the light-receiving part are directly fixed with a conductor to the electrodes of the computing part, it is compact, the transmission distances are short, and as a result there is no danger of noise entering the electrical signal. Also, when the shape of the light-receiving part is to be changed, by making the disposition of the electrodes on the new light-receiving part the same

as the disposition of the electrodes on the original computing part, the two can be connected.

[0007]

[Embodiment Example] A first embodiment example of a photodiode with a computing function will be described on the basis of Fig. 1. In the figure, (a) is a perspective view and (b) is a sectional view showing a configuration.

[0008] A photodiode with a computing function according to this embodiment example has electrodes 3 of a chip 1 having a light-receiving part 2 and electrodes 6 of a chip 4 having a computing part 5 fixed together with solder 7 with the electrodes facing each other. An optical signal picked up by the light-receiving part 2 of the chip 1 is converted into an electrical signal, passes through the solder 7, is operated upon in the computing part 5 of the chip 4, and passes through the solder 7 again and returns to the chip 1. And, a photodiode with a computing function according to this embodiment example is connected to another circuit by electrodes 10.

[0009] The connection between the electrodes 3 and the electrodes 6 can alternatively be made with conducting paste instead of solder. And, the light-receiving part 2 may be circular or rhomboidal instead of rectangular, and may consist of a group of multiple light-detecting devices.

[0010] In the case of a photodiode with a computing function according to this embodiment example, because the electrodes 3 of the chip 1 and the electrodes 6 of the chip 4 are directly connected by the solder 7, it is compact, and because the transmission distances are short there is no danger of noise entering the electrical signal. And when the shape of the light-receiving part 2 of the chip 1 is to be changed, it can be changed cheaply by a chip having the same disposition of electrodes as the electrodes 3 of the chip 1 and having a light-receiving part of the desired shape being connected to the chip 4 by the same method as when the chip 1 was connected.

[0011] A second embodiment example of a photodiode with a computing function of the invention will be described below on the basis of Fig. 3. In the figure, (a) is a perspective view and (b) is a sectional view.

[0012] A photodiode with a computing function according to this embodiment example is an example where a light-receiving part 21 and electrodes 25 are located on opposite sides of a chip 23, and the electrodes 25 of the chip 23 are fixed to electrodes 22 of a chip 20 by solder 26 with the electrodes facing each other. An optical signal picked up by the light-receiving part 21 of the chip 23 is converted into an electrical signal, passes through the solder 26, is operated upon in a computing part 24 of the chip 20, and is passed on to another circuit through electrodes 27.

[0013] A chip 28 shown in Fig. 5 can be used instead of the chip 23. The chip 28 is mounted on the chip 20 using electrodes 29. The chip 28 has a lens-shaped light-receiving part 30 which has a light-concentrating effect. Because the lens-shaped light-receiving part 30 has a smaller opto-electric conversion region compared to the light-receiving part 21, its high-speed responsiveness is good.

[0014] A third embodiment example of a photodiode with a computing function according of the invention will be described below on the basis of Fig. 4. In the figure, (a) is a perspective view and (b) is a sectional view.

[0015] A photodiode with a computing function according to this embodiment example is made by forming metal bumps 18 with a metal bump forming apparatus on electrodes 14 of a chip 12 having a light-receiving part 13 or on electrodes 17 of a chip 15 having a computing part 16, and bringing the chip 12 and the chip 15 face-to-face and joining together the electrodes 14 and the electrodes 17 by way of the metal bumps 18. It is connected to another device or component by wire bonding of the electrodes 19. With this configuration, because the chip 12 and the chip 15 can be connected just by ultrasonic heating or thermocompression bonding, there is the merit that the most ordinary material Al can be used for the electrodes 14 and the electrodes 17.

[0016] Metal bumps can also be used in a photodiode with a computing function having as a constituent element a chip with a light-receiving part and electrodes located on opposite sides of it.

[0017]

[Effect of the Invention] As described above, if a photodiode with a computing function of this invention is used, it is possible to realize a photodiode with a computing function having the merits that the shape of the light-receiving part can be changed inexpensively and furthermore it is compact and resistant to electrical noise.

[Brief Description of the Drawings]

[Fig. 1] An explanatory view showing a first embodiment example of a photodiode with a computing function of the invention, in which (a) is a perspective view and (b) is a sectional view.

[Fig. 2] A perspective view showing a photodiode with a computing function of prior art.

[Fig. 3] A view showing a second embodiment example of a photodiode with a computing function of the invention, in which (a) is a perspective view and (b) is a sectional view showing a configuration.

