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OPTICAL MODULATOR INTEGRATED LASER DEVICE, OPTICAL DEVICE, AND OPTICAL MODULATOR

Abstract

An optical modulator integrated laser device comprising: a substrate; a laser unit provided on the substrate and configured to output laser light; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate the laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the second signal pad.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is based upon and claims the benefit of the priority from Japanese patent application No. 2024-022273 filed on Feb. 16, 2024, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an optical modulator integrated laser device, an optical device, and an optical modulator.

BACKGROUND

[0003] Japanese Unexamined Patent Publication No. 2001-308130 discloses techniques for a high-frequency circuit and a module and a communicator on which the high-frequency circuit is mounted. In the high-frequency circuit, a signal line for transmitting a high-frequency signal is connected to an element having capacitance by a first bonding wire. The element having capacitance is connected to a terminating resistor for impedance matching by a second bonding wire. In the high-frequency circuit, a magnitude of a characteristic impedance of a transmission line constituted by the first bonding wire, the second bonding wire, and the element having capacitance is larger than that of a characteristic impedance on an input side of the high-frequency signal. In the high-frequency circuit, a magnitude of inductance of the first bonding wire is smaller than that of inductance of the second bonding wire.

SUMMARY

[0004] An optical modulator integrated laser device according to an embodiment of the present disclosure includes a substrate, a laser unit, an optical modulation unit, a first signal pad, a second signal pad, and a first terminating resistor. The laser unit is provided on the substrate and outputs laser light. The optical modulation unit is provided on the substrate, includes a modulation electrode supplied with one of modulation signals, and modulates the laser light. The first signal pad is provided on the substrate, receives an input of the one of the modulation signals as a positive phase signal of a differential signal, and is connected to the modulation electrode. The second signal pad is provided on the substrate side by side with the first signal pad and receives an input of another of the modulation signals as a negative phase signal of the differential signal. The first terminating resistor is provided on the substrate and includes a first end connected to the first signal pad and a second end connected to the second signal pad.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a plan view illustrating a transmission micro optical device which is an optical device according to a first embodiment of the present disclosure.

[0006] FIG. **2** is a circuit diagram of the transmission micro optical device.

[0007] FIG. **3** is a perspective view illustrating enlargement of a part of the transmission micro optical device.

[0008] FIG. **4** is a plan view illustrating enlargement of a part of the transmission micro optical device.

[0009] FIG. **5** is a sectional view taken along line V-V in FIG. **4**.
[0010] FIG. **6** is a sectional view illustrating some steps for manufacturing an optical modulator integrated semiconductor laser.
[0011] FIG. **7** is a sectional view illustrating some steps for manufacturing an optical modulator integrated semiconductor laser.
[0012] FIG. **8** is a perspective view illustrating enlargement of a part of a transmission micro optical device according to a first modified example.
[0013] FIG. **9** is a plan view illustrating enlargement of a part of the transmission micro optical device according to the first modified example.
[0014] FIG. **10** is a perspective view illustrating enlargement of a part of a transmission micro optical device according to a second modified example.
[0015] FIG. **11** is a plan view illustrating enlargement of a part of the transmission micro optical device according to the second modified example.
[0016] FIG. **12** is a plan view illustrating enlargement of a part of the transmission micro optical device according to the second modified example.
[0017] FIGS. **13**A and **13**B are circuit diagrams illustrating simplification of a circuit according to the first embodiment and a circuit according to the second modified example.
[0018] FIG. **14** is a plan view illustrating a transmission micro optical device according to a comparative example.
[0019] FIG. **15** is a circuit diagram of the transmission micro optical device.
[0020] FIG. **16** is a plan view illustrating partial enlargement of the transmission micro optical device.

DETAILED DESCRIPTION

[0021] With an increase in speed and capacity of optical communication, there is need for an increase in frequency bandwidth of an optical modulator of an optical device. However, when a modulation signal has a high frequency such as 100 GHz or higher, electrical reflection of the modulation signal is likely to increase. As reflection of the modulation signal increases, a loss of the modulation signal increases. Accordingly, for example, the modulation signal may not be likely to be satisfactorily transmitted to the optical modulator.
[0022] An objective of the present disclosure is to provide an optical modulator integrated laser device, an optical device, and an optical modulator that can decrease a loss of a modulation signal due to reflection.

Embodiments of Present Disclosure

[0023] Details of embodiments of the present disclosure will be first mentioned below. [0024] [1] An optical modulator integrated laser device according to an embodiment of the present disclosure includes a substrate, a laser unit, an optical modulation unit, a first signal pad, a second signal pad, and a first terminating resistor. The laser unit is provided on the substrate and outputs laser light. The optical modulation unit is provided on the substrate, includes a modulation electrode supplied with one of modulation signals, and modulates the laser light. The first signal pad is provided on the substrate, receives an input of the one of the modulation signals as a positive phase signal of a differential signal, and is connected to the modulation electrode. The second signal pad is provided on the substrate side by side with the first signal pad and receives an input of another of the modulation signals as a negative phase signal of the differential signal. The first terminating resistor is provided on the substrate and includes a first end connected to the first signal pad and a second end connected to the second signal pad.
[0025] In the optical modulator integrated laser device according to [1], a wire (hereinafter referred to as a first wire) connected to the first signal pad and a wire (hereinafter referred to as a second wire) connected to the second signal pad are provided side by side. Since the first wire inputs one of the modulation signals and the second wire inputs the other of the modulation signals of a phase opposite to that of the one of the modulation signals, a virtual reference potential line appears

