Statements of invention

1. An apparatus, comprising:

a substrate having a first surface;

a photonic integrated circuit (PIC) coupled to the substrate and having a first surface proximate the first surface of the substrate and a second surface opposite the first surface of the PIC and distal the first surface of the substrate;

a lid, contacting the first surface of the substrate;

a fiber holder disposed on the lid; and

an optical fiber coupled to the PIC and in contact with the fiber holder.

2. The apparatus according to claim 1, wherein a portion of the optical fiber is coiled around the fiber holder.

3. The apparatus according to claim 2, wherein the portion of the optical fiber is coiled around the fiber holder within a plane that is substantially parallel to the second surface of the PIC.

4. The apparatus according to claim 1, wherein the optical fiber is edge-coupled to the PIC.

5. The apparatus according to claim 1, further comprising an electronic integrated circuit disposed on the first surface of the substrate.

6. The apparatus according to claim 1, further comprising a circuit board on which the substrate in mounted.

7. The apparatus according to claim 6, wherein the substrate is electrically connected to the circuit board through a ball grid array.

8. The apparatus according to claim 1, wherein the fiber holder is made of copper.

9. The apparatus according to claim 1, further comprising an interposer having a first surface proximate the first surface of the substrate and a second surface opposite the first surface of the interposer and proximate the first surface of the PIC.

10. The apparatus according to claim 1, further comprising a fiber assembly containing a groove on which the optical fiber is disposed.

11. The apparatus according to claim 10, further comprising a thermal pad contacting the fiber assembly.

12. A method, comprising:

packaging a photonic integrated circuit (PIC) in a package comprising a substrate and a lid;

mounting a fiber holder on the lid of the package such that the lid is between the PIC and the fiber holder;

coupling an optical fiber to the PIC;

mechanically coupling the optical fiber to the fiber holder.

13. The method according to claim 12, further comprising surface-mounting the package on a chip carrier.

14. The method according to claim 13, further comprising securing an end of the optical fiber on the fiber holder.

15. The method according to claim 12, further comprising performing reflow soldering of the package.

16. The method according to claim 15, further comprising removing the fiber holder from the package subsequent to the reflow soldering.

17. The method according to claim 12, wherein mechanically coupling the optical fiber to the fiber holder comprises coiling a portion of the optical fiber around the fiber holder.

18. The method according to claim 17, wherein the portion of the optical fiber is coiled around the fiber holder with a radius that is less than a minimum bend radius of the optical fiber.

19. The method according to claim 12, further comprising splicing the optical fiber to an optical component.

20. The method according to claim 12, wherein mounting the fiber holder on the lid of the package comprises mounting the fiber holder with at least one screw inserted on the lid.

21. An apparatus, comprising:

a substrate having a first surface;

a photonic integrated circuit (PIC) coupled to the substrate and having a first surface proximate the first surface of the substrate and a second surface opposite the first surface of the PIC and distal the first surface of the substrate;

a lid, contacting the first surface of the substrate and at least partially covering the PIC, exhibiting at least one retaining feature; and

an optical fiber coupled to the PIC and in contact with the retaining feature of the lid.

22. The apparatus of claim 21, wherein the retaining feature comprises a groove in the lid.

23. The apparatus of claim 21, wherein the retaining feature comprises a fiber channel.

24. The apparatus of claim 21, wherein the lid is formed of a thermally conductive material.

Claims

1. An apparatus, comprising:

a substrate having a first surface and a second surface opposite the first surface of the substrate;

a photonic integrated circuit (PIC) coupled to the substrate and having a first surface, wherein the first surface of the substrate is proximate the first surface of the PIC and the second surface of the substrate is distal the first surface of the PIC;

a lid, contacting the first surface of the substrate and at least partially covering the PIC, exhibiting at least one retaining feature; and

an optical fiber coupled to the PIC and in contact with the retaining feature of the lid.

