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(71) Applicant: **SUMITOMO ELECTRIC INDUSTRIES,
LTD.**
Osaka-shi, Osaka (JP)

(72) Inventor: **Ooe, Satoshi,**
c/o Sumitomo Electric Industries Ltd
Itami-shi, Hyogo (JP)

(74) Representative:
Cross, Rupert Edward Blount et al
BOULT WADE TENNANT,
Verulam Gardens
70 Gray's Inn Road
London WC1X 8BT (GB)

(54) **Electronic component-mounting substrate and electronic components**

(57) The invention provides an electronic component-mounting substrate wherein joint reliability of microstrip lines at the line of intersection between two signal line surfaces is enhanced, and also an increase in signal reflection and a decrease in transmission due to a line impedance mismatching can be prevented. The width of a line junction 22a of microstrip lines 22 formed on two signal line surfaces of a rectangular-solid dielec-

tric 21 is provided to be broader than the width of a line end portion 22b. In addition, the width of the line junction 22a is designed such that the impedance would be equivalent to an impedance at a line end portion of the substituted lines if the microstrip lines 22 be equivalently substituted with lines on a substrate having a thickness equal to the length of a diagonal line of a cross section of the dielectric 21.

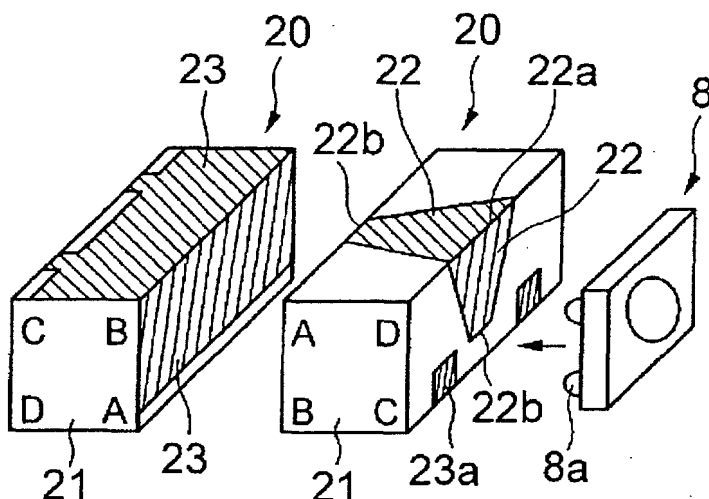


FIG. 3(a)

FIG. 3(b)

FIG. 3(c)

Description

[0001] The present invention relates to an electronic component-mounting substrate on which a photodiode or a laser element is mounted and an electronic component using the same.

[0002] In recent years, with the development of information communications technologies, communication speed of communications equipment has been remarkably improved. Also, with regard to optical communications modules which play central roles in backbone communications, there are growing demands for speedier photodiodes and laser elements for carrying out a conversion between an optical signal and an electric signal. Connection to a substrate has also changed from mounting by conventional wire bonding to mounting by flip-chip bonding.

[0003] For example, an optical receiver module employing a general flip-chip bonding has a structure such that a substrate 10 to which a photodiode 8 is mounted by flip-chip bonding is mounted on a package 1 provided with a lens 2 and an electrode terminal 5, as shown in Figure 1. A signal line 12 of the substrate 10 is bonded to the electrode terminal 5 via a ribbon wire 7, an optical fiber 3 is fixed so as to be covered with a ferrule 4, and the package 1 is sealed with a lid 6.

[0004] A substrate to be used for such an optical receiver module is a substrate which allows flip-chip bonding of a photodiode, which has been disclosed in Japanese Unexamined Patent Publication No. Hei-10-41739, for example. Namely, as shown in Figures 2, a substrate 10 is composed of a rectangular solid-shaped dielectric 11, wherein (a) is a perspective view of the ground side, (b) is a perspective view of the signal line side, and (c) illustrates a photodiode 8 to be mounted on the substrate 10. Herein, in Figure 2(a) and Figure 2(b), symbols A-D are designated as indicating the four corners of the rectangular solid-shaped dielectric 11.

