

Description

The present invention relates generally to optical pickup devices and more particularly to an optical pickup device in which a light emitting element and a light receiving element are formed integrally on a semi-conductor substrate.

Optical heads with various structures have been proposed so far to detect information from information pits formed on the surface of a substrate, as in a compact disc (CD) or the like. Fig 1 illustrates in perspective a structure of an optical pickup device employing a composite light emitting and/or light receiving element that we have proposed in Japanese patent application number 61-38575 (published on 31st August 1987).

As fig 1 shows, there is provided an optical head 1 in which a first photo detector 3 constituted by a so-called PIN diode or the like is formed, for example, on the left-hand side half of a major surface 2A of a rectangular semi-conductor substrate 2 made of silicon or the like to act as a light receiving element. The first photo detector 3 is formed of, for example, two sets of photo detectors 3a and 3b, each of which is divided to provide three photo detecting portions. A second photo detector 4 constituted by a PIN diode or the like for monitoring is formed on the right-hand side half of the major surface 2A of the semi-conductor substrate 2 as a light receiving element, if necessary. Between the first and second photo detectors 3 and 4, a light emitting element 5 such as a semi-conductor laser chip or the like is directly soldered to the major surface 2A of the semi-conductor substrate 2. Also, there is provided an optical path branching part, ie, a prism 6. This prism 6 is trapezoidal in cross-section and is mounted on the major surface 2A of the semi-conductor substrate 2 to cover the first photo detector 3, thus forming a composite light emitting/light receiving element 1a. The prism 6 has a face 6a opposing the light emitting point of the active layer in the semi-conductor laser chip 5. This face 6a is formed as a semi-transparent reflection face. Meanwhile, in a face 6b of the prism 6 contacting with the semi-conductor substrate 2, the area other than that contacting the photo detectors 3a and 3b and a face 6c of the prism 6 opposing the face 6b are each formed as a reflection face.

With the above mentioned arrangement, a laser beam 7a emitted from the active layer of the semi-conductor laser chip 5 is reflected on the semi-transparent reflection face 6a of the prism 6 and is then irradiated on to an optical disc through an objective lens (not shown) as an incident laser beam 7b. The light of the incident laser beam 7b reflected from the optical disc travels through the face 6a of the prism 6 and is incident on the first

set of photo detectors 3a. The light passed through the face 6a is reflected by a semi-transparent layer (not shown) formed between the prism 6 and the first set of photo detectors 3a and is then reflected on the face 6c of the prism 6 to become incident on the second set of photo detectors 3b, whereby the data corresponding to the information pits on the optical disc are detected. A laser beam 7c is emitted from an opposite active layer of the semi-conductor laser chip 5 for monitoring.

In the above mentioned composite light emitting/light receiving element 1a, a part of the laser beam, which is emitted from the semi-conductor laser chip 5, travels through the prism 6 and directly becomes incident on the first photo detector 3 and this undesired, stray light constitutes noise added to the detecting signal.

From experimental results, it was noted that while the undesired light incident on the prism 6 can be removed in the conventional composite light emitting/light receiving element 1a, another kind of undesired light is produced which exerts a bad influence upon the detecting signal that the first photo detector 3 produces.

Referring to fig 2, let us now explain why such other kind of undesired light is produced. Fig. 2 is a fragmentary cross-sectional side view taken through the line II-II of Fig. 1, looking in the direction indicated by the arrow A. Except for the semi-transparent reflection face 6a of the prism 6 formed on the major surface 2A of the semi-conductor substrate 2 to cover the first photo detector 3, left, right and rear side wall faces 6d, 6e and 6f are formed as faces that are not calendered. For example, they are formed as smoked-glass faces. For this reason, a part of the laser beam 7a emitted from the active layer of the semi-conductor laser chip 5 travels through the semi-transparent reflection face 6a and is then reflected and/or scattered on the side wall faces 6d, 6e and 6f in the prism 6. Thus, as shown by reflected and/or scattered laser beams 8 represented as broken lines in Fig. 2, undesired light again becomes incident on the light receiving faces of the photo detectors 3a and 3b with a smaller incident angle θ_1 . Such an undesired light is superimposed upon an RF signal from the first photo detector 3 as a DC offset signal, thereby to exert a bad influence on the detecting signal. Another reason that there exists much undesired light beams which are repeatedly reflected and/or scattered within the prism 6 is that the refractive index of the material forming the prism 6 is larger than the refractive index of air and hence the undesired light beams are not radiated from the prism 6 to the air.