2. The apparatus according to claim 1, wherein the retaining feature comprises a groove in the lid.

3. The apparatus according to claim 1, wherein the retaining feature comprises a fiber channel.

4. The apparatus according to claim 1, wherein the lid is formed of a thermally conductive material.

5. The apparatus according to claim 1, further comprising a thermal material in contact with the lid and the PIC.

6. The apparatus according to claim 1, wherein a portion of the optical fiber is coiled around the retaining feature.

7. The apparatus according to claim 1, further comprising a circuit board on which the substrate in mounted.

8. The apparatus according to claim 1, wherein the optical fiber is edge-coupled to the PIC.

9. The apparatus according to claim 1, further comprising an electronic integrated circuit disposed on the first surface of the substrate.

10. The apparatus according to claim 1, further comprising a fiber assembly containing a groove on which the optical fiber is disposed.

11. A method comprising:

packaging a photonic integrated circuit (PIC) in a package comprising a substrate and a lid, such that:

a first surface of the substrate is proximate a first surface of the PIC and a second surface of the substrate is distal the first surface of the PIC,

the lid contacts the first surface of the substrate, and

the lid at least partially covers the PIC;

coupling an optical fiber to the PIC;

mechanically coupling the optical fiber to a retaining feature of the lid; and

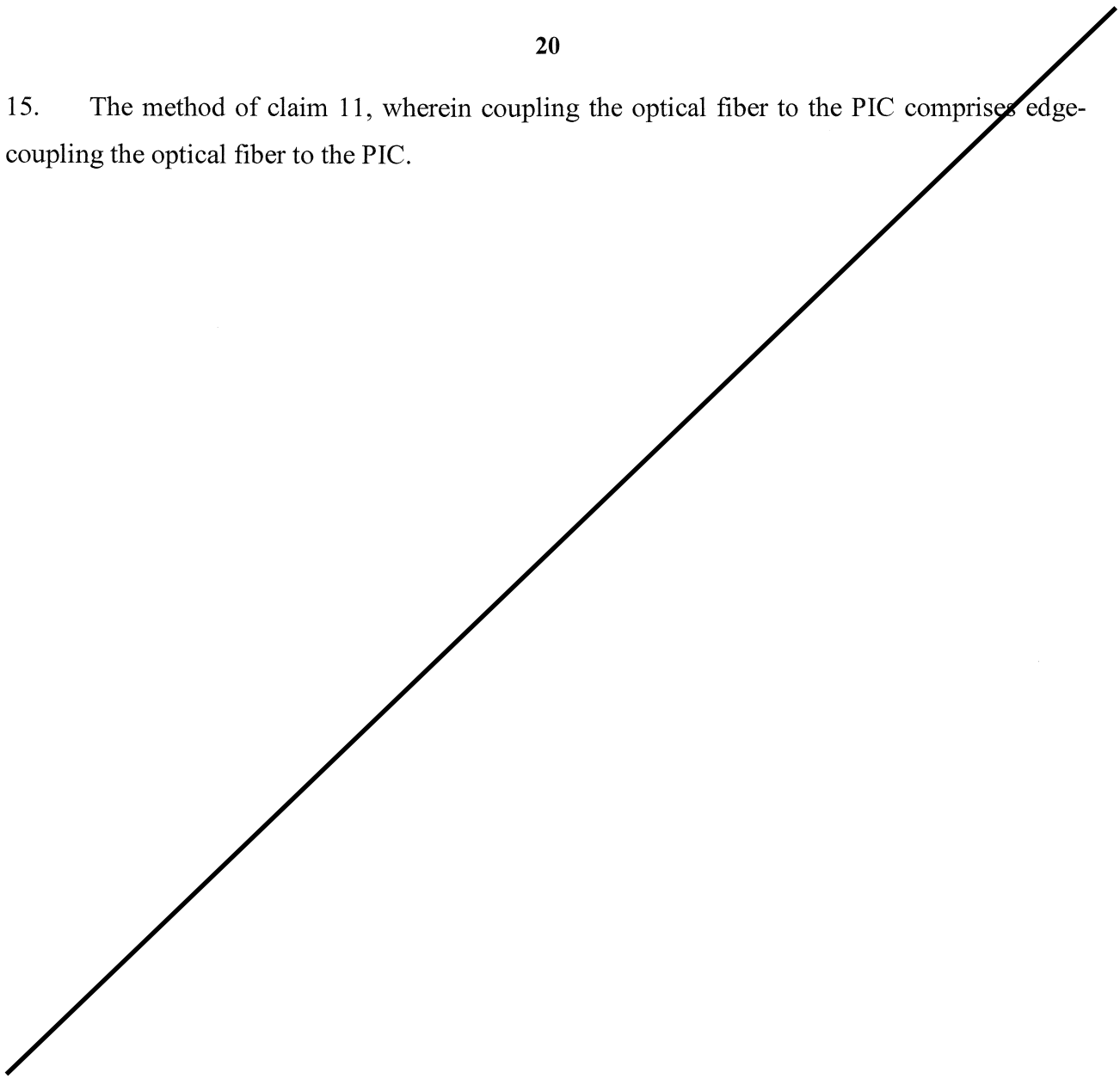
performing reflow soldering of the package while the optical fiber is mechanically coupled to the retaining feature of the lid.