[0005] As shown in Fig. 2(b), the rectangular solid-shaped dielectric 11 for this substrate 10 is provided with microstrip lines 12 of an identical line width for a high-frequency signal (hereinafter, also referred to as a signal line) on two orthogonal surfaces thereof. In addition, as shown in Fig. 2(a), a part of two surfaces opposed to the two signal line surfaces is a ground 13, and at this ground 13, the substrate 10 is joined to the package 1. Furthermore, as shown in Fig. 2(b), a pad portion 13a is provided on one signal line surface in a manner extended from the ground 13, and bump portions 8a of the photodiode 8 are joined to these pad portions 13a.

[0006] In a conventional mounting substrate composed of the above-described rectangular solid-shaped dielectric, since the line width of the microstrip lines 12 is the same throughout as shown in Fig. 2(b), the drawback is that, when forming the lines, a disconnection of the signal lines 12 easily occurs at a line junction 12a on the line of the intersection between the two signal line surfaces as compared to other portions.

[0007] In addition, since the shape of the signal line 12 is rectilinear, line impedance increases as it proceeds from the line end portions 12b to the line junction 12a. Therefore, with a high-frequency signal, an increase in signal reflection and a decrease in transmission due to a line impedance mismatching easily occur, as well as the problem of the deterioration of the reception sensitivity of the photodiode.

[0008] In light of such conventional circumstances, it is an object of the present invention to provide an electronic component-mounting substrate wherein, in terms of microstrip lines formed on two surfaces which are orthogonal on a rectangular solid-shaped dielectric, joint reliability of a line junction at the line of intersection between two signal line surfaces has been enhanced. In addition, it is an object of the present invention to prevent an increase in signal reflection and a decrease in transmission due to a line impedance mismatching by approximating impedance at each line portion of the microstrip lines to one objective value or a fixed value.

[0009] Furthermore, it is an object of the present invention to provide an electronic component wherein an electronic component in which high-frequency characteristics are required is mounted on a mounting substrate, and in particular an electronic component wherein deterioration of electrical characteristics can be suppressed.

[0010] In order to achieve the above objects, the present invention provides an electronic component-mounting substrate wherein microstrip lines for a high-frequency signal are formed on two orthogonal signal line surfaces of a rectangular-solid dielectric and a part of two surfaces opposed to these two signal line surfaces is a ground, the width of the microstrip lines being broader at junction thereof at intersecting line between these two signal line surfaces as compared with the width of the end portions of the microstrip lines.

[0011] In the above electronic component-mounting substrate of the present invention, the cross-section of a dielectric which is perpendicular to the microstrip lines is square, and the width of the line junction of the microstrip lines at intersecting line between two signal line surfaces is designed such that if the thickness of the microstrip lines substrate be equivalently substituted with a thickness equal to the length of a diagonal line of the dielectric section, the impedance of the microstrip lines would be equivalent to an impedance at the end portion of the substituted microstrip lines.

[0012] In addition, the present invention provides an electronic component wherein a photodiode or a laser element is mounted on the above electronic component-mounting substrate of the present invention.

[0013] According to the present invention, an electronic component-mounting substrate wherein joint reliability of a line junction of microstrip lines at the line of intersection between two signal line surfaces has been enhanced can be provided, and moreover, design of the lines is simple, and it becomes possible to approximate

an impedance at each line portion of the microstrip lines to an objective value of an external signal line or the like or a fixed value, thus an increase in signal reflection and a decrease in transmission due to a line impedance mismatching can be prevented.

[0014] Furthermore, by using an electronic component-mounting substrate of the present invention, an electronic component in which an electronic component, such as a photodiode or a laser element, having preferable high-frequency characteristics is mounted without losing its characteristics can be provided.