EP-A-0199565 discloses an optical pickup device comprising:

(a) a substrate;

(b) a semi-conductor laser element mounted on said substrate;

(c) a photo detector for receiving a laser beam emitted from said semi-conductor laser element formed on said substrate; and

(d) an optical path branching optical element fixed to said substrate over said photo detector, said optical element including an inclined front face positioned opposite said laser element and having a semi-transparent reflection film deposited thereon and a rear face positioned opposite said front face. This optical pickup device is susceptible to the abovementioned problem of stray laser light from the laser element becoming incident on the photo detector to cause electrical noise.

It is an aim of the present invention and/or the preferred embodiments to provide an improved optical pickup device which can produce a stable detecting signal from a photo detector thereof and be manufactured at low cost.

According to the present invention, there is provided an optical pickup device characterised, relative to the device of EP-A-0199565, in that the rear face of the optical path branching element is shaped to substantially prevent light incident thereon from being reflected into said photo detector by reflecting said incident light such that it is multiply internally reflected between faces of the optical element before being radiated from the optical element at an edge of the rear face.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an example of optical pickup device not in accordance with the present invention;

Fig. 2 is a cross-sectional side view taken through the line II-II in Fig. 1, looking in the direction represented by arrow A;

Fig. 3 is a perspective view illustrating an embodiment of an optical pickup device according to the present invention;

Fig. 4 is a cross-sectional side view taken through the line IV-IV in fig 3;

Figs 5 and 6 are respectively fragmentary cross-sectional side views used to explain other embodiments of the optical pickup device according to the present invention; and

Fig 7 is a perspective view used to explain a further embodiment of the present invention.

Now, embodiments of an optical pickup device according to the present invention will hereinafter be described in detail with reference to figs 3 to 7.

Fig 3 illustrates in perspective an embodiment of an optical pickup device or so-called optical head which employs a composite light emitting/light receiving element of the present invention.

In fig 3, like parts corresponding to those of figs 1 and 2 are marked with the same references and therefore need not be described in detail.

Referring to fig 3, the optical assembly part for branching the optical path of laser beam, ie, prism 6 of the composite light emitting/light receiving element 1a is mounted on the first photo detectors 3a and 3b which are used as the light receiving elements. The semi-conductor laser chip 5 is used as the light emitting element and the laser beam 7a emitted therefrom is incident on the semi-transparent reflection face 6a of the prism 6. The prism 6 used in the present invention forms undesired light preventing means by changing the shape of the rear side wall face 6f thereof, thus to solve the problem of the prior art that the undesired light caused by the repetitive reflection and/or scattering within the prism 6 detracts from the sensitivity of the detecting signals derived from the first photo detectors 3a and 3b, increasing the error in detection.

The arrangement of the above mentioned undesired light preventing means will be described with reference to fig 4 that forms a fragmentary cross-sectional view taken through the line IV-IV in fig 3. The prism 6 is formed as a substantially lozenge shaped as viewed from the side as shown in fig 4 and the included angle $\theta 2$ of the rear side wall face 6f of the prism 6 from the major surface 2A of the substrate 2 is selected to be an obtuse angle. If the prism 6 is constructed as described above, the laser beam 7a emitted from the semi-conductor laser chip 5 reaches the semi-transparent reflection face 6a of the prism 6 and a part of the laser beam 7a is introduced through the face 6a into the prism 6. Depending on the light emitting angle of the laser beam 7a from the semi-conductor laser chip 5, within the prism 6, there are different optical paths, ie, an optical path 11a in which the laser beam reaches the lower wall face 6a of the prism 6 and is then reflected thereon to reach the rear side wall face 6f, an optical path 11b in which the laser beam reaches directly to the rear side wall face 6f of the prism 6, an optical path 11c in which the laser beam reaches the upper wall face 6c of the prism 6 and is then reflected thereon to reach the rear side wall 6f of the prism 6 and so on. The laser beams travelling through the prism 6 and reaching to the rear side wall face 6f along the optical paths 11a to 11c are repeatedly reflected between the upper wall face 6c and the rear side wall face 6f so as to be radiated outside the prism 6 from its upper edge 12a, thus providing undesired light preventing means 9a.

Other embodiments of the optical pickup device or its composite light emitting/light receiving element 1a according to the present invention will be described with reference to figs 5 to 7. Particu-

larly in the embodiments, undesired light preventing means 9b to 9d arranged on the basis of the above mentioned principle will be described. In this case, figs 5 and 6 are respectively fragmentary cross-sectional side views showing embodiments of the optical pickup device or its composite light emitting/light receiving element 1a of the present invention. Fig 7 is a perspective view of a further embodiment of the composite light emitting/light reflecting element 1a.

