PHOTONIC INTEGRATED CIRCUIT CONNECTOR WITH TEMPERATURE-INDEPENDENT MECHANICAL ALIGNMENT

Summary

In some aspects of the present description, an optical assembly is provided, including an optical ferrule configured to receive light from an optical fiber and including at least four ferrule alignment features; and a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle including at least four cradle alignment features configured to make contact or near contact with the at least four ferrule alignment features in a one to one correspondence in at least four corresponding contact regions, such that as a temperature of at least one of the cradle and the optical ferrule changes, the corresponding alignment features of the optical ferrule and the cradle slide relative to each other causing the corresponding alignment features of the optical ferrule and the cradle to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four ferrule alignment features and the at least four cradle alignment features pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an assembly is provided, including an optical ferrule having a first coefficient of thermal expansion C1; and a cradle having a second coefficient of thermal expansion C2, $C2 \leq 0.5\ C1$, the optical ferrules and cradles making at least four contacts or near contacts with each other in at least four corresponding contact regions, the contacts or near contacts keeping the an optical ferrule secured relative to the cradle over at least a predetermined operational temperature range of the assembly, such that as a temperature of at least one of the optical ferrules and cradles changes, the at least four contact regions move to define at least four corresponding traversed regions, such that when extended, the traversed regions pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an optical ferrule is provided, the optical ferrule configured to receive a central light ray from an optical fiber bonded to the optical ferrule along a first direction and redirect the received central light ray along a different second direction as a redirected central light ray, the optical ferrule configured to be secured within a cradle by virtue of making a plurality of surface contacts or near contacts with the cradle, such that when extended, the plurality of surface contacts or near contacts and the redirected central light ray pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an optical ferrule is provided, the optical ferrule configured to receive a central light ray from an optical fiber bonded to the optical ferrule along a

first direction and redirect the received central light ray along a different second direction as a redirected central light ray, the optical ferrule configured to be secured within a cradle by virtue of making a plurality of line contacts or near contacts with the cradle, such that as a temperature of optical ferrule changes, the line contacts move to define corresponding traversed regions, such that when extended, the traversed regions and the redirected central light ray pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an optical assembly is provided, the optical assembly including an optical ferrule configured to receive light from an optical fiber and including at least four ferrule alignment features; and a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle including at least four cradle alignment features configured to make contact or near contact with the at least four ferrule alignment features in a one to one correspondence in at least four corresponding contact regions, such that when a size of at least one of the cradle and the optical ferrule changes, the corresponding alignment features of the optical ferrule and the cradle slide relative to each other causing the corresponding alignment features of the optical ferrule and the cradle to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four ferrule alignment features and the at least four cradle alignment features pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an optical ferrule is provided, the optical ferrule configured to be secured within a cradle by virtue of making at least four surface contacts or near contacts with the cradle with at least four of the at least four surface contacts or near contacts not being coplanar, such that when extended, the at least four surface contacts or near contacts pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

In some aspects of the present description, an optical assembly is provided, the optical assembly including an optical ferrule configured to receive light from an optical waveguide and including at least four non-coplanar ferrule alignment surfaces that when extended, pass within 10 microns of a first point; and a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle including at least four non-coplanar cradle alignment surfaces that when extended, pass within 10 microns of a second point, such that within a predetermined operational temperature range of the optical assembly, the first and second points remain within 20 microns of each other.

In some aspects of the present invention, an assembly is provided, the assembly including a an optical ferrule with at least four first alignment features, and a cradle securing the an optical

ferrule therein, the cradle including at least four second alignment features. The four second alignment features may be configured to make contact or near contact with the at least four first alignment features in a one to one correspondence in at least four corresponding contact regions. When a size of at least one of the optical ferrules and cradles changes, the corresponding alignment features of the optical ferrules and cradles may slide relative to each other, causing the corresponding alignment features of the optical ferrules and cradles to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four first alignment features and the at least four second alignment features pass within 20 microns of a same first point, wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

Brief Description of the Drawings

FIG. 1A is an exploded perspective view of an optical assembly, in accordance with an embodiment of the present description;

FIG. 1B is an assembled perspective view of an optical assembly, in accordance with an embodiment of the present description;

FIG. 1C is a perspective view of an optical assembly, in accordance with an alternate embodiment of the present description;

FIG. 1D is a cut-away view of an optical assembly, in accordance with an embodiment of the present description;

FIGS. 2A-2D are perspective views of an optical ferrule, in accordance with an embodiment of the present description;

FIGS. 3A-3C are perspective views of a cradle for an optical assembly, in accordance with an embodiment of the present description;

FIG. 4 is a close-up cut-away perspective view of alignment features for an optical assembly, in accordance with an embodiment of the present description;

FIG. 5 is a close-up perspective view of alignment features for an optical assembly, in accordance with an embodiment of the present description;

FIGS. 6A-6C illustrate the interaction of alignment features for an optical assembly, in accordance with an embodiment of the present description;

FIG. 7 details the placement of an alignment feature for an optical ferrule, in accordance with an embodiment of the present description;

FIG. 8 details the placement of alignment features for an optical ferrule, in accordance with an embodiment of the present description;

FIG. 9 details the interactions of alignment features for components of an optical assembly, in accordance with an embodiment of the present description;

CLAIMS

1. An optical assembly, comprising:

an optical ferrule configured to receive light from an optical fiber and comprising at least four ferrule alignment features; and

a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle comprising at least four cradle alignment features configured to make contact or near contact with the at least four ferrule alignment features in a one to one correspondence in at least four corresponding contact regions, such that as a temperature of at least one of the cradle and the optical ferrule changes, the corresponding alignment features of the optical ferrule and the cradle slide relative to each other causing the corresponding alignment features of the optical ferrule and the cradle to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four ferrule alignment features and the at least four cradle alignment features pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

2. The optical assembly of claim 1, wherein the optical ferrule is configured to receive light from an optical waveguide along a first direction and redirect the received light along a different second direction.