Figure 1 is a partially cut-away side view schematically illustrating an optical receiver module by a general flip-chip bonding,

Figures 2 are perspective views illustrating an electronic component-mounting substrate of the present invention, wherein (a) is a view of the ground side, (b) is a view of the signal line side, and (c) illustrates a photodiode to be mounted on the substrate,

Figures 3 are perspective views illustrating an electronic component-mounting substrate of the prior art, wherein (a) is a view of the ground side, (b) is a view of the signal line side, and (c) illustrates a photodiode to be mounted on the substrate,

Figure 4 is a diagram for explaining an equivalent substitution of a signal line when the width of the signal line on the electronic component-mounting substrate of the present invention is determined,

Figure 5 is a graph indicating reflection characteristics at the signal line of the electronic component-mounting substrate in the present invention and prior art, and

Figure 6 is a graph indicating transmission characteristics at the signal line of the electronic component-mounting substrate in the present invention and prior art.

[0015] In an electronic component-mounting substrate 20 of the present invention, as shown in Figure 3, for example, microstrip lines (signal lines) 22 for a high-frequency signal are formed on two orthogonal signal line surfaces of a rectangular solid-shaped dielectric 21 such that the width of a line junction 22a at intersecting line between the two signal line surfaces is broader than the width of line end portions 22b. Figure 3(a) is a perspective view of the ground side, Figure 3(b) is a perspective view of the signal line side, and Figure 3(c) illustrates a photodiode 8 to be mounted to the substrate 20. In addition, in Fig. 3(a) and Fig. 3(b), symbols A-D are designated, respectively to indicate the four corners of the rectangular solid-shaped dielectric 21.

[0016] Since the width of the line junction 22a at intersecting line between the two signal line surfaces becomes broad owing to such a construction, the joint reliability can be enhanced, and in addition, it becomes possible to approximate the impedance of the overall

signal lines 22 to an impedance of an external signal line, whereby it is possible to prevent an increase in signal reflection and a decrease in transmission in a case where a high-frequency signal due to line impedance mismatching passes.

[0017] In particular, when a cross-section which is perpendicular to the two signal line surfaces of the dielectric is a square, signal line design can be carried out simply so that the impedance of each portion of the signal lines 22 becomes a desirable fixed value or approximates thereto. Namely, as shown in Figure 4, in the case where a cross-section of the dielectric 21 which is vertical to the signal lines 22 of the electronic component-mounting substrate 20 is a square, it is satisfactory to equivalently substitute the signal lines 22 of the two signal line surfaces with signal lines on a substrate having a thickness equal to the length of a diagonal line of the cross-section thereof (refer to the left-side diagram) and to set the width of the line junction 22a at intersecting line between the two signal line surfaces to a width such that the impedance of the signal lines would become equivalent to the impedance of a line end portion of the substituted lines.

[0018] In addition, by mounting an electronic component such as a photodiode or a laser element, which requires preferable high-frequency characteristics, on the aforementioned electronic component-mounting substrate according to the present invention, it becomes possible to fabricate an electronic component wherein deterioration of electrical characteristics can be suppressed.

Examples

[0019] An electronic component-mounting substrate 20 as shown in Figures 3 was fabricated by using alumina with a size of 0.5 millimeters square and 5 millimeters long (specific inductive capacity of 9.5) as a rectangle solid-shaped dielectric 21. Namely, microstrip lines (signal lines) 22 were formed on two orthogonal surfaces of the dielectric 21, and a ground 23 was formed on two faces opposite to these two signal line surfaces. The signal lines 22 and the ground 23 were formed by depositing sequentially Ti with 0.1 μ m, Ni with 0.2 μ m, and Au with 2.0 μ m by an evaporation method. The signal lines and ground may also be formed by a printing method.

[0020] At this time, a design objective impedance of the signal lines 22 was provided as 50 Ω , which was the same as that of an external signal line. The width of both line end portions 22b was determined as 0.09mm through a calculation using, for example, a port calibration function of a simulator, the commercially available HFSS (Agilent Technologies) so that the impedance becomes 50 Ω . On the other hand, the width of the line junction 22a of the signal lines 22 at intersecting line between the two signal line surfaces was designed to 0.7mm by calculating using the aforementioned HFSS

such that an equivalent substitution of the microstrip lines with microstrip lines substrate (right-side diagram) having a thickness equal to the length of a diagonal line of the cross-section as shown in Figure 4 would result in an impedance of 50Ω .