Referring to fig 5, the prism 6 is formed in a trapezoidal shape as viewed from the side of composite light emitting/light receiving element 1a. In this case, the undesired light is radiated outside the prism 6 from its lower edge 12b. That is, undesired light preventing means 9b is constructed on the rear side wall face 6f of the prism 6.

Referring to fig 6, a triangular-shaped cut-away if formed on the rear side wall face 6f of the prism 6 in its thickness direction, as viewed from the side of the composite light emitting/light receiving element 1a, thereby to radiate the undesired light outside the prism 6 from its upper and lower edges 12a and 12b, thus constructing undesired light preventing means 9c.

Referring to fig 7 which is a perspective view of a further embodiment of the composite light emitting/light receiving element 1a according to this invention, a plurality of triangular-shaped cut-aways are formed on the rear side wall face 6f of the prism 6 in its width direction to reflect the light beams within the respective triangular-shaped cut-away portions, whereby the undesired light beams 11d are radiated outside the prism 6 from its edge 13 along the apex of each triangular-shaped cut-away portion, thus providing the undesired light preventing means 9d.

Because in the illustrated, preferred embodiments of the present invention the prism is provided with undesired light beam preventing means, formed by changing the shape of the rear side wall face of the prism, to avoid the undesired light reflected and/or scattered within the prism, the detecting signal and the undesired light do not have to be separated electrically. Thus, without such a separation circuit, the illustrated embodiments of optical pickup device can prevent the undesired light and can produce a stable detecting signal from their photo detecting means, as well as be manufactured at low cost.

Claims

1. An optical pickup device comprising:
 - (a) a substrate (2);
 - (b) a semi-conductor laser element (5) mounted on said substrate (2);

(c) a photo detector (3) for receiving a laser beam emitted from said semi-conductor laser element (5) formed on said substrate (2); and

(d) an optical path branching optical element (6) fixed to said substrate (2) over said photo detector (3), said optical element (6) including an inclined front face (6a) positioned opposite said laser element (5) and having a semi-transparent reflection film deposited thereon and a rear face (6f) positioned opposite said front face; characterised in that said rear face (6f) is shaped to substantially prevent light (11a, 11b, 11c) incident thereon from being reflected into said photo detector (3) by reflecting said incident light such that it is multiply internally reflected between faces (6b, 6c, 6f) of the optical element (6) before being radiated from the optical element at an edge (12a, 12, 13) of the rear face (6f).

2. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from the optical element (6) at an upper edge (12a) of the rear face.
3. An optical pickup device as claimed in claim 2, wherein the optical element (6) is substantially lozenge-shaped.
4. An optical pickup device as claimed in claim 3, wherein the included angle between the rear face (6f) of the optical element (6) and the substrate (2) below the optical element (6) is an obtuse angle.
5. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from the optical element (6) at a lower edge (12b) of the rear face.
6. An optical pickup device as claimed in claim 5, wherein the optical element (6) is substantially trapezoidal in shape.
7. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from both upper and lower edges (12a, 12b) of the rear face (6f).
8. An optical pickup device as claimed in claim 7, wherein a triangular-shaped cut-away portion is formed at the rear face (6f) of the optical element (6).



larly in the embodiments, undesired light preventing means 9b to 9d arranged on the basis of the above mentioned principle will be described. In this case, figs 5 and 6 are respectively fragmentary cross-sectional side views showing embodiments of the optical pickup device or its composite light emitting/light receiving element 1a of the present invention. Fig 7 is a perspective view of a further embodiment of the composite light emitting/light reflecting element 1a.

Referring to fig 5, the prism 6 is formed in a trapezoidal shape as viewed from the side of composite light emitting/light receiving element 1a. In this case, the undesired light is radiated outside the prism 6 from its lower edge 12b. That is, undesired light preventing means 9b is constructed on the rear side wall face 6f of the prism 6.

Referring to fig 6, a triangular-shaped cut-away is formed on the rear side wall face 6f of the prism 6 in its thickness direction, as viewed from the side of the composite light emitting/light receiving element 1a, thereby to radiate the undesired light outside the prism 6 from its upper and lower edges 12a and 12b, thus constructing undesired light preventing means 9c.