between the first wire and the second wire. Accordingly, mismatching in input impedance of the modulation signal in the first wire is reduced. The modulation electrode, the first signal pad, and the first terminating resistor are provided on the same substrate. Accordingly, it is possible to much shorten the distance of the conductive path between the modulation electrode and the first end of the first terminating resistor. As a result, it is possible to reduce electrical reflection of one of the modulation signals at the first end of the first terminating resistor. Accordingly, it is possible to reduce a loss of the modulation signal due to reflection. [0026] [2] In the optical modulator integrated laser device according to [1], a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0027] [3] In the optical modulator integrated laser device according to [2], a distance of a conductive path between the connection point and the modulation electrode may be less than ¼ of the wavelength of the modulation signals. [0028] [4] The optical modulator integrated laser device according to any one of [1] to [3] may further include: a third signal pad provided on the substrate on a side opposite to the second signal pad with respect to the first signal pad; a fourth signal pad provided on the substrate on a side opposite to the first signal pad with respect to the second signal pad; a second terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the third signal pad; and a third terminating resistor provided on the substrate and including a first end connected to the second signal pad and a second end connected to the fourth signal pad. [0029] [5] In the optical modulator integrated laser device according to [4], a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the second terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0030] [6] In the optical modulator integrated laser device according to [4] or [5], a distance of a conductive path between a connection point of the second signal pad to which a second wire for inputting another of the modulation signals is connected and the first end of the third terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0031] [7] In the optical modulator integrated laser device according to any one of [4] to [6], a distance of a conductive path between a connection point of the third signal pad to which a third wire with a ground potential is connected and the second end of the second terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0032] [8] In the optical modulator integrated laser device according to any one of [4] to [7], a distance of a conductive path between a connection point of the fourth signal pad to which a fourth wire with a ground potential is connected and the second end of the third terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0033] [9] An optical modulator integrated laser device according to another embodiment of the present disclosure includes: a substrate; a laser unit provided on the substrate and configured to output laser light; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate the laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the modulation electrode and a second end connected to the second signal pad. [0034] [10] The optical modulator integrated laser device according to [9] may further include a line connecting the second end of the first terminating resistor to the second signal pad. The line may be provided on a side opposite to the first signal pad with respect to the second signal pad and extend along the modulation electrode. [0035] [11] An optical device according to another embodiment of the present disclosure includes: the optical modulator integrated laser device according to any one of [1] to [3]; a carrier in which a first transmission line and a second transmission line are provided on a top surface and in which the optical modulator integrated laser device is mounted; a first wire connecting the first signal pad to the first transmission line; and a second wire connecting the second signal pad to the second transmission line. [0036] [12] In the optical device according to [11], a distance of a conductive path between a connection point of the first signal pad to which the first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0037] [13] In the optical device according to [12], a distance of a conductive path between the connection point and the modulation electrode may be less than ¼ of the wavelength of the modulation signals. [0038] [14] An optical modulator according to another embodiment of the present disclosure includes: a substrate; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the second signal pad. [0039] [15] In the optical modulator according to [14], a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor may be less than ¼ of a wavelength of the modulation signals. [0040] [16] In the optical modulator according to [15], a distance of a conductive path between the connection point and the modulation electrode may be less than ¼ of the wavelength of the modulation signals. [0041] [17] The optical modulator according to any one of to may further include a laser unit provided on the substrate and configured to output the laser light.

Details of Embodiments of Present Disclosure

[0042] Specific examples of an optical modulator integrated laser device, an optical device, and an optical modulator according to the present disclosure will be described below with reference to the accompanying drawings. The present disclosure is not limited to such examples, is defined by the appended claims, and is intended to include all modifications within meanings and scopes equivalent to the claims. In the following description, the same elements in the drawings will be referred to by the same reference signs, and repeated description thereof will be omitted. In the following description, a reference potential may be referred to as a ground potential.

First Embodiment

[0043] FIG. **1** is a plan view illustrating a transmission micro optical device **1** which is an optical device according to a first embodiment of the present disclosure. FIG. **2** is a circuit diagram of the transmission micro optical device **1**. A configuration of the transmission micro optical device **1** will be described below with reference to FIGS. **1** and **2**.

[0044] As illustrated in FIG. **1**, the transmission micro optical device **1** includes a package **20**, a substrate **21** (a chip-on-carrier), a substrate **22** (a mount carrier), and a substrate **23**. The package **20** accommodates the substrate **21**, the substrate **22**, and the substrate **23**. The substrate **22** is disposed side by side with the substrate **23**. The substrate **21** is disposed on the substrate **22**. A material of the substrate **21** and the substrate **22** is, for example, an insulator such as ceramic.

[0045] The transmission micro optical device **1** further includes wiring patterns P**1**, P**2**, P**3**, P**4**, and P**5**, ground potential lines P**6** and P**7**, signal lines P**8** and P**9**, and a differential driver IC **24** (a differential drive circuit) which are provided on the substrate **23**. The wiring patterns P**1**, P**2**, P**3**, P**4**, and P**5**, the ground potential lines P**6** and P**7**, and the signal lines P**8** and P**9** extend from one side wall of the package **20** toward the substrate **22** and are connected to an external circuit outside of the transmission micro optical device **1** via terminals which are not illustrated. The signal line P**8** allows one of high-frequency modulation signals (hereinafter referred to as a positive phase signal) which is input from the outside of the transmission micro optical device **1** to propagate therein. The signal line P**9** allows the other of the modulation signals (hereinafter referred to as a negative phase signal) which has a phase opposite to the one of the modulation signals, the negative phase signal is input from the outside of the transmission micro optical device **1** to propagate therein. That is, the positive phase signal propagating in the signal line P**8** and the negative phase signal propagating in the signal line P**9** form a differential signal. The ground potential lines P**6** and P**7** have a ground potential (a reference potential) which is input from a circuit on the outside of the transmission micro optical device **1**. The signal lines P**8** and P**9** and the ground potential lines P**6** and P**7** constitute a transmission line.

[0046] Four input terminals of the differential driver IC **24** are connected to the ground potential lines P**6** and P**7** and the signal lines P**8** and P**9**, respectively. The differential driver IC **24** amplifies the differential signal propagating in the signal lines P**8** and P**9** and outputs the amplified differential signal (the positive phase signal and the negative phase signal).

[0047] The transmission micro optical device **1** further includes wiring patterns P**10**, P**11**, and P**12**, ground potential lines P**13** and P**14**, signal lines P**15** and P**16**, a thermistor **25**, a monitoring photodiode **26**, and a lens **27** which are provided on the substrate **22**.

