



DESCRIPTION

G00002

OPTICAL INTEGRATED ELEMENT

TECHNICAL FIELD

The present invention relates to an optical integrated element which is employed, for example, in an optical disk, an optical magnetic disk, an optical servo type magnetic disk or the like.

BACKGROUND ART

An optical integrated element usually radiates laser light outputted from a laser diode onto an optical disk, an optical magnetic disk, an optical servo type magnetic disk or the like (hereinafter, referred to as "optical disk" generically), makes the reflected light incident to a signal photo diode, and thereafter, replays and detects an information signal or a locating signal which are recorded on the optical disk from an output detected from the signal photo diode.

Hereinafter, the above-mentioned conventional optical integrated element will be described with reference to figure 7 to figure 10.

Figure 7 is a diagram illustrating a signal detecting system of the optical disk employing the conventional optical integrated element.

In figure 7, numeral 1 denotes an optical integrated element, numeral 4 denotes an optical disk, numeral 6 denotes a field lens which converges a laser light into the optical disk. The optical integrated element is constituted of each device described hereinafter. Numeral 2 denotes a laser diode which radiates laser light toward two directions. Numeral 3 denotes rising mirror which changes the proceeding path of one of the laser lights emitted from the laser diode 2 so as to direct to the optical disk 4. Numeral 5 denotes a hologram which diffracts a light which is produced by that the laser light incident to the optical disk 4 is reflected thereby. Numeral 7 denotes a signal photo diode to which the reflected light diffracted by the hologram 5 is incident. Numeral 8 denotes a current/voltage amplifier which converts the output current of the signal photo diode 7 into a voltage signal with a desired amplification factor. Numeral 9 denotes a monitor photo diode to which the other laser light is incident.

Further, the laser diode 2, the raising mirror 3, the signal photo diode 7, the monitor photo diode 9 and the current/voltage amplifier 8 are provided integrated on the same semiconductor substrate 10.

An optical integrated element thus constituted will be described, particularly on an operation thereof, with reference to figure 7.

At first, the laser diode 2 formed on the semiconductor substrate 10 radiates laser light toward two directions. The

proceeding path of one of the laser lights is changed by the raising mirror 3, and one of the laser lights is converged by the field lens 6 to be radiated onto the optical disk 4. The laser light radiated onto the optical disk 4 is reflected accompanied by an output component which is recorded on the optical disk 4, and is diffracted by the hologram 5 to be incident to the signal photo diode 7. The output current of the signal photo diode 7 is converted into a voltage signal by the current/voltage amplifier 8 with a desired amplification factor.

However, the other irradiation light from the laser diode 2 is incident to the monitor photo diode 9. The laser light emitted from the laser diode 2 is directly incident to the monitor photo diode 9, and the current in proportion to an emission output of the laser diode 2 is outputted from the photo diode 9.

Figure 8 is a diagram illustrating a view of the semiconductor substrate constituting the conventional optical integrated element from the direction of the optical disk. As shown in figure 8, the signal photo diode 7 is constituted by signal photo diodes 7A-7F which are divided into plurality.

Figure 10 is a circuit diagram of the conventional optical integrated element.

As shown in figure 10, numeral 1 denotes an optical integrated element, numeral 2 denotes a laser diode which radiates laser light toward two directions. Numeral 7 denotes a signal photo diode which detects a light which is produced by that one of the laser lights

emitted from the laser diode 2 is incident to the optical disk (not shown in figure) and is reflected. Numeral 8 denotes a current/voltage amplifier which converts a current detected signal outputted by the signal photo diode 7 into a voltage and amplifies it.

In addition, Q1, Q2 and Q4 denote PNP transistors, and numeral 14 denotes a current mirror circuit which controls the emission output of the laser diode 2 to be constant. Numeral 15 denotes a power terminal, numeral 17 and 21 denote amplifiers, numeral 20 denotes a voltage terminal and numeral 19 denotes a laser power control circuit. R2 denotes a feedback resistor and R3 denotes a semi-fixed resistor for laser power correction.

Further, the laser diode 2 constituting the optical integrated element 1, the monitor photo diode 9, the signal photo diode 7 and the current/voltage amplifier 8 are produced on the same substrate.

Subsequently, the circuit construction of the optical integrated element will be described in more detail with reference to figure 10.

The PNP transistor Q1 and the PNP transistor Q2 constitute the current mirror circuit 14. An emitter of the PNP transistor Q1 and an emitter of the PNP transistor Q2 are connected with each other, and then connected to the power terminal 15. In addition, a base or a collector of the PNP transistor Q1 and a base of the PNP transistor Q2 are connected with each other, and then connected to

a cathode of the monitor photo diode 9.