Referring to fig 7 which is a perspective view of a further embodiment of the composite light emitting/light receiving element 1a according to this invention, a plurality of triangular-shaped cut-aways are formed on the rear side wall face 6f of the prism 6 in its width direction to reflect the light beams within the respective triangular-shaped cut-away portions, whereby the undesired light beams 11d are radiated outside the prism 6 from its edge 13 along the apex of each triangular-shaped cut-away portion, thus providing the undesired light preventing means 9d.

Because in the illustrated, preferred embodiments of the present invention the prism is provided with undesired light beam preventing means, formed by changing the shape of the rear side wall face of the prism, to avoid the undesired light reflected and/or scattered within the prism, the detecting signal and the undesired light do not have to be separated electrically. Thus, without such a separation circuit, the illustrated embodiments of optical pickup device can prevent the undesired light and can produce a stable detecting signal from their photo detecting means, as well as be manufactured at low cost.

Claims

1. An optical pickup device comprising:

- (a) a substrate (2);
- (b) a semi-conductor laser element (5) mounted on said substrate (2);

5

10

15

20

25

30

35

40

45

50

55

5

(c) a photo detector (3) for receiving a laser beam emitted from said semi-conductor laser element (5) formed on said substrate (2); and

(d) an optical path branching optical element (6) fixed to said substrate (2) over said photo detector (3), said optical element (6) including an inclined front face (6a) positioned opposite said laser element (5) and having a semi-transparent reflection film deposited thereon and a rear face (6f) positioned opposite said front face; characterised in that said rear face (6f) is shaped to substantially prevent light (11a, 11b, 11c) incident thereon from being reflected into said photo detector (3) by reflecting said incident light such that it is multiply internally reflected between faces (6b, 6c, 6f) of the optical element (6) before being radiated from the optical element at an edge (12a, 12, 13) of the rear face (6f).

2. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from the optical element (6) at an upper edge (12a) of the rear face.

3. An optical pickup device as claimed in claim 2, wherein the optical element (6) is substantially lozenge-shaped.

4. An optical pickup device as claimed in claim 3, wherein the included angle between the rear face (6f) of the optical element (6) and the substrate (2) below the optical element (6) is an obtuse angle.

5. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from the optical element (6) at a lower edge (12b) of the rear face.

6. An optical pickup device as claimed in claim 5, wherein the optical element (6) is substantially trapezoidal in shape.

7. An optical pickup device as claimed in claim 1, wherein the rear face (6f) is shaped to reflect said incident light such that it is radiated from both upper and lower edges (12a, 12b) of the rear face (6f).

8. An optical pickup device as claimed in claim 7, wherein a triangular-shaped cut-away portion is formed at the rear face (6f) of the optical element (6).



9. An optical pickup device as claimed in claim 1, wherein a plurality of triangular-shaped cut-away portions are formed at the rear face of the optical element (6).

Patentansprüche

1. Optische Wandlervorrichtung mit:

- (a) einem Substrat (2);
- (b) einem Halbleiter-Laserelement (5), das auf dem Substrat (2) angebracht ist;
- (c) einem Photodetektor (3) zum Empfangen eines Laserstrahls, der von dem auf dem Substrat (2) gebildeten Halbleiter-Laserelement abgestrahlt wird; und
- (d) einem optischen Strahlengangablennungs-Element (6), das über dem Photodetektor (3) am Substrat (2) befestigt ist, wobei dieses optische Element (6) eine schräge vordere Fläche (6a), die dem Laserelement (5) gegenüberliegend angeordnet ist und eine auf ihr aufgebrachte halbdurchlässige Reflektionsschicht aufweist, und eine hintere Fläche (6f) umfaßt, die der vorderen Fläche abgewandt angeordnet ist, dadurch gekennzeichnet, daß die hintere Fläche (6f) so geformt ist, daß sie die Reflektion auf sie auftreffenden Lichtes (11a, 11b, 11c) in den Photodetektor (3) dadurch im wesentlichen verhindert, daß sie das auftreffende Licht derart reflektiert, daß es intern mehrfach zwischen Flächen (6b, 6c, 6f) des optischen Elementes (6) reflektiert wird, bevor es vom optischen Element an einem Rand (12a, 12b, 13) der hinteren Fläche (6f) abgestrahlt wird.

2. Optische Wandlervorrichtung nach Anspruch 1, in welcher die hintere Fläche (6f) so geformt ist, daß sie das auftreffende Licht derart reflektiert, daß es vom optischen Element (6) an einem oberen Rand (12a) der hinteren Fläche abgestrahlt wird.