[0021] In addition, on a surface of the substrate 20 where a photodiode 8 was to be mounted, one line end portion 22b of the signal line 22 was provided so as to end at a mid-point of the surface, and two pad portions 23a, which were provided on both sides of this line end portion 22b so as to face each other, were joined to the ground 23 of the neighboring surface. Furthermore, a ground 23 of the neighboring surface which was continuous from the ground 23 joined to these pad portions 23a was provided by covering, as the ground 23, the whole surface from a position 0.1mm apart from the line end portion 22b adjacent at the corner A of the dielectric 21.

[0022] On pad portions 23a of this electronic component-mounting substrate 20, the photodiode 8 was mounted by flip-chip bonding. Thereafter, as shown in Fig. 1, the substrate 20 was mounted on a package 1 which was provided with a lens 2 and an electrode terminal 5, a ribbon wire 7 was bonded, and moreover, the position of an optical fiber 3 was determined aligning so that light struck a light-receiving surface of the photodiode 8, and the optical fiber 3 was fixed with a ferrule 4. Finally, the package was shielded with a lid 6, whereby a high-frequency optical receiver module according to one example of the present invention was fabricated.

[0023] For comparison, a prior-art electronic component-mounting substrate 10 as shown in Figs. 2 (a) through (c) was fabricated. A dielectric 11 was of alumina with the size of 0.5 millimeters square and 5 millimeters long (specific inductive capacity of 9.5). By depositing sequentially Ti with $0.1\mu\text{m}$, Ni with $0.2\mu\text{m}$, and Au with $2.0\mu\text{m}$ by an evaporation method, signal lines 12 were formed on two orthogonal surfaces of this dielectric 11 and a ground 23 was formed on two faces opposed to these two signal line surfaces.

[0024] A design objective impedance of the signal lines 12 was provided as 50Ω , which was the same as that of an external signal line. Design was carried out so that an impedance of a section becomes 50Ω with the width of both line terminal portions 12b at 0.09mm, and signal lines 12 having an identical width not only at a line junction 12a but also at other portions were used. In addition, on the surface of the substrate 10 where a photodiode 8 was to be mounted, one line end portion 12b of the signal line 12 was provided so as to end at a mid-point of the surface, and two pad portions 13a, which were provided on both sides of this line end portion 12b so as to face each other, were joined to the ground 13 of the neighboring surface. Furthermore, a ground 13 of the neighboring surface which was continuous from the ground 13 joined to these pad portions 13a was provided by covering, as a ground 13, the whole surface from a position 0.1mm apart from the line

end portion 12b which is adjacent at the corner A of the dielectric 11.

[0025] On pad portions 13a of this electronic component-mounting substrate 10, the photodiode 8 was mounted by flip-chip bonding. Thereafter, as shown in Fig. 1, the substrate 10 was mounted on a package 1 with a lens 2 and an electrode terminal 5. A ribbon wire 7 was bonded, and moreover, the position of an optical fiber 3 was determined by aligning so that light struck a light-receiving surface of the photodiode 8, and then the optical fiber 3 was fixed with a ferrule 4. Finally, the package was shielded with a lid 6, whereby a high-frequency optical receiver module according to one example of a prior art was fabricated.

[0026] With respect to the respective samples fabricated as described above as optical receiver modules of the present invention example and prior-art example, a burn-in test was performed at a high temperature of 80°C . As a result, the lifetime of the module using the substrate of the prior-art example, until a breakage occurred in the substrate wiring, was one hundred thousand hours, whereas a module using the substrate of the present invention example had a lifetime of two hundred and forty thousand hours: a lifetime approximately 2.4 times as long as that of the prior-art example.