Further, a collector of the PNP transistor Q2 is connected to the laser power control circuit 19 which is constituted by the amplifier 17, the PNP transistor Q4 and the like, and the collector of the PNP transistor Q2 is connected to the semi-fixed resistor R3 which is mounted externally of the optical integrated element 1. The laser power control circuit 19 drives the laser diode 2 with a constant current which is set by the laser power control voltage terminal 20.

A cathode of the signal photo diode 7 is connected to an input terminal of the current/voltage amplifier 8 which is constituted by the amplifier 21 and the feedback resistor R2. While omitted in figure 10, the signal photo diode 7 is, actually, constituted by plural signal photo diodes 7A-7F, as shown in figure 8, and there are also provided plural current/voltage amplifiers 8 corresponding to respective signal photo diodes 7.

In the conventional optical integrated element 1 thus constituted, it is ideal that only the light reflected from the optical disk 4 is incident to the signal photo diode 7. However, actually, stray light due to the reflected light by the laser diode 2 or stray light due to irregular reflection and the like in the optical integrated element 1, together with the reflected light from the optical disk 4, is incident to the signal photo diode 7. As a result, there is a problem in that the dynamic range of the circuit should be narrowed.

Therefore, in order to solve the problem, a stray light cancel circuit disclosed in Japanese Published Patent Application No.Hei.6-45838 is proposed.

This stray light cancel circuit as disclosed in Japanese Published Patent Application No.Hei.6-45838 is one which, utilizing the characteristic that the stray light generated by irregular reflection and the like is in proportion to the output of the laser light, generates a cancel signal by multiplying the emission output of the laser diode by a coefficient and subtracts the same from the output signal of the signal photo diode, thereby to remove the optical DC error component.

By the way, accompanying with recent demands for smaller size and thickness devices, a miniaturization of the device has been required for the optical integrated element without being an exception. Accordingly, the area of the semiconductor substrate is also necessarily required to be miniaturized. However, in figure 8, the laser diode 2, the monitor photo diode 9, the signal photo diode 7 and the current/voltage amplifier 8 are produced on the same semiconductor substrate, therefore, it is not easy to realize the miniaturization of the semiconductor substrate.

Figure 9 is an arrangement diagram of each device in case where miniaturization of the semiconductor substrate is attempted in the optical integrated element shown in figure 8.

As shown in figure 9, in the case where the miniaturization of the optical integrated element 1 is attempted, the signal photo

diode 7 and the monitor photo diode 9 would be arranged close to each other. However, when the monitor photo diode 9 generates the output current in proportion to incident laser light, the monitor photo diode 9 also generates, at the same time, stray current 11 from the peripheral position of the monitor photo diode 9 in the semiconductor substrate 10.

The stray current 11 flows into the signal photo diode 7 which is located next to the monitor photo diode 9 and, particularly, into the signal photo diode 7C and the signal photo diode 7F, thereby generating a DC error component in the output of the signal photo diode 7. The stray current which is generated from the monitor photo diode 9 and gives DC error component to the output of the signal photo diode 7 will be referred as electric stray light.

The DC error component contained in the output of the signal photo diode 7 comprises the sum total of the stray light and the like due to irregular reflection in the optical integrated element and the electric stray light and the like due to the stray current of the monitor photo diode 9. In recent years, in particular, because the monitor photo diode 9 and the signal photo diode 7 are located close to each other from the demand for miniaturization of the optical integrated element, the DC error component due to the electric stray light has become larger than the DC error component due to irregular reflection and the like.

Figure 6 shows the characteristics of the electric stray light, and the stray light due to irregular reflection and the like, against

the output current of the monitor photo diode, in case where the miniaturization of the semiconductor substrate is attempted in the conventional optical integrated element. In figure 6, the abscissas indicates the output current value of the monitor diode (μA), and the ordinate coordinate indicates the DC error current of the signal photo diode output (μA).

As shown in figure 6, it is apparent that the error current of the stray light due to irregular reflection and the like is in proportion to the current value of the monitor photo diode. On the other hand, the error current due to the electric stray light presents non-linear correlation characteristic against the current value of the monitor photo diode.

The stray light cancel circuit as disclosed in Japanese Published Patent Application No.Hei.6-45838 is one which gives the cancel quantity in proportion to the emission output of the laser diode, thereby resulting in incapability of giving sufficient cancel effects to the DC error component mainly comprising the electric stray light having non-linear correlation characteristic against the output current of the monitor photo diode.