[Fig. 4] A view showing a third embodiment example of a photodiode with a computing function of the invention, in which

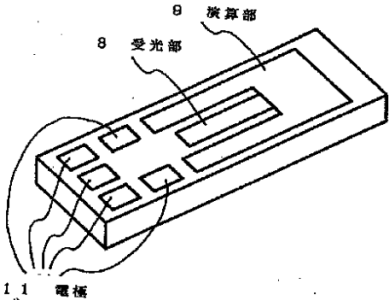
(a) is a perspective view and (b) is a sectional view showing a configuration.

[Fig. 5] A view showing an embodiment example of a chip of a photodiode with a computing function of the invention, in which (a) is a perspective view and (b) is a sectional view showing a configuration.

[Explanation of the Symbols]

- 1 chip
- 2 light-receiving part
- 3 electrodes
- 4 chip
- 5 computing part
- 6 electrodes
- 7 solder
- 8 light-receiving part
- 9 computing part
- 10 electrodes
- 11 electrodes
- 12 chip
- 13 light-receiving part
- 14 electrodes
- 15 chip
- 16 computing part
- 17 electrodes
- 18 metal bumps
- 19 electrodes
- 20 chip
- 21 light-receiving part
- 22 electrodes
- 23 chip
- 24 computing part
- 25 electrodes
- 26 solder
- 27 electrodes
- 28 chip
- 29 electrodes
- 30 lens-shaped light-receiving part

Fig. 2



(4)

Fig. 1

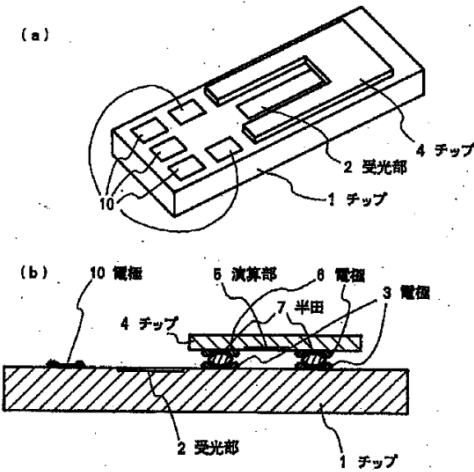


Fig. 3

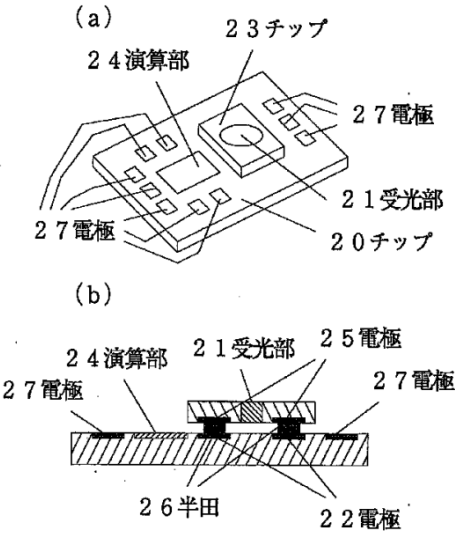


Fig. 4

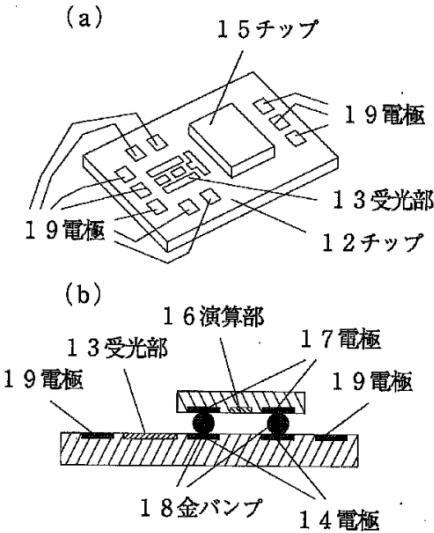
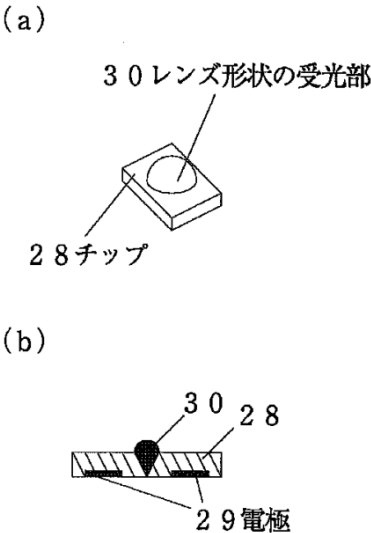


Fig. 5



[See previous page for number key]



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- H6-29507

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James Thornton

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