3. The optical assembly of claim 1, wherein at at least a room temperature, each pair of corresponding ferrule and cradle alignment features make near contact with each other, the near contact defining a clearance gap at the contact region between the ferrule and cradle alignment features.

4. The optical assembly of claim 1, wherein at at least one temperature, at least one pair of corresponding ferrule and cradle alignment features make near contact with each other, and at least one other pair of corresponding ferrule and cradle alignment features make contact with each other.

5. The optical assembly of claim 1, wherein at least one traversed region is a line, such that when extended, the line passes within 10 microns of the first point.

6. The optical assembly of claim 1, wherein the traversed regions of the at least four ferrule alignment features and the at least four cradle alignment features pass within 10 microns of the first point.

7. The optical assembly of claim 1, wherein all the traversed regions are planes, such that when extended, each plane passes within 10 microns of the first point.

8. The optical assembly of claim 1, such that within a predetermined operational temperature range of the optical assembly, contacts or near contacts between the at least four ferrule and cradle alignment surfaces prevent relative lateral movement between the optical ferrule and the cradle.

9. The optical assembly of claim 1, wherein at least one ferrule alignment feature in the at least four ferrule alignment features is perpendicular to a thickness direction of the ferrule.

10. The optical assembly of claim 1, wherein at least two ferrule alignment features in the at least four ferrule alignment features are perpendicular to each other.

11. The optical assembly of claim 1, wherein at least one cradle alignment feature in the at least four cradle alignment features is perpendicular to a thickness direction of the cradle.

12. The optical assembly of claim 1, wherein at least two cradle alignment features in the at least four cradle alignment features are perpendicular to each other.

13. The optical assembly of claim 1, wherein the coefficients of thermal expansion of the optical ferrule and the cradle are different by at least a factor of 2.

14. An assembly comprising:

an optical ferrule having a first coefficient of thermal expansion C1; and

a cradle having a second coefficient of thermal expansion C2, $C2 \leq 0.5\ C1$, the optical ferrules and cradles making at least four contacts or near contacts with each other in at least four corresponding contact regions, the contacts or near contacts keeping the optical ferrule secured relative to the cradle over at least a predetermined operational temperature range of the assembly, such that as a temperature of at least one of the optical ferrules and cradles changes, the at least four contact regions move to define at least four corresponding traversed regions, such that when extended, the traversed regions pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

15. An optical ferrule configured to receive a central light ray from an optical fiber bonded to the optical ferrule along a first direction and redirect the received central light ray along a different second direction as a redirected central light ray, the optical ferrule configured to be secured within a cradle by virtue of making a plurality of surface contacts or near contacts with the cradle, such that when extended, the plurality of surface contacts or near contacts and the redirected central light ray pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

16. An optical ferrule configured to receive a central light ray from an optical fiber bonded to the optical ferrule along a first direction and redirect the received central light ray along a different second direction as a redirected central light ray, the optical ferrule configured to be secured within a cradle by virtue of making a plurality of line contacts or near contacts with the cradle, such that as a temperature of optical ferrule changes, the line contacts move to define corresponding traversed regions, such that when extended, the traversed regions and the redirected central light ray pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

17. An optical assembly, comprising:

an optical ferrule configured to receive light from an optical fiber and comprising at least four ferrule alignment features; and

a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle comprising at least four cradle alignment features configured to make contact or near contact with the at least four ferrule alignment features in a one to one correspondence in at least four corresponding contact regions, such that when a size of at least one of the cradle and the optical ferrule changes, the corresponding alignment features of the optical ferrule and the cradle slide relative to each other causing the corresponding alignment features of the optical ferrule and the cradle to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four ferrule alignment features and the at least four cradle alignment features pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

18. An optical ferrule configured to be secured within a cradle by virtue of making at least four surface contacts or near contacts with the cradle with at least four of the at least four surface contacts or near contacts not being coplanar, such that when extended, the at least four surface contacts or near contacts pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.

19. An optical assembly, comprising:

an optical ferrule configured to receive light from an optical fiber and comprising at least four non-coplanar ferrule alignment surfaces that when extended, pass within 10 microns of a first point; and

a cradle securing the optical ferrule therein and configured to align the optical ferrule to an optical component, the cradle comprising at least four non-coplanar cradle alignment surfaces that when extended, pass within 10 microns of a second point, such that within a predetermined operational temperature range of the optical assembly, the first and second points remain within 20 microns of each other.

20. An assembly comprising:

an optical ferrule comprising at least four first alignment features; and

a cradle securing the optical ferrule therein, the cradle comprising at least four second alignment features configured to make contact or near contact with the at least four first alignment features in a one to one correspondence in at least four corresponding contact regions, such that when a size of at least one of the optical ferrules and cradles changes, the corresponding alignment features of the optical ferrules and cradles slide relative to each other causing the corresponding alignment features of the optical ferrules and cradles to move to define corresponding traversed regions, such that when extended, the traversed regions of the at least four first alignment features and the at least four second alignment features pass within 20 microns of a same first point,

wherein a near contact is defined as a clearance gap which is configured to be reduced to zero distance due to a change in size of the optical ferrule due to a change in temperature of the optical ferrule.