3. Optische Wandlervorrichtung nach Anspruch 2, in welcher das optische Element (6) im wesentlichen rautenförmig ist.

4. Optische Wandlervorrichtung nach Anspruch 3, in welcher der zwischen der hinteren Fläche (6f) des optischen Elementes (6) und dem Substrat (2) unterhalb des optischen Elementes (6) eingeschlossene Winkel ein stumpfer Winkel ist.

5. Optische Wandlervorrichtung nach Anspruch 1, in welcher die hintere Fläche (6f) so geformt ist, daß sie das auftreffende Licht derart reflek-

tiert, daß es vom optischen Element an einem unteren Rand (12b) der hinteren Fläche abgestrahlt wird.

- 5 6. Optische Wandlervorrichtung nach Anspruch 5, in welcher das optische Element im wesentlichen trapezförmig ist.

- 10 7. Optische Wandlervorrichtung nach Anspruch 1, in welcher die hintere Fläche (6f) so geformt ist, daß sie das auftreffende Licht derart reflektiert, daß es sowohl vom oberen als auch vom unteren Rand (12a, 12b) der hinteren Fläche abgestrahlt wird.

- 15 8. Optische Wandlervorrichtung nach Anspruch 7, in welcher ein dreieckförmiger ausgeschnittener Abschnitt an der hinteren Fläche (6f) des optischen Elementes (6) ausgebildet ist.

- 20 9. Optische Wandlervorrichtung nach Anspruch 1, in welcher mehrere dreieckförmige ausgeschnittene Abschnitte an der hinteren Fläche des optischen Elementes (6) ausgebildet sind.

Revendications

1. Dispositif de lecteur optique comprenant :

- (a) un substrat (2) ;
- (b) un élément de laser à semiconducteur (5) monté sur ledit substrat (2) ;
- (c) un photodétecteur (3) pour recevoir un faisceau laser émis depuis ledit élément de laser à semiconducteur (5) formé sur ledit substrat (2) ; et
- (d) un élément optique d'établissement de chemin optique (6) fixé audit substrat (2) au-dessus dudit photodétecteur (3), ledit élément optique (6) incluant une face avant inclinée (6a) positionnée à l'opposé dudit élément de laser (5) et comportant un film de réflexion semi-transparent déposé dessus et une face arrière (6f) positionnée à l'opposé de ladite face avant,

caractérisé en ce que ladite face arrière (6f) est conformée de manière à empêcher significativement qu'une lumière (11a, 11b, 11c) qui arrive en incidence dessus ne soit réfléchié dans ledit photodétecteur (3) en réfléchissant ladite lumière incidente de telle sorte qu'elle soit réfléchié de façon interne et multiple entre des faces (6b, 6c, 6f) de l'élément optique (6) avant d'être irradiée depuis l'élément optique au niveau d'un bord (12a, 12, 13) de la face arrière (6f).

2. Dispositif de lecteur optique selon la revendication 1, dans lequel la face arrière (6f) est



conformée pour réfléchir ladite lumière incidente de telle sorte qu'elle soit irradiée depuis l'élément optique (6) au niveau d'un bord supérieur (12a) de la face arrière.

3. Dispositif de lecteur optique selon la revendication 2, dans lequel l'élément optique (6) est conformé sensiblement en losange.

5

4. Dispositif de lecteur optique selon la revendication 3, dans lequel l'angle inscrit entre la face arrière (6f) de l'élément optique (6) et le substrat (2) au-dessous de l'élément optique (6) est un angle obtus.

10

5. Dispositif de lecteur optique selon la revendication 1, dans lequel la face arrière (6f) est conformée pour réfléchir ladite lumière incidente de telle sorte qu'elle soit irradiée depuis l'élément optique (6) au niveau d'un bord inférieur (12b) de la face arrière.

15

6. Dispositif de lecteur optique selon la revendication 5, dans lequel l'élément optique (6) présente une conformation sensiblement trapézoïdale.

20

25

7. Dispositif de lecteur optique selon la revendication 1, dans lequel la face arrière (6f) est conformée pour réfléchir ladite lumière incidente de telle sorte qu'elle soit irradiée depuis à la fois des bords supérieur et inférieur (12a, 12b) de la face arrière (6f).

30

8. Dispositif de lecteur optique selon la revendication 7, dans lequel une partie taillée de conformation triangulaire est formée au niveau de la face arrière (6f) de l'élément optique (6).

35

9. Dispositif de lecteur optique selon la revendication 1, dans lequel une pluralité de parties taillées de conformation triangulaire sont formées au niveau de la face arrière de l'élément optique (6).

40

45

50

55

7