[0027] Reflection characteristics and transmission characteristics at signal lines of the electronic component-mounting substrate of the present invention example and prior-art example were measured. Based on the results obtained, reflection characteristics are shown in Figure 5 and transmission characteristics are shown in Figure 6. As can be understood from these results, the electronic component-mounting substrate of the present invention example at 40GHz, was improved in reflection by 4dB and in transmission by 0.7dB compared to the prior-art example.

[0028] The present invention is not limited to the aforementioned embodiments, and various modifications can be made in terms of the material, size, application and the like, provided that it does not depart from the spirit of the present invention. For example, aluminum nitride, glass ceramic or the like can be used as a dielectric, and as for an application, the electronic component-mounting substrate may be used with a high-frequency laser or the like mounted thereto.

Claims

1. An electronic component-mounting substrate in which microstrip lines for a high-frequency signal are formed on two orthogonal signal line surfaces of a rectangular-solid dielectric, a part of two surfaces which are opposed to these two signal line surfaces is a ground, wherein the width of a line junction of the microstrip lines at intersecting line between these two signal line surfaces is broader than the width of a line end portion of the microstrip

lines.

2. An electronic component-mounting substrate according to Claim 1, wherein

a dielectric cross-section which is vertical to said microstrip lines is a square, and

the width of the line junction of the microstrip lines at intersecting line between two signal line surfaces is designed such that the impedance thereof would be equivalent to an impedance at a line end portion of the substituted microstrip lines, if these microstrip lines be equivalently substituted with microstrip lines on a substrate having a thickness equal to the length of a diagonal line of said section.

3. An electronic component wherein a photodiode or a laser element is mounted on the electronic component-mounting substrate according to Claim 1 or Claim 2.

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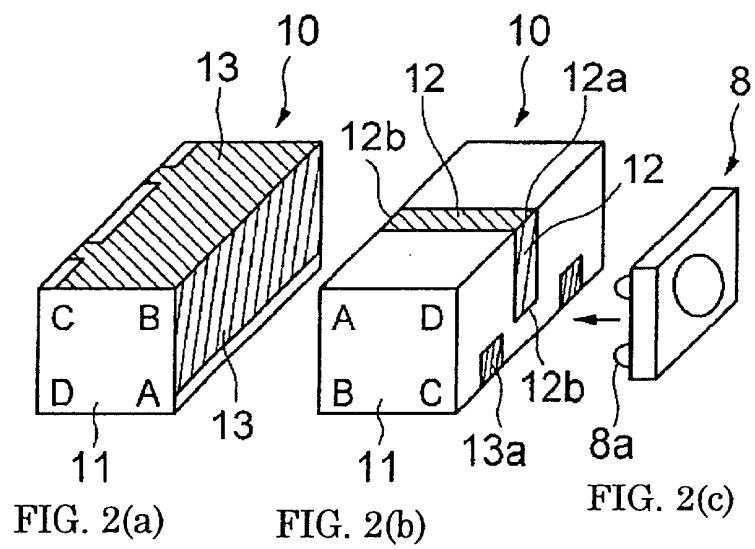
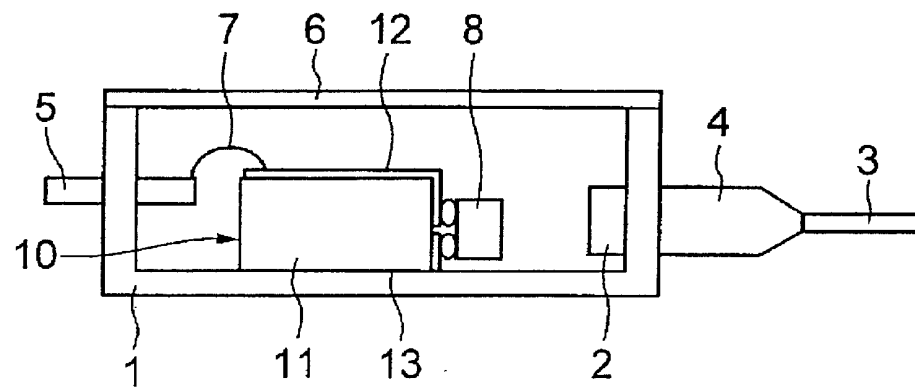
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FIG. 1