In addition, when the DC error component is large, in the current/voltage amplifier for amplifying the output of the signal photo diode, the dynamic range is narrowed because of an increase in the DC offset, thereby resulting in incapability of performing the correct signal reading. More particularly, in systems in which the numerical aperture is small and the optical utilization

efficiency is low as in an optical servo type magnetic disk, it is necessary to set an amplification factor of the current/voltage amplifier at a high value, thereby resulting in further decreased dynamic range due to the electric stray light.

The present invention is made to solve the above-mentioned problems, and has for its object to provide an optical integrated element which can remove the electric stray light, which means the DC error component contained in the output of the signal photo diode by the stray current generated from the monitor photo diode.

DISCLOSURE OF INVENTION

To solve the above-mentioned problems, there is provided an optical integrated element according to a first aspect of the present invention which comprises a laser diode which radiates laser light toward two directions, a current mirror circuit which controls an emission output of the laser diode to be constant, a monitor photo diode which detects the emission output of one of the irradiation lights from the laser diode, a signal photo diode which detects a light which is produced by that the other irradiation light from the laser diode is incident to an information recording medium and is reflected, a current/voltage amplifier which converts a current detecting signal outputted from the signal photo diode into a voltage with amplifying the current, and an electric stray light cancel circuit which generates a cancel signal on the basis of a non-linear correlation characteristic between the output of the monitor photo

diode and the DC error component occurred by stray current generated in the optical integrated element, and which adds or subtracts the cancel signal to/from the output of the signal photo diode.

According to the optical integrated element of the first aspect, a cancel signal is generated on the basis of a non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by the stray current generated in the optical integrated element, and the cancel signal is added or subtracted to/from the output of the signal photo diode. Thereby, it is possible to remove the electric stray light component contained in the output of the signal photo diode.

Further, since the electric stray light component contained in the output of the signal photo diode can be removed, in the current/voltage amplifier which amplifies the output of the signal photo diode, the dynamic range is broadened because of the reduction in the DC offset, thereby it is possible to read signals appropriately.

According to a second aspect of the present invention, there is provided an optical integrated element of the first aspect, wherein there is provided the electric stray light cancel circuit which comprises a transistor connected to a cathode of the monitor photo diode, a transistor connected to a cathode of the signal photo diode and a resistor which is inserted into the emitter side of the transistor connected to the signal photo diode, and which, by setting the value of the resistor at an optional value, generates

a cancel signal on the basis of non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and adds or subtracts the cancel signal to/from the output of the signal photo diode.

According to the optical integrated element of the second aspect, by setting the value of the resistor included in the electric stray light cancel circuit at an optional value, it is possible to generate a cancel signal on the basis of a non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and to add or subtract the cancel signal to/from the output of the signal photo diode, thereby it is possible to remove appropriately the electric stray light which is generated from the monitor photo diode and has the non-linear correlation characteristic. Further, the electric stray light cancel circuit can be produced by adding only the PNP transistor and the resistor, therefore, it is possible to produce the electric stray light cancel circuit easily on the same semiconductor substrate with providing few changes in the circuit area.

According to a third aspect of the present invention, there is provided an optical integrated element of the second aspect wherein there is provided the electric stray light cancel circuit which comprises that the first resistor is inserted into the emitter side of the transistor which is connected to the signal photo diode,

the second resistor is inserted into the emitter side of the transistor which is connected to the monitor photo diode and, further, the third resistor is inserted into the emitter side of the transistor included in the current mirror circuit, and in which the resistance values of the second resistor and the third resistor are equal to each other and the resistance value of the first resistor is larger than that of the second resistor and larger than that of the third resistor.

According to the optical integrated element of the third aspect, by setting the value of the first resistor at an optional value with relative to the second resistor and the third resistor, it is possible to generate a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and to add or subtract the cancel signal to/from the output of the signal photo diode, thereby it is possible to remove appropriately the stray light which is generated from the monitor photo diode and has the non-linear correlation characteristic. Further, the electric stray light circuit can be produced by adding only the PNP transistor and the resistor, therefore, it is possible to produce the electric stray light cancel circuit easily with providing few changes in the circuit area on the same semiconductor substrate.