[0048] The wiring pattern P**10** is connected to the wiring pattern P**3** by a wire W**1**. The wiring pattern P**11** is connected to the wiring pattern P**4** by a wire W**2**. The wiring pattern P**12** is connected to the wiring pattern P**5** by a wire W**3**. The ground potential line P**13** is connected to one output terminal with the reference potential out of four output terminals of the differential driver IC **24** by a wire W**4**. The ground potential line P**14** is connected to another output terminal with the reference potential out of the four output terminals of the differential driver IC **24** by a wire W**5**. The signal line P**15** is connected to an output terminal for outputting a positive phase signal out of the four output terminals of the differential driver IC **24** by a wire W**6**. The signal line P**16** is connected to an output terminal for outputting a negative phase signal out of the four output terminals of the differential driver IC **24** by a wire W**7**.

[0049] The thermistor **25** is provided on the wiring pattern P**12**. The thermistor **25** shows a resistance value corresponding to the temperature. This resistance value is output via the wiring pattern P**12**, the wire W**3**, and the wiring pattern P**5** and is detected by an external circuit outside of the transmission micro optical device **1**.

[0050] The monitoring photodiode **26** is connected between the wiring pattern P**10** and the ground potential line P**13**. In order to make an average intensity of emission light M constant, the monitoring photodiode **26** detects backlight which is emitted from an optical modulator integrated semiconductor laser **10** (which will be described later). The monitoring photodiode **26** outputs an electrical signal corresponding to the intensity of the backlight to an external circuit outside of the transmission micro optical device **1** via the wiring pattern P**10**, the wire W**1**, and the wiring pattern P**3**. The lens **27** is optically coupled to a light emitting end of an optical modulator integrated semiconductor laser **10** and collimates the emission light M which is emitted from the optical modulator integrated semiconductor laser **10**.

[0051] A temperature control element (thermoelectric cooler (TEC)) **28** (which is illustrated in only FIG. **2**) is provided on the rear of the substrate **22**. One electrode of the TEC **28** is connected to the wiring pattern P**1** by a wire W**8**. The other electrode of the TEC **28** is connected to the wiring pattern P**2** by a wire W**9**. Electric power for driving the TEC **28** is input from a circuit outside of the transmission micro optical device **1** via the wiring pattern P**1** and the wiring pattern P**2**. The circuit outside of the transmission micro optical device **1** controls a magnitude of electric power for driving the TEC **28** on the basis of the ambient temperature (that is, the resistance value of the thermistor **25**) of the optical modulator integrated semiconductor laser **10**. Accordingly, the temperature of the optical modulator integrated semiconductor laser **10** is maintained at a predetermined temperature, and the wavelength of the emission light M is maintained at a predetermined wavelength.

[0052] A ground potential line P**20**, a wiring pattern P**21**, and a bypass capacitor **29** are provided on the substrate **21**. The ground potential line P**20** is connected to the ground terminal of the thermistor **25** by a wire W**10**. The ground potential line P**20** is connected to a ground pattern P**19** (which will be described later). The ground potential line P**20** has the ground potential (the reference potential).
[0053] The bypass capacitor **29** is provided on the ground potential line P**20**. A lower electrode of the bypass capacitor **29** is connected to the ground potential line P**20**. An upper electrode of the bypass capacitor **29** is connected to the wiring pattern P**21** by a wire W**11**. The wiring pattern P**21** is connected to the wiring pattern P**11** by a wire W**12**.
[0054] The transmission micro optical device **1** includes an optical modulator integrated semiconductor laser **10**, a ground pattern P**19**, and a transmission line **30**. The ground pattern P**19** is a metal film provided on the substrate **21**. The ground pattern P**19** has the ground potential (the reference potential).
[0055] The transmission line **30** includes a ground potential line P**22**, a ground potential line P**23**, a signal line P**24** (a first transmission line), and a signal line P**25** (a second transmission line). The signal line P**24** and the signal line P**25** are metal films which are provided side by side with each other in a direction crossing an extending direction thereof. The ground potential line P**22** and the ground potential line P**23** are metal films which are provided at positions at which the signal line P**24** and the signal line P**25** are interposed therebetween. The ground potential line P**22** extends along the signal line P**24**, and the ground potential line P**23** extends along the signal line P**25**. As illustrated in FIG. **1**, a first end of the ground potential line P**22** is connected to the ground potential line P**13** by a wire W**13**. A first end of the ground potential line P**23** is connected to the ground potential line P**14** by a wire W**14**. Second ends of the ground potential line P**22** and the ground potential line P**23** are connected to the ground pattern P**19**. A first end of the signal line P**24** is connected to the signal line P**15** by a wire W**15**. A first end of the signal line P**25** is connected to the signal line P**16** by a wire W**16**. A positive phase signal from the differential driver IC **24** is transmitted from the signal line P**24** to a signal pad **15** via a wire W**21**. A negative phase signal from the differential driver IC **24** is transmitted to a signal pad **16** via a wire W**22**.
[0056] The optical modulator integrated semiconductor laser **10** according to the present embodiment is an example of the optical modulator integrated laser device according to the present disclosure. The optical modulator integrated semiconductor laser **10** is provided on the ground pattern P**19**. FIG. **3** is a perspective view illustrating enlargement of a part of the transmission micro optical device **1**. FIG. **4** is a plan view illustrating enlargement of a part of the transmission micro optical device **1**. As illustrated in FIGS. **3** and **4**, the optical modulator integrated semiconductor laser **10** includes a substrate **101**, a laser unit **11**, an optical modulation unit **12**, a terminating resistive film **17** (a first terminating resistor), a wire W**21** (a first wire), and a wire W**22** (a second wire). The substrate **101** has a rectangular parallelepiped shape. The laser unit **11** is disposed in an area which is closer to the substrate **23** than the optical modulation unit **12** on the substrate **101**. As illustrated in FIG. **1**, the laser unit **11** is interposed between the transmission line **30** and the ground potential line P**20**. The laser unit **11** includes an active area and generates laser light with a light intensity which is temporally constant by supplying a current to the active area. The laser unit **11** includes a drive electrode **14** and a pad **18** on the surface thereof. The drive electrode **14** extends in a laser resonance direction (an arrangement direction of the laser unit **11** and the optical modulation unit **12**) and supplies a current to the active area. The pad **18** is arranged side by side with the drive electrode **14** in a direction crossing an extending direction of the drive electrode **14** and is connected to the drive electrode **14**. The pad **18** is connected to the upper electrode of the bypass capacitor **29** by a wire W**17**. Accordingly, a drive current is supplied from the outside of the transmission micro optical device **1** to the drive electrode **14** via the wiring pattern P**4**, the wiring pattern P**11**, the wiring pattern P**21**, the upper electrode of the bypass capacitor **29**, and the pad **18**.