12. The method of claim 11, further comprising surface-mounting the package on a chip carrier.

13. The method of claim 11, further comprising mechanically uncoupling the optical fiber from the retaining feature of the lid subsequent to the reflow soldering.

14. The method of claim 11, wherein mechanically coupling the optical fiber to the retaining feature of the lid comprises coiling a portion of the optical fiber around the retaining feature of the lid.

15. The method of claim 11, wherein coupling the optical fiber to the PIC comprises edge-coupling the optical fiber to the PIC.



CLAIMS

1. An apparatus, comprising:

a substrate having a first surface and a second surface opposite the first surface of the substrate;

a photonic integrated circuit (PIC) coupled to the substrate and having a first surface, wherein the first surface of the substrate is proximate the first surface of the PIC and the second surface of the substrate is distal the first surface of the PIC;

a lid, contacting the first surface of the substrate;

a fiber holder disposed on the lid and covering at least partially the PIC, such that the lid is disposed between the fiber holder and the PIC; and

an optical fiber coupled to the PIC and in contact with the fiber holder.

2. The apparatus according to claim 1, wherein a portion of the optical fiber is coiled around the fiber holder.

3. The apparatus according to claim 2, wherein the PIC comprises a second surface opposite the first surface of the PIC, and wherein the portion of the optical fiber is coiled around the fiber holder within a plane that is substantially parallel to the second surface of the PIC.

4. The apparatus according to claim 1, wherein the optical fiber is edge-coupled to the PIC.

5. The apparatus according to claim 1, further comprising an electronic integrated circuit disposed on the first surface of the substrate.

6. The apparatus according to claim 1, further comprising a circuit board on which the substrate in mounted.

7. The apparatus according to claim 6, wherein the substrate is electrically connected to the circuit board through a ball grid array.

8. The apparatus according to claim 1, wherein the fiber holder is made of copper.

9. The apparatus according to claim 1, further comprising an interposer having a first surface proximate the first surface of the substrate and a second surface opposite the first surface of the interposer and proximate the first surface of the PIC.

10. The apparatus according to claim 1, further comprising a fiber assembly containing a groove on which the optical fiber is disposed.

11. The apparatus according to claim 10, further comprising a thermal pad contacting the fiber assembly.

12. An apparatus, comprising:

a substrate having a first surface and a second surface opposite the first surface of the substrate;

a photonic integrated circuit (PIC) coupled to the substrate and having a first surface, wherein the first surface of the substrate is proximate the first surface of the PIC and the second surface of the substrate is distal the first surface of the PIC;

a lid, contacting the first surface of the substrate and at least partially covering the PIC, exhibiting at least one retaining feature; and

an optical fiber coupled to the PIC and in contact with the retaining feature of the lid.

13. The apparatus of claim 12, wherein the retaining feature comprises a groove in the lid.

14. The apparatus of claim 12, wherein the retaining feature comprises a fiber channel.

15. The apparatus of claim 12, wherein the lid is formed of a thermally conductive material.

16. The apparatus of claim 12, further comprising a thermal material in contact with the lid and the PIC.