According to a fourth aspect of the present invention, there is provided an optical integrated element of the first aspect,

wherein there is provided the electric stray light cancel circuit which comprises a transistor connected to a cathode of the monitor photo diode and a transistor connected to a cathode of the signal photo diode, and by employing the emitter side of the transistor connected to the signal photo diode as an external correction terminal for the optical integrated element and setting a value of a semi-fixed resistor connected to the external correction terminal at an optional value, generates a cancel signal on the basis of a non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and adds or subtracts the cancel signal to/from the output of the signal photo diode.

According to the optical integrated element of the fourth aspect, by setting a value of the semi-fixed resistor at an optional value, it is possible to generate a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and to add or subtract the cancel signal generated to/from the output of the signal photo diode, thereby it is possible to remove appropriately the stray light which is generated from the monitor photo diode and has the non-linear correlation characteristic. Further, the semi-fixed resistor is mounted externally of the optical integrated element, therefore, it is easy to operate it.

According to a fifth aspect of the present invention, there is provided an optical integrated element of any of the first aspect to the fourth aspect, wherein there is provided the electric stray light cancel circuit which is produced on the same semiconductor substrate.

According to the optical integrated element of the fifth aspect, even when the electric stray light cancel circuit is added, it is possible to provide the optical integrated element which maintains the miniaturization of the apparatus with providing few changes in the substrate area of the semiconductor substrate.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a circuit diagram of an optical integrated element according to a first embodiment of the present invention.

Figure 2 is a diagram illustrating a signal detecting system of an optical disk which employs the optical integrated element according to the first embodiment of the present invention.

Figure 3 is a circuit diagram of an optical integrated element according to a second embodiment of the present invention.

Figure 4 is a circuit diagram of an optical integrated element according to a third embodiment of the present invention.

Figure 5 is a diagram illustrating a cancel current characteristic of electric stray light in an electric stray light cancel circuit according to the first embodiment of the present invention.

Figure 6 is a diagram illustrating the characteristics of the electric stray light and the stray light due to irregular reflection and the like against the output current of the monitor photo diode in a conventional optical integrated element.

Figure 7 is a diagram illustrating a signal detecting system of an optical disk employing a conventional optical integrated element.

Figure 8 is a diagram in which a semiconductor substrate constituting a conventional optical integrated element is viewed in the direction of an optical disk.

Figure 9 is an arrangement diagram of respective devices in case where the miniaturization of the semiconductor substrate is attempted in the optical integrated element shown in figure 8.

Figure 10 is a circuit diagram of a conventional optical integrated element.

BEST MODE TO EXECUTE THE INVENTION

(Embodiment 1.)

Hereinafter, an optical integrated element according to a first embodiment of the present invention will be described with reference to figure 1 and figure 2.

Figure 1 is a circuit diagram of the optical integrated element according to the first embodiment of the present invention.

In figure 1, numeral 1 denotes an optical integrated element. The optical integrated element 1 comprises a laser diode 2 which

radiates laser light toward two directions, a signal photo diode 7 which reads out a light which is obtained when one of the irradiation lights from the laser diode 2 is incident to the optical disk and is reflected thereby, a monitor photo diode 9 from which the current in proportion to the emission output of the other irradiation light from the laser diode 2 is outputted, a current/voltage amplifier 8 which converts the output current of the signal photo diode 7 into a voltage signal with a desired amplification factor, a current mirror circuit 14 for controlling the emission output of the laser diode 2 to be constant, and an electric stray light cancel circuit 25 for performing a cancel action of the electric stray light.

References Q1, Q2, Q3 and Q4 denote PNP transistors, numeral 15 denotes a power terminal, numeral 17 and 21 denote amplifiers, numeral 20 denotes a voltage terminal, and numeral 19 denotes a laser power control circuit. R1 and R2 denote resistors, and R3 denotes a semi-fixed resistor for laser power correction.

Next, the circuit construction of the optical integrated element 1 will be described in more detail with reference to figure 1.

In figure 1, the current mirror circuit 14 including the PNP transistor Q2 controls the emission output of the laser diode 2 to be constant, together with the PNP transistor Q1. Further, the PNP transistor Q1 and the PNP transistor Q3 insert the resistor R1 into the emitter side of the PNP transistor Q3, to produce an electric stray light cancel circuit 25, which performs canceling of the

electric stray light.

The emitter of the PNP transistor Q3, the emitter of the PNP transistor Q1 and the emitter of the PNP transistor Q2 are connected with one another, and then connected to the power terminal 15. The base or the corrector of the PNP transistor Q1 and the base of the PNP transistor Q2 are connected with one another, and then connected to the cathode of the monitor photo diode 9. The base of the PNP transistor Q3 is connected to the base of the PNP transistor Q1 and to the base of the PNP transistor Q2 respectively, and the corrector of the PNP transistor Q3 is connected to the cathode of the signal photo diode 7.