[0057] The optical modulation unit **12** is provided closer to the lens **27** than the laser unit **11**. The optical modulation unit **12** includes a light absorbing layer, allows the light absorbing layer to modulate laser light output from the laser unit **11**, and outputs the modulated emission light M. The backlight is laser light which is output from the laser unit **11** without passing through the optical modulation unit **12**. The laser unit **11** and the optical modulation unit **12** are monolithically formed on the substrate **101**. The optical modulation unit **12** includes a modulation electrode **13**, a signal pad **15** (a first signal pad), and a signal pad **16** (a second signal pad). The optical modulation unit **12** modulates the laser light by transmitting or cutting off the laser light with supply of a current to the light absorbing layer. The modulation electrode **13** supplies a modulation current (a modulation signal) to the light absorbing layer. Accordingly, the laser light is transmitted or cut off by the light absorbing layer on the basis of the input modulation signal. The modulation electrode **13** extends in the same direction as a propagation direction of laser light in a plan view. On the top surface of the optical modulator integrated semiconductor laser **10**, the modulation electrode **13** is provided substantially at the center in a direction perpendicular to the propagation direction of laser light.
[0058] The signal pad **15** and the signal pad **16** are provided closer to the transmission line **30** than the modulation electrode **13**. The signal pad **15** is connected to a first end of the wire W**21** connected to the modulation electrode **13** to input a positive phase signal to the optical modulation unit **12**. The signal pad **16** is provided side by side with the signal pad **15** in a length direction of the modulation electrode **13**. The signal pad **16** is connected to a first end of the wire W**22** for inputting a negative phase signal to the optical modulation unit **12**. The signal pad **15** is provided closer to the laser unit **11** than the signal pad **16**. The signal pad **15** and the signal pad **16** have a film shape and has a substantially rectangular shape in a plan view. The material of the signal pad **15** and the signal pad **16** is metal and is, for example, gold (Au). The thickness of the signal pad **15** and the signal pad **16** are, for example, equal to or greater than 3 μm and equal to or less than 10 μm.
[0059] A second end of the wire W**21** is connected to a second end of the signal line P**24** of the transmission line **30**. A second end of the wire W**22** is connected to a second end of the signal line P**25** of the transmission line **30**. When seen in the thickness direction of the substrate **101**, the extending direction of the wire W**21** and the wire W**22** crosses the extending direction of the modulation electrode **13**. The wire W**21** and the wire W**22** are arranged side by side in the extending direction of the modulation electrode **13**. For example, when seen in the thickness direction of the substrate **101**, the wire W**21** and the wire W**22** are parallel with each other. The wire W**21** and the wire W**22** are, for example, bonding wires formed of Au. A diameter of a cross-section of the wire W**21** and the wire W**22** is, for example, 25 μm. A gap between the wire W**21** and the wire W**22** is, for example, several tens of μm. A difference between the length of the wire W**21** and the length of the wire W**22** is less than ¼, less than ⅛, less than 1/10, or less than 1/12 of a wavelength of a modulation signal.
[0060] The terminating resistive film **17** is provided between the signal pad **15** and the signal pad **16**. The terminating resistive film **17** reduces reflection of a modulation signal. A first end **17**_a_ (see FIG. **4**) of the terminating resistive film **17** is connected to the signal pad **15**. A second end **17**_b_ (see FIG. **4**) of the terminating resistive film **17** is connected to the signal pad **16**. A distance of a conductive path (an electrical length) L**1** between a connection point between the wire W**21** and the signal pad **15** and the first end **17**_a_ of the terminating resistive film **17** is, for example, less than ¼, less than ⅛, less than 1/10, or less than 1/12 of a wavelength of a modulation signal. The distance L**1** is, for example, equal to or greater than 1/1000 of the wavelength of the modulation signal. Similarly, a distance of a conductive path (an electrical length) L**2** between a connection point between the wire W**21** and the signal pad **15** and the modulation electrode **13** is, for example, less than ¼, less than ⅛, less than 1/10, or less than 1/12 of the wavelength of the modulation signal. The distance L**2** is, for example, equal to or greater than 1/1000 of the wavelength of the modulation signal. Specifically, when the wavelength of the modulation signal is, for example,