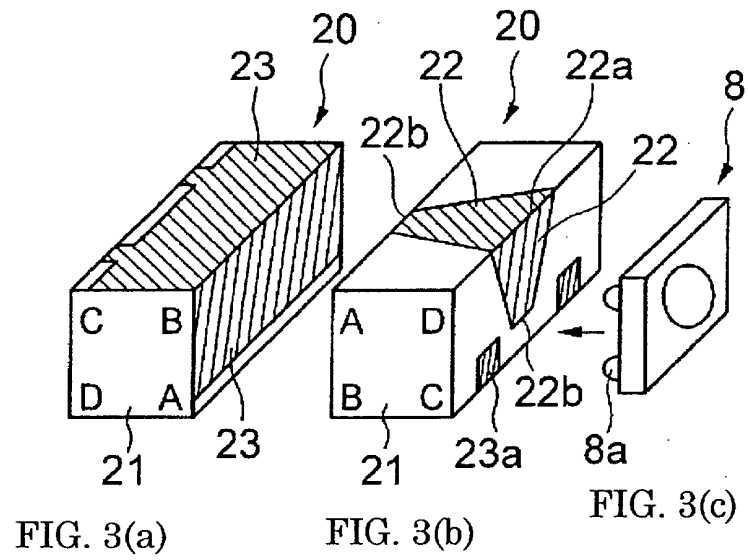


FIG. 4

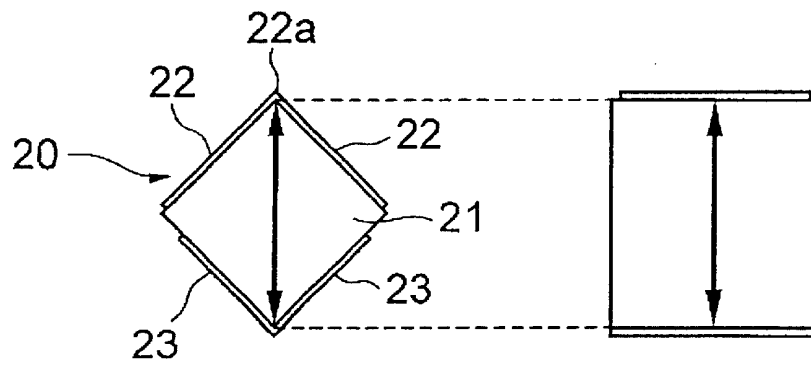


FIG. 5

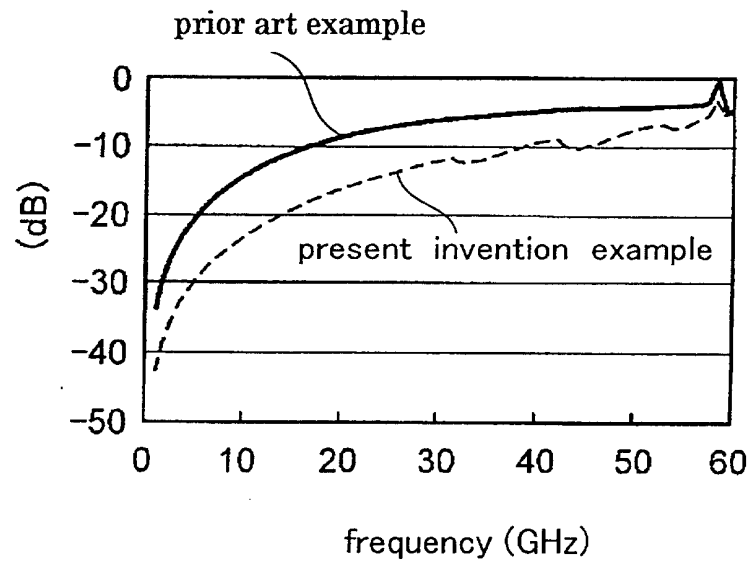


FIG. 6