Further, the corrector of the PNP transistor Q2 is connected to the laser power control circuit 19 which is constituted by the amplifier 17, transistor Q4, and the like, and is connected to the semi-fixed resistor R3 which is provided externally to the optical integrated element 1. The laser power control circuit 19 drives the laser diode 2 with a constant current which is set by the laser power control voltage terminal 20.

The electric stray light cancel circuit 25 according to the first embodiment of the present invention produces the PNP transistors Q1 and Q3 which constitute the circuit and the resistor R1 which is inserted into the emitter side of the PNP transistor Q3 on the same semiconductor substrate.

A description is given of the optical integrated element thus constructed, and particularly a mechanism by which the optical

integrated element detects information stored in an optical disk with reference to figure 2.

Figure 2 is a diagram illustrating a signal detecting mechanism for an optical disk which employs the optical integrated element according to the first embodiment of the present invention.

In figure 2, numeral 1 denotes an optical integrated element, numeral 4 denotes an optical disk, numeral 6 denotes a field lens which converges laser light onto the optical disk 4. The optical integrated element 1 is constituted by respective devices described hereinafter. Numeral 2 denotes a laser diode which radiates laser light toward two directions. Numeral 3 denotes a rising mirror which changes the proceeding path of one of the laser lights emitted from the laser diode 2 so as to direct to the optical disk 4. Numeral 5 is a hologram which diffracts a light which is produced by that the laser light incident to the optical disk 4 is reflected thereby. Numeral 7 denotes a signal photo diode to which the reflected light diffracted by the hologram 5 is incident. Numeral 8 denotes a current/voltage amplifier which converts the output current of the signal photo diode 7 into a voltage signal with a desired amplification factor. Numeral 9 is a monitor photo diode to which the other laser light is incident. Numeral 25 denotes an electric stray light cancel circuit which performs canceling of electric stray light.

A description is given of the optical integrated element thus constituted, and particularly on an operation thereof with reference

to figure 2.

At first, the laser diode 2 produced on the semiconductor substrate 10 radiates laser light toward two directions. The proceeding path of one of the laser lights is changed by the rising mirror 3, and the laser light is converged by the field lens 6 to be radiated onto the optical disk 4. The laser light radiated onto the optical disk 4 is reflected accompanied by an output component which is recorded on the optical disk 4, and is diffracted by the hologram 5 to be incident to the signal photo diode 7. The output current of the signal photo diode 7 is converted into a voltage signal by the current/voltage amplifier 8 with a desired amplification factor.

On the other hand, the other irradiation light from the laser diode 2 is incident to the monitor photo diode 9. The laser light emitted from the laser diode 2 directly is incident to the monitor photo diode 9, and, the output current in proportion to the emission output of the laser diode 2 is generated from the monitor photo diode 2, and at the same time, stray light is generated at peripheral portion of the monitor photo diode 9 in the semiconductor substrate 10. This stray current has a non-linear output characteristic with respect to the output of the monitor photo diode, and this stray current flowing into the signal photo diode 7 gives a DC error component due to the electric stray light to the output of the signal photo diode 7.

So, the electric stray light cancel circuit 25 by generating

a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode 9 and the DC error component occurred by the stray current generated in the optical integrated element by setting a value of the resistor R1 shown in figure 1 at an optional value by the electric stray light cancel circuit 25, and adding or subtracting the cancel signal to/from the output of the signal photo diode 7, it is possible to remove the DC error component occurred by the electric stray light.

Next, the electric stray light cancel circuit 25, which is a characteristic element of the present invention, will be described in more detail with reference to figure 1 and figure 5.

At first, in figure 1, the electric stray light cancel circuit 25 is constituted by the PNP transistor Q3 and the resistor R1, and the resistor R1 is provided only at the emitter side of the PNP transistor Q3 between the power terminal 15. The corrector current value I_{3c} of the PNP transistor Q3 then can be obtained by the following equation.

$$\ln(I_{mon}) = \ln(I_{3c}) + I_{3c} \times (qR1/kT) \dots (1)$$

Where I_{mon} denotes collector current of the PNP transistor Q2, and this value is equal to the output current of the monitor photo diode 9. Further, q denotes an electron charge, $R1$ denotes a resistance value of the resistor R1, k denotes Boltzmann's constant and T denotes the absolute temperature.