1200 μm, the distance L**1** and the distance L**2** are less than 300 μm, less than 150 μm, less than 120 μm, or less than 100 μm and equal to or greater than 1 μm.
[0061] The terminating resistive film **17** has a rectangular shape. The material of the terminating resistive film **17** is, for example, a metal such as nickel chromium (NiCr), titanium tungsten (TiW), tantalum nitride (TaN), or platinum (Pt). The thickness of the terminating resistive film **17** is, for example, equal to or greater than 100 nm and equal to or less than 300 nm. The terminating resistive film **17** is formed of a resistive pattern of a thin film which is formed by vapor deposition and lifting-off thereafter, sputtering, or the like. By setting the resistance value of the terminating resistive film **17** to, for example, 100Ω, a value of terminating impedance is 50Ω. The value of terminating impedance is generally often 50Ω or may be different from 50Ω by addition of a capacitor, an inductor, or the like or adjustment of a resistance value.
[0062] FIG. **5** is a sectional view taken along line V-V in FIG. **4**. The optical modulation unit **12** includes a passivation film **102** and a seed layer **103** on the substrate **101**. The substrate **101** is provided on the ground pattern P**19** in contact with the ground pattern P**19**. The substrate **101** is formed of, for example, semi-insulating InP or n-type InP, or an insulator. The passivation film **102** is provided on the substrate **101**. The material of the passivation film **102** is, for example, an insulator such as SiO.sub.2 or SiN. The thickness of the passivation film **102** is, for example, equal to or greater than 300 nm and equal to or less than 500 nm. The terminating resistive film **17** is provided on the passivation film **102**. The signal pad **15** and the signal pad **16** are provided on the passivation film **102** and include a part provided on the terminating resistive film **17** and a part provided in an area of the passivation film **102** without the terminating resistive film **17**. The seed layer **103** is provided between the passivation film **102** and both the signal pad **15** and the signal pad **16** and between the terminating resistive film **17** and both the signal pad **15** and the signal pad **16**. The material of the seed layer **103** is, for example, gold (Au). The thickness of the seed layer **103** is, for example, equal to or greater than 100 nm and equal to or less than 200 nm. The signal pad **15** and the signal pad **16** are not in contact with each other, and the terminating resistive film **17** includes parts exposed from the signal pad **15** and the signal pad **16**.
[0063] FIGS. **6** and **7** are sectional views illustrating some steps of a process of manufacturing the optical modulator integrated semiconductor laser **10**. Some steps of the process of manufacturing the optical modulator integrated semiconductor laser **10** will be described below. In the optical modulation unit **12**, first, the substrate **101** is prepared. Then, the passivation film **102** is formed on the substrate **101**. Thereafter, a resist mask which is not illustrated is formed on the surface of the passivation film **102** through photolithography and the terminating resistive film **17** is formed on the passivation film **102**. Then, the seed layer **103** is formed on the surfaces of the terminating resistive film **17** and the passivation film **102**. Thereafter, a resist mask **104** in which an opening **104***a* and an opening **104***b* are provided is formed on the surface of the seed layer **103** through photolithography. Subsequently, by performing gold plating on the opening **104***a* and the opening **104***b*, the signal pad **15** is formed in the opening **104***a* and the signal pad **16** is formed in the opening **104***b* as illustrated in FIG. **7**. Finally, the resist mask **104** is removed from the optical modulation unit **12**, and the exposed parts of the seed layer **103** are removed using the signal pad **15** and the signal pad **16** as a mask. Accordingly, the signal pad **15**, the terminating resistive film **17**, and the signal pad **16** illustrated in FIG. **5** are formed.
[0064] Advantages which are obtained by the transmission micro optical device **1** and the optical modulator integrated semiconductor laser **10** having the aforementioned configuration will be described below in comparison with a comparative example. FIG. **14** is a plan view illustrating a transmission micro optical device **2** according to a comparative example. FIG. **15** is a circuit diagram of the transmission micro optical device **2**. FIG. **16** is a plan view illustrating enlargement of a part of the transmission micro optical device **2**. The transmission micro optical device **2** is different from the transmission micro optical device **1** mainly in the following points. The transmission micro optical device **2** includes an optical modulator integrated semiconductor laser

10C and a transmission line **30**C instead of the optical modulator integrated semiconductor laser **10** and the transmission line **30**. The transmission micro optical device **2** includes a terminating portion **80**.

[0065] The optical modulator integrated semiconductor laser **10**C includes an optical modulation unit **12**C instead of the optical modulation unit **12**. The optical modulation unit **12**C is different from the optical modulation unit **12** in that the signal pad **16** and the wire W**22** are not provided and a first end of a wire W**41** is connected to the signal pad **15**. The terminating resistive film **17** is not provided on the substrate. The transmission line **30**C is different from the transmission line **30** in that the ground potential line P**23** and the signal line P**25** are not provided. The terminating portion **80** is provided on a side opposite to the transmission line **30**C with respect to the optical modulator integrated semiconductor laser **10**C on the substrate **21**. The terminating portion **80** includes a protruding portion from the ground pattern P**19**, a pad **81**, and a terminating resistive film **82**. A second end of the wire W**41** is connected to the pad **81**. The terminating resistive film **82** includes a first end connected to the protruding portion from the ground pattern P**19** and a second end connected to the pad **81**.

[0066] In the transmission micro optical device **2**, since the terminating resistive film **82** is provided outside of the optical modulator integrated semiconductor laser **10**C, a transmission line from the second end of the terminating resistive film **82** to a connection point between the wire W**21** and the signal pad **15** is elongated. Accordingly, since mismatching in impedance increases, reflection of a modulation signal in the terminating resistive film **82** is likely to increase due to an increase in frequency bandwidth of the optical modulator integrated semiconductor laser **10**C. On the other hand, in the transmission micro optical device **1** according to the present embodiment, the modulation electrode **13**, the signal pad **15**, and the terminating resistive film **17** are provided on the same substrate **101**. Accordingly, it is possible to extremely decrease the distance of the conductive path between the modulation electrode **13** and the first end **17***a* of the terminating resistive film **17**. As a result, it is possible to decrease electrical reflection of a modulation signal at the first end **17***a* of the terminating resistive film **17**. Accordingly, it is possible to reduce a loss of the modulation signal due to reflection.

[0067] In the transmission micro optical device **1** according to the present embodiment, the wire W**21** and the wire W**22** are provided side by side with each other. Since the wire W**21** inputs a positive phase signal and the wire W**22** inputs a negative phase signal in which the phase is opposite to that of the positive phase signal, a virtual reference potential line appears between the wire W**21** and the wire W**22**. Accordingly, since mismatching in input impedance of the modulation signal in the wire W**21** is reduced, it is possible to further reduce a loss of the modulation signal due to reflection. With this configuration, a gap between the wires can be substantially doubled in comparison with a single-phase driving configuration, that is, a configuration in which a wire with a ground potential is disposed on one or both sides of a single wire for transmitting a modulation signal. Accordingly, it is possible to increase a margin of the wire gap and to reduce difficulty in manufacturing. In the single-phase driving configuration, when an amount of heat generated changes according to an applied voltage and particularly an interval between bits included in the modulation signal is close to a thermal response time constant, the change in the amount of generated heat causes a change in quenching characteristics. On the other hand, in a differential driving configuration described in the present embodiment, since an amount of heat generated is maintained almost constant, it is possible to curb a change in quenching characteristics.