In addition, the output voltage V_{out} of the current/voltage amplifier 8 can be obtained by the following equation, in which the

output current of the signal photo diode 7 is represented as I_{SPD} and the reference voltage of the current/voltage amplifier 8 is represented as V_{ref} .

$$V_{out} = V_{ref} + R1 \times (I_{SPD} - I_{3c}) \cdots (2)$$

It comes to light from the equation (2) that the collector current I_{3c} of the PNP transistor Q3 is the cancel component for the output current I_{SPD} of the signal photo diode 7. So, the relationship between the output current I_{mon} of the monitor photo diode 9 and the cancel quantity I_{3c} will be shown in figure 5.

Figure 5 is a diagram illustrating a cancel current characteristic of the electric stray light in the electric stray light cancel circuit according to a second embodiment of the present invention. In figure 5, the abscissas presents the output current value (I_{mon}) of the monitor photo diode, and the ordinate presents the cancel current quantity (I_{3c}) of the PNP transistor Q3 for the output current value of the monitor photo diode.

When the cancel current characteristic for the electric stray light by the electric stray light cancel circuit shown in figure 5 and the characteristic of the electric stray light in the conventional optical integrate element shown in figure 6 are compared, it is apparent that the both values show close approximation. Therefore, it is possible to remove the electric stray light component appropriately by subtracting the collector current I_{3c} of the PNP transistor Q3 from the output current I_{SPD} of the signal photo diode 7.

Further, the electric stray light cancel circuit 25 can be produced by adding only the PNP transistor Q3 and the resistor R1. Therefore, by employing a bipolar monolithic integrated circuit technique, it is easily possible to produce the PNP transistor Q3 and the resistor R1 on the semiconductor substrate 10 on which the conventional current mirror circuit 14 and current/voltage amplifier 8 are also produced, with providing few changes in the substrate area of the semiconductor substrate.

As described above, according to the optical integrated element of the first embodiment, by setting a value of the resistor R1 included in the electric stray light cancel circuit 25 at an option value, the electric stray light cancel circuit 25 can generate a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode 9 and the DC error component occurred by the stray current generated in the optical integrated element 1 and can add or subtract the cancel signal to/from the output of the signal photo diode, and therefore, it is possible to remove appropriately the electric stray light which is generated from the monitor photo diode and has the non-linear correlation characteristic.

In addition, since it is possible to appropriately remove the electric stray light component contained in the output of the signal photo diode 7, the current/voltage amplifier which amplifies the output of the signal photo diode can have a broadened dynamic range from the reduction in the DC offset, thereby resulting in an

appropriate reading out of signals. Particular in systems in which optical utilization efficiency is low as in an optical servo type magnetic recording disk, splended effects can be obtained.

Further, the electric stray light circuit 25 can be produced by adding only the PNP transistor and the resister, therefore, the electric stray light cancel circuit can be produced easily on the same semiconductor substrate with providing few changes in the circuit area.

While a device for removing only DC error component occurred by the electric stray light was described in the first embodiment of the present invention, it is possible to construct a device which is provided with a stray light cancel circuit as disclosed in Japanese Published Patent Application No.Hei.6-45838 and also removes even the optical DC error component occurred by stray light generated by reflected light of the laser diode 2 or stray light generated by irregular reflection and the like in the optical integrated element.

(Embodiment 2.)

Hereinafter, an optical integrated element according to a second embodiment of the present invention will be described with reference to figure 3.

Figure 3 is a circuit diagram of the optical integrated element according to the second embodiment of the present invention. This optical integrated element according to the second embodiment of the present invention differs from the optical integrated element

according to the first embodiment of the present invention in which the electric stray light cancel circuit is produced by the PNP transistor Q1, the PNP transistor Q3 and the resistor R1, only in that an electric stray light cancel circuit according to the second embodiment is formed by the PNP transistor Q1, the PNP transistor Q3, the resistor R1, a resistor R4 and a resistor R5. So, description about components in common with components of the first embodiment will be omitted by employing the same references as those employed in the first embodiment.

In figure 3, R1, R4, and R5 denote resistors respectively, and an electric stray light cancel current 35 is produced by the PNP transistor Q1, the PNP transistor Q3, the resistor R1, the resistor R4 and the resistor R5. Further, the electric stray light cancel circuit 35 is constituted such that the first resistor R1 is inserted at the emitter side of the transistor Q3 which is connected to the signal photo diode 7, the second resistor R4 is inserted at the emitter side of the transistor Q1 which is connected to the monitor photo diode 9, and further, the third resistor R5 is inserted at a position between the emitter side of the transistor Q2 and the power terminal 15. The collector side of the transistor Q2 is led out to an external terminal provided for being connected to a semi-fixed resistor R3 or a laser power control circuit 19 which are provided externally to the optical integrated element 1.