[0068] As in the present embodiment, the distance L**1** of the conductive path between the connection point between the wire W**21** and the signal pad **15** and the first end **17***a* of the terminating resistive film **17** may be less than ¼ of the wavelength of the modulation signal. The distance L**2** of the conductive path between the connection point between the wire W**21** and the signal pad **15** and the modulation electrode **13** may be less than ¼ of the wavelength of the modulation signal. With the knowledge of the inventor, when the frequency of the input modulation signal is, for example, a high frequency equal to or higher than 100 GHz and the distances L**1** and L**2** are less than ¼ of the wavelength of the modulation signal, electrical reflection of the modulation signal at the first end **17***a* of the terminating resistive film **17** is less likely to increase. Accordingly, it is possible to effectively reduce the loss of the modulation signal due to reflection. In 100 Gbps communication, the value of ¼ of the wavelength of the modulation signal is, for example, 300 μm, and the distances L**1** and L**2** are, for example, equal to or less than 100 μm.

[0069] As in the present embodiment, when seen in the thickness direction of the substrate **101**, the wire W**21** may be disposed in parallel with the wire W**22**. In this case, it is possible to more effectively reduce mismatching in impedance of the modulation signal in the wire W**21**. Accordingly, it is possible to further reduce the loss of the modulation signal due to the mismatching in impedance.

[0070] As in the present embodiment, a difference between the length of the wire W**21** and the length of the wire W**22** may be less than ¼ of the wavelength of the modulation signal. In this case, it is possible to reduce a skew between a positive phase signal and a negative phase signal.

[0071] As described above, the terminating resistive film **17** may include a material of at least one included in a group constituting of nickel chromium, titanium tungsten, tantalum nitride, and platinum. Accordingly, adhesiveness between the terminating resistive film **17** and the passivation film **102** is improved. It is possible to realize a desired resistance value.

[0072] As in the present embodiment, the laser unit **11** that outputs laser light may be provided on the substrate **101**. Accordingly, it is possible to monolithically form the laser unit **11** and the optical modulation unit **12** on the same substrate **101**, and to decrease the size of the transmission micro optical device **1**.

First Modified Example

[0073] FIG. **8** is a perspective view illustrating enlargement of a part of a transmission micro optical device according to a first modified example. FIG. **9** is a plan view illustrating enlargement of a part of the transmission micro optical device according to the first modified example. The transmission micro optical device according to the present modified example is different from the transmission micro optical device **1** according to the first embodiment in the following points, and they are the same in the other points. The transmission micro optical device according to the present modified example includes an optical modulator integrated semiconductor laser **10**A instead of the optical modulator integrated semiconductor laser **10** according to the first embodiment. The optical modulator integrated semiconductor laser **10**A includes an optical modulation unit **12**A instead of the optical modulation unit **12** according to the first embodiment. The other constituents of the optical modulator integrated semiconductor laser **10**A are the same as those of the optical modulator integrated semiconductor laser **10**.

[0074] The optical modulator integrated semiconductor laser **10**A further includes a terminating resistive film **43** (a second terminating resistor) and a terminating resistive film **44** (a third terminating resistor) in addition to the terminating resistive film **17**. The optical modulation unit **12**A further includes a reference potential pad **41** (a third signal pad) and a reference potential pad **42** (a fourth signal pad) in addition to the signal pads **15** and **16**. The optical modulation unit **12**A further includes a wire W**23** (a third wire) and a wire W**24** (a fourth wire) in addition to the wires W**21** and W**22**.

[0075] The reference potential pad **41** is provided in an area opposite to the signal pad **16** with respect to the signal pad **15** on the substrate **101**. The reference potential pad **42** is provided in an area opposite to the signal pad **15** with respect to the signal pad **16** on the substrate **101**. That is, the reference potential pad **41**, the signal pad **15**, the signal pad **16**, and the reference potential pad **42** are sequentially arranged in the extending direction of the modulation electrode **13**. The reference potential pad **41** and the reference potential pad **42** have a film shape and have a substantially rectangular shape in a plan view. The material of the reference potential pad **41** and the reference potential pad **42** are metal and are, for example, gold (Au). The thickness of the reference potential pad **41** and the reference potential pad **42** are, for example, equal to or greater than 3 μm and equal to or less than 10 μm.

[0076] The first end of the wire W**23** is connected to the reference potential pad **41**, and the second end of the wire W**23** is connected to the ground potential line P**22**. The first end of the wire W**24** is connected to the reference potential pad **42**, and the second end of the wire W**24** is connected to the ground potential line P**23**. Accordingly, the wire W**23** and the wire W**24** are set to the reference potential. The wire W**23** and the wire W**24** are provided side by side with the wire W**21** and the wire W**22** at positions at which the wire W**21** and the wire W**22** are interposed. That is, the wire W**23**, the wire W**21**, the wire W**22**, the wire W**24** are sequentially arranged in the extending direction of the modulation electrode **13**. When seen in the thickness direction of the substrate **101**, the wire W**23** and the wire W**24** may be parallel with the wire W**21** and the wire W**22**. The wire W**23** and the wire W**24** are, for example, bonding wires formed of Au. A diameter of a cross-section of the wire W**23** and the wire W**24** is, for example, 25 μm. The gap between the wire W**21** and the wire W**23** and the gap between the wire W**22** and the wire W**24** are, for example, several tens of μm.

[0077] The terminating resistive film **43** is provided between the signal pad **15** and the reference potential pad **41**. The first end of the terminating resistive film **43** is connected to the signal pad **15**. The second end of the terminating resistive film **43** is connected to the reference potential pad **41**. The terminating resistive film **44** is provided between the signal pad **16** and the reference potential pad **42**. The first end of the terminating resistive film **44** is connected to the signal pad **16**. The second end of the terminating resistive film **44** is connected to the reference potential pad **42**. The terminating resistive films **43** and **44** reduce reflection of a modulation signal. The terminating resistive films **43** and **44** have a rectangular shape. The material of the terminating resistive films **43** and **44** is, for example, a metal such as nickel chromium, titanium tungsten, tantalum nitride, or platinum. The thickness range and the formation method of the terminating resistive films **43** and **44** are the same as the terminating resistive film **17**.