The optical integrated element thus constituted, particularly on the operation thereof will be described with reference to figure

3.

The laser diode 2 radiates laser light toward two directions, and one of the laser light is radiated onto the optical disk (not to be shown in figure) and is reflected to be incident to the signal photo diode 7. The other laser light is incident to the monitor photo diode 9. In this case, the monitor photo diode 9 generates the output current in proportion to the emission output of the laser diode 2, and at the same time it also generates the stray current from peripheral portion of the monitor photo diode 9 in the semiconductor substrate 10. This stray current has a non-linear output characteristic against the output of the monitor photo diode, and the stray current flowing into the signal photo diode 7 gives a DC error component due to electric stray light in the output of the signal photo diode 7.

So, in order to remove the DC error component due to the electric stray light, the electric stray light cancel circuit 35 sets a resistance value of the resistor R1, a resistance value of the resistor R4 and a resistance value of the resistor R5 respectively, on the basis of the above-mentioned equations (1) and (2). In this case, respective values of the resistor R1, the resistor R4 and the resistor R5 are set so that the values of the resistor R4 and R5 should be equal to each other ($R4=R5$), and the value of the resistor R1 should be larger than that of the resistor R4 and the resistor R5 ($R1>R4 (=R5)$).

In other words, by setting a value of the resistor R1 at an

optional value against the resistors R4 and R5, whose resistance values are set equally, the electric stray light cancel circuit 35 generates a cancel signal which corresponds to the DC error component having a non-linear correlation characteristic against the output of the monitor photo diode 9 and adds or subtracts the cancel signal to/from the output of the signal photo diode, thereby to remove the DC error component having the non-linear correlation characteristic against the output of the monitor photo diode 9.

As described above, in the optical integrated element according to the present invention, the resistor R4 is provided between the PNP transistor Q1 and the power terminal 15, the resistor R5 is provided between the transistor Q2 and the power terminal 15, and the resistor R1 is mounted between the PNP transistor Q3 and the power terminal 15, respectively. Further, the resistance values of the resistor R4 and the resistor R5 are set equally, and the resistance value of the resistor R1 is set to be larger than that of the resistor R4 and the resistor R5, and, thus, the value of the resistor R1 is set at an optional value against the resistor R4 and the resistor R5. Thereby, it is possible to remove appropriately the DC error component occurred by the stray light which is generated from the monitor photo diode 9 and has the non-linear correlation characteristic against the output of the monitor photo diode 9.

In addition, even when the number of resistors is increased, it is possible to produce the electric stray light cancel circuit 35 easily on the same semiconductor substrate with providing few

changes in the circuit area.

(Embodiment 3.)

Hereinafter, an optical integrated element according to a third embodiment of the present invention will be described with reference to figure 4.

Figure 4 is a circuit diagram according to the third embodiment of the present invention. This optical integrated element according to the third embodiment of the present invention differs from the optical integrated element according to the first embodiment of the present invention only in that the resistor R1 constituting the electric stray light cancel circuit is provided externally to the optical integrated element 1 as a semi-fixed resistor R6 connected through an external correction terminal 22 included in the electric stray light cancel circuit. So, description about components in common with components of the first embodiment will be omitted by employing the same references as those employed in the first embodiment.

In figure 4, numeral 22 denotes an external correction terminal and numeral 6 denotes a semi-fixed resistor, and the electric stray light cancel circuit 45 is constituted such that the emitter side of the PNP transistor Q3 connected to the cathode of the signal photo diode 7 is employed as an external correction terminal 22 for the optical integrated element and that the semi-fixed resistor R6 is connected to the external correction terminal 22.

A operation of the optical integrated element thus constituted

will be described with reference to figure 4.

At first, the laser diode 2 radiates laser light toward two directions, and one of the laser lights is radiated onto the optical disk (not to be shown in figure) and is reflected to be incident to the signal photo diode 7. The other laser light is incident to the monitor photo diode 9. In this case, the monitor photo diode 9 generates the output current in proportion to the emission output of the laser diode 2, and at the same time it also generates the stray current from the peripheral portion of the monitor photo diode 9 in the semiconductor substrate 10. This stray current has a non-linear output characteristic against the output of the monitor photo diode, and the stray current flowing into the signal photo diode 7 gives a DC error component due to electric stray light in the output of the signal photo diode 7.