[0078] Here, the distance L**3** is a distance of a conductive path (an electrical length) between the connection point between the wire W**21** and the signal pad **15** and the first end of the terminating resistive film **43**. The distance L**4** is a distance of a conductive path (an electrical length) between the connection point between the wire W**22** and the signal pad **16** and the first end of the terminating resistive film **44**. The distance L**5** is a distance of a conductive path (an electrical length) between a connection point between the wire W**23** and the reference potential pad **41** and the second end of the terminating resistive film **43**. The distance L**6** is a distance of a conductive path (an electrical length) between a connection point between the wire W**24** and the reference potential pad **42** and the second end of the terminating resistive film **44**. These distances L**3**, L**4**, L**5**, and L**6** are, for example, less than ¼, less than ⅛, less than 1/10, or less than 1/12 of the wavelength of the modulation signal. The distances L**3**, L**4**, L**5**, and L**6** are, for example, equal to or greater than 1/1000 of the wavelength of the modulation signal.

[0079] For example, when differential impedance is 100Ω, the terminating resistive film **17** has only to have impedance of 200Ω, and the terminating resistive film **43** and the terminating resistive film **44** have only to have 100Ω. The gaps among the wire W**23**, the wire W**21**, the wire W**22**, and the wire W**24** can be adjusted such that the differential impedance becomes closer to 100Ω.

[0080] In the optical modulator integrated semiconductor laser **10**A according to the present modified example, the wire W**23** and the wire W**24** are set to the reference potential. Accordingly, a positive phase signal and a negative phase signal passing through the wire W**21** and the wire W**22** which are disposed between the wire W**23** and the wire W**24** are interposed between the ground potential. Accordingly, since mismatching in input impedance is further reduced, it is possible to further reduce a loss of a modulation signal.

[0081] The reference potential pad **41**, the reference potential pad **42**, the terminating resistive film

43, and the terminating resistive film **44** are provided on the same substrate **101** as provided with the signal pad **15** and the signal pad **16**. Accordingly, the distance of the conductive path between the signal pad **15** and the first end of the terminating resistive film **43**, the distance of the conductive path between the reference potential pad **41** and the second end of the terminating resistive film **43**, the distance of the conductive path between the signal pad **16** and the first end of the terminating resistive film **44**, and the distance of the conductive path between the reference potential pad **42** and the second end of the terminating resistive film **44** can be extremely decreased. Accordingly, it is possible to reduce reflection of a modulation signal in the terminating resistive film **43** and the terminating resistive film **44**. As a result, it is possible to further reduce a loss of the modulation signal due to reflection.

[0082] As in the present modified example, the distances L**3**, L**4**, L**5**, and L**6** may be less than ¼ of the wavelength of the modulation signal. Accordingly, it is possible to decrease reflection of the modulation signal in the terminating resistive film **43** and the terminating resistive film **44**. Accordingly, it is possible to further reduce a loss of the modulation signal due to reflection.

Second modified example

[0083] FIG. **10** is a perspective view illustrating enlargement of a part of a transmission micro optical device according to a second modified example. FIG. **11** is a plan view illustrating enlargement of a part of the transmission micro optical device according to the second modified example. The transmission micro optical device according to the present modified example is different from the transmission micro optical device **1** according to the first embodiment in the following points, and they are the same in the other points. The transmission micro optical device according to the present modified example includes an optical modulator integrated semiconductor laser **10**B instead of the optical modulator integrated semiconductor laser **10** according to the first embodiment. The optical modulator integrated semiconductor laser **10**B includes an optical modulation unit **12**B instead of the optical modulation unit **12** according to the first embodiment. The other constituents of the optical modulator integrated semiconductor laser **10**B are the same as those of the optical modulator integrated semiconductor laser **10**.

[0084] The optical modulation unit **12**B includes a terminating resistive film **45** (a first terminating resistor) provided on the substrate **101** instead of the terminating resistive film **17** according to the first embodiment. The optical modulation unit **12**B includes a line **46** provided on the substrate **101**. The line **46** is disposed on a side opposite to the signal pad **15** with respect to the signal pad **16**. The line **46** includes a part extending along the modulation electrode **13**. For example, the part of the line **46** is parallel with the modulation electrode **13**. A first end of the terminating resistive film **45** is connected to the modulation electrode **13**. A second end of the terminating resistive film **45** is connected to the signal pad **16** via the line **46**. In other words, the line **46** connects the signal pad **16** to the terminating resistive film **45**. The material, the thickness, and the formation method of the terminating resistive film **45** are the same as the terminating resistive film **17** according to the first embodiment.

[0085] The signal pad **15** and the signal pad **16** according to the present modified example are disposed in an area closer to the laser unit **11** in the optical modulation unit **12**B. On the other hand, the terminating resistive film **45** is disposed in an area closer to the light emitting end in the optical modulation unit **12**B. The first end of the terminating resistive film **45** is connected to a part of the modulation electrode **13** closer to the light emitting end of the optical modulation unit **12**B.

[0086] In the present modified example, similarly to the first embodiment, the wire W**21** and the wire W**22** are provided side by side with each other. Since the wire W**21** inputs a positive phase signal and the wire W**22** inputs a negative phase signal in which the phase is opposite to that of the positive phase signal, a virtual reference potential line appears between the wire W**21** and the wire W**22**. Accordingly, it is possible to reduce mismatching in input impedance of the modulation signal in the wire W**21**. The modulation electrode **13**, the signal pad **16**, and the terminating resistive film **45** are provided on the same substrate **101**. Accordingly, it is possible to extremely