So, in order to remove the DC error component due to the electric stray light, the electric stray light cancel circuit 45 sets a resistance value of the semi-fixed resistor R6 on the basis of the above-mentioned equations (1) and (2). In other words, the electric stray light cancel circuit 45 sets a value of the semi-fixed resistor R6 at an optional value and generates a cancel signal which corresponds to the DC error component having a non-linear correlation characteristic against the output of the monitor photo diode 9, and adds or subtracts the cancel signal to/from the output of the signal photo diode, thereby to remove the DC error component having the non-linear correlation characteristic against the output

of the monitor photo diode 9.

As described above, in the optical integrated element according to the third embodiment of the present invention, the emitter side of the PNP transistor Q3 constituting the electric stray light cancel circuit 45 is employed as an external correction terminal 22, and the value of the semi-fixed resistor R6 connected to the external correlation terminal 22 is set at an optional value, thereby it is possible to remove appropriately the DC error component occurred by the electric stray current which is generated from the monitor photo diode 9 and has the non-linear correlation characteristic against the output of the monitor photo diode 9.

Further, in the optical integrated element according to the third embodiment of the present invention, it is possible to generate the cancel signal for the electric stray light generated from the monitor photo diode 9 by adjusting the semi-fixed resistor R6 which is provided externally to the optical integrated element 1, and therefore, the operation of the circuit is easily.

APPLICABILITY IN INDUSTRY

The optical integrated element according to the present invention can appropriately remove the electric stray light which is generated from the monitor photo diode and has a non-linear correlation characteristic against the output of the monitor photo diode. In this way, in the current/voltage amplifier for amplifying the output of the signal photo diode, it is possible to obtain a

wide dynamic range, thereby it is possible to read out signals appropriately. This is particularly effective in systems having a low optical utilization efficiency as in an optical servo type magnetic recording disk.

CLAIMS

1. An optical integrated element, comprising:

a laser diode which radiates laser light toward two directions;

a current mirror circuit which controls an emission output of the laser diode to be constant;

a monitor photo diode which detects the emission output of one of the irradiation lights from the laser diode;

a signal photo diode which detects a light which is produced by that the other irradiation light from the laser diode is incident to an recording medium and is reflected;

a current/voltage amplifier which converts a current detecting signal outputted from the signal photo diode into a voltage with amplifying the current; and

an electric stray light cancel circuit which generates a cancel signal on the basis of a non-linear correlation characteristic between the output of the monitor photo diode and a DC error component occurred by stray current generated in the optical integrated element and adds or subtracts the cancel signal to/from the output of the signal photo diode.

2. The optical integrated element as defined in claim 1, wherein

there is provided the electric stray light cancel circuit which comprises a transistor connected to a cathode of the monitor

photo diode, a transistor connected to a cathode of the signal photo diode and a resistor which is inserted into the emitter side of the transistor connected to the signal photo diode,

and which, by setting a value of the resistor at an optional value, generates a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and adds or subtracts the cancel signal to/from the output of the signal photo diode.

3. The optical integrated element as defined in claim 2, wherein there is provided the electric stray light cancel circuit which comprises that the first resistor is inserted into the emitter side of the transistor connected to the signal photo diode, the second resistor is inserted into the emitter side of the transistor connected to the monitor photo diode, and further, the third resistor is inserted into the emitter side of the transistor which is included in the current mirror circuit,

and in which the resistance value of the second resistor and the resistance value of the third resistor are equal to each other, and the resistance value of the first resistor is larger than that of the second resistor and larger than that of the third resistor.

4. The optical integrated element as defined in claim 1, wherein there is provided the electric stray light cancel circuit which comprises a transistor connected to a cathode of the monitor photo diode and a transistor connected to a cathode of the signal photo

diode,

and by employing the emitter side of the transistor connected to a cathode of the signal photo diode as an external correction terminal for the optical integrated element and setting the value of a semi-fixed resistor connected to the external correction terminal at an optional value, generates a cancel signal on the basis of the non-linear correlation characteristic between the output of the monitor photo diode and the DC error component occurred by stray current generated in the optical integrated element and adds or subtracts the cancel signal to/from the output of the signal photo diode.

5. The optical integrated element as defined in any of claim 1 to 4, wherein

the electric stray light cancel circuit is produced on the same semiconductor substrate.