decrease a distance of a conductive path between the modulation electrode **13** and the first end of the terminating resistive film **45**. As a result, it is possible to reduce electrical reflection of the modulation signal at the first end of the terminating resistive film **45**. Accordingly, it is possible to reduce a loss of the modulation signal due to reflection.
[0087] When seen in the thickness direction of the substrate **101**, the wire W**21** may be disposed in parallel with the wire W**22**. In this case, it is possible to more effectively reduce mismatching in impedance of the modulation signal in the wire W**21**.
[0088] As in the present modified example, the optical modulator integrated semiconductor laser **10**B may include the line **46** provided on the substrate **101** and connecting the signal pad **16** to the terminating resistive film **45**. The line **46** may include a part extending along the modulation electrode **13**. In this way, since the part of the line **46** in which a negative phase signal propagates extends in the modulation electrode **13**, it is possible to reduce reflection of a negative phase signal in the terminating resistive film **45**. Accordingly, it is possible to further reduce a loss of the modulation signal due to reflection. As illustrated in FIG. **12**, the line **46** may be omitted, and the terminating resistive film **45** may be disposed between the signal pad **16** and the modulation electrode **13**.
[0089] The first end of the terminating resistive film **17** in the first embodiment is connected to the signal pad **15**, and the first end of the terminating resistive film **45** in the present modified example is connected to the modulation electrode **13**. FIG. **13**A is a circuit diagram illustrating simplification of a circuit according to the first embodiment. FIG. **13**B is a circuit diagram illustrating simplification of a circuit according to the present modified example. When these circuit diagrams are compared, the modulation electrode **13** is present at positions branching from the wire W**21** and the wire W**22** (which include the terminating resistive film **45**) which are signal lines in FIG. **13**A, which constitutes a stub. This stub looks like capacitance or inductance according to the frequency. On the other hand, in FIG. **13**B, the modulation electrode **13** is present between the wire W**21** and the wire W**22** (which include the terminating resistive film **45**) which are signal lines. Accordingly, in comparison with FIG. **13**A, it is possible to expect an advantageous effect of reducing an influence because of the stub looking like capacitance or inductance according to the frequency.
[0090] The optical modulator integrated laser device, the optical device, and the optical modulator according to the present disclosure are not limited to the aforementioned embodiment and the modified examples and can be modified in various forms. In the aforementioned embodiment, the wire W**21** and the wire W**22** are parallel with each other. The wire W**21** and the wire W**22** may be oblique with respect to each other. In this case, by arranging the wire W**21** and the wire W**22** side by side, it is possible to achieve the aforementioned advantageous effects.
[0091] In the aforementioned embodiment, the ground potential lines P**22** and P**23** of the transmission line **30** are provided on the substrate **21** side by side with the signal lines P**24** and P**25**. The form of the transmission line is not limited thereto. For example, even when the transmission line is formed as a so-called micro strip line in which the ground potential lines are provided on the rear surface of the substrate **21**, it is possible to achieve the aforementioned advantageous effects.
[0092] In the aforementioned description, resistive films are exemplified as examples of the first terminating resistor, the second terminating resistor, and the third terminating resistor. These terminating resistors are not limited to a resistive film, but may be another resistor.

Claims

1. An optical modulator integrated laser device comprising: a substrate; a laser unit provided on the substrate and configured to output laser light; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate the laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the second signal pad.

2. The optical modulator integrated laser device according to claim 1, wherein a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor is less than **1**/**4** of a wavelength of the modulation signals.

3. The optical modulator integrated laser device according to claim 2, wherein a distance of a conductive path between the connection point and the modulation electrode is less than **1**/**4** of the wavelength of the modulation signals.

4. The optical modulator integrated laser device according to claim 1, further comprising: a third signal pad provided on the substrate on a side opposite to the second signal pad with respect to the first signal pad; a fourth signal pad provided on the substrate on a side opposite to the first signal pad with respect to the second signal pad; a second terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the third signal pad; and a third terminating resistor provided on the substrate and including a first end connected to the second signal pad and a second end connected to the fourth signal pad.

5. The optical modulator integrated laser device according to claim 4, wherein a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the second terminating resistor is less than ¼ of a wavelength of the modulation signals.

6. The optical modulator integrated laser device according to claim 4, wherein a distance of a conductive path between a connection point of the second signal pad to which a second wire for inputting the another of the modulation signals is connected and the first end of the third terminating resistor is less than ¼ of a wavelength of the modulation signals.

7. The optical modulator integrated laser device according to claim 4, wherein a distance of a conductive path between a connection point of the third signal pad to which a third wire with a ground potential is connected and the second end of the second terminating resistor is less than ¼ of a wavelength of the modulation signals.

8. The optical modulator integrated laser device according to claim 4, wherein a distance of a conductive path between a connection point of the fourth signal pad to which a fourth wire with a ground potential is connected and the second end of the third terminating resistor is less than ¼ of a wavelength of the modulation signals.

9. An optical modulator integrated laser device comprising: a substrate; a laser unit provided on the substrate and configured to output laser light; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate the laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the modulation electrode and a second end connected to the second signal pad.

10. The optical modulator integrated laser device according to claim 9, further comprising a line connecting the second end of the first terminating resistor to the second signal pad, wherein the line is provided on a side opposite to the first signal pad with respect to the second signal pad and extends along the modulation electrode.

11. An optical device comprising: the optical modulator integrated laser device according to claim 1; a carrier in which a first transmission line and a second transmission line are provided on a top surface and in which the optical modulator integrated laser device is mounted; a first wire connecting the first signal pad to the first transmission line; and a second wire connecting the second signal pad to the second transmission line.

12. The optical device according to claim 11, wherein a distance of a conductive path between a connection point of the first signal pad to which the first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor is less than ¼ of a wavelength of the modulation signals.

13. The optical device according to claim 12, wherein a distance of a conductive path between the connection point and the modulation electrode is less than ¼ of the wavelength of the modulation signals.

14. An optical modulator comprising: a substrate; an optical modulation unit provided on the substrate, including a modulation electrode supplied with one of modulation signals, and configured to modulate laser light; a first signal pad provided on the substrate, configured to receive an input of the one of the modulation signals as a positive phase signal of a differential signal, and connected to the modulation electrode; a second signal pad provided on the substrate side by side with the first signal pad and configured to receive an input of another of the modulation signals as a negative phase signal of the differential signal; and a first terminating resistor provided on the substrate and including a first end connected to the first signal pad and a second end connected to the second signal pad.

15. The optical modulator according to claim 14, wherein a distance of a conductive path between a connection point of the first signal pad to which a first wire for inputting the one of the modulation signals is connected and the first end of the first terminating resistor is less than ¼ of a wavelength of the modulation signals.

16. The optical modulator according to claim 15, wherein a distance of a conductive path between the connection point and the modulation electrode is less than ¼ of the wavelength of the modulation signals.

17. The optical modulator according to claim 14, further comprising a laser unit provided on the substrate and configured to output the laser light.