What is claimed is:

1. A method of forming a stack of wafers, the method comprising:

providing a sub-stack comprising a first wafer and a second wafer, each of which has a respective upper surface and lower surface, the sub-stack including a first thermally-curable adhesive at an interface between the upper surface of the first wafer and the lower surface of the second wafer;

placing a third wafer on the upper surface of the second wafer, the third wafer having an upper surface and a lower surface, wherein a second thermally-curable adhesive is present at an interface between the upper surface of the second wafer and the lower surface of the third wafer;

providing ultra-violet (UV) radiation in a direction of the upper surface of the third wafer to cure a UV-curable adhesive in openings in the second wafer and in contact with portions of the third wafer so as to bond the third wafer to the sub-stack at discrete locations; and

subsequently heating the third wafer and the sub-stack so to cure the first and second thermally-curable adhesives.

2. The method of claim 1 wherein the openings in the second wafer are located near the periphery of the second wafer.

3. The method of claim 2 wherein each of the openings in the second wafer is a through-holes that extends from the upper surface of the second wafer to its lower surface, wherein the UV-curable adhesive substantially fills the openings.

4. The method of claim 1 wherein the UV radiation reaches the UV-curable adhesive by passing through UV-transparent windows in the third wafer.

5. The method of claim 4 further including:

prior to placing the third wafer on the upper surface of the second wafer, dispensing the UV-curable adhesive into the openings of the second wafer;

subsequently moving the third wafer onto the upper surface of the second wafer, wherein the UV-transparent windows in the third wafer are substantially aligned over the openings in the second wafer containing the UV-curable adhesive; and

providing the UV radiation through the UV-transparent windows in the third wafer after moving the third wafer onto the upper surface of the second wafer.

6. The method of claim 1 wherein the third wafer includes through-holes that extend from the upper surface of the third wafer to its lower surface, the method further including:

after moving the third wafer onto the upper surface of the second wafer, dispensing the UV-curable adhesive into the openings in the second wafer through the through-holes in the third wafer; and

subsequently providing the UV radiation through the through-holes in the third wafer.

7. The method of claim 1 wherein moving the third wafer onto the upper surface of the second wafer and providing the UV radiation to cure the UV-curable adhesive are performed in a mask aligner.

8. The method of claim 7 further including removing from the mask aligner the third wafer attached to the sub-stack after providing the UV radiation to cure the UV-curable adhesive, and heating the third wafer attached to the sub-stack so to cure the first and second thermally-curable adhesives in a location other than in the mask aligner.

9. The method of claim 1 further including separating the stack of wafers into individual modules each of which includes a portion of the first, second and third wafers.

10. The method of claim 1 wherein the wafers are made of materials substantially non-transparent to UV-radiation.

11. The method of claim 1 wherein the first wafer includes an array of light emitting and light detecting elements mounted on its upper surface, and wherein the third wafer includes an array of optical features.

12. The method of claim 1 wherein the first wafer includes an array of optical features, and wherein the third wafer includes an array of light emitting and light detecting elements mounted on its upper surface.

13. A wafer-level method of fabricating opto-electronic modules, the method comprising:

providing a sub-stack comprising a substrate wafer and a spacer wafer, each of which has a respective upper surface and lower surface, wherein the substrate wafer has an array of light emitting and light detecting elements mounted on its upper surface, each of the light emitting and light detecting elements fits within a respective opening in the spacer wafer, and the sub-stack includes a first thermally-curable adhesive at an interface between the upper surface of the substrate wafer and the lower surface of the spacer wafer;

aligning an optics wafer with the sub-stack in a mask aligner, the optics wafer having an upper surface and a lower surface, and further including an array of optical features;

placing the optics wafer onto the sub-stack such that the lower surface of the optics wafer is on the upper surface of the spacer wafer, wherein a second thermally-curable adhesive is present at an interface between the upper surface of the spacer wafer and the lower surface of the optics wafer;

providing ultra-violet (UV) radiation in a direction of the upper surface of the optics wafer to cure a UV-curable adhesive in openings in the spacer wafer and in contact with portions of the optics wafer so as to bond the optics wafer to the sub-stack at discrete locations;

subsequently moving the optics wafer attached to the sub-stack to another location; and

subsequently heating the optics wafer attached to the sub-stack so to cure the first and second thermally-curable adhesives.

14. The method of claim 13 wherein the openings in the spacer wafer are located near its periphery.

15. The method of claim 14 wherein each of the openings in the spacer wafer is a through-hole that extends from its upper surface to its lower surface, wherein the UV-curable adhesive substantially fills the openings.

16. The method of claim 14 wherein the UV radiation reaches the UV-curable adhesive by passing through UV-transparent windows in the optics wafer, wherein the windows are substantially aligned with the openings in the spacer wafer.

17. The method of claim 16 further including:

prior to placing the optics wafer on the sub-stack, dispensing the UV-curable adhesive into the openings of the spacer wafer;

subsequently placing the optics wafer on the upper surface of the spacer wafer; and

providing the UV radiation through the UV-transparent windows in the optics wafer after placing the optics wafer on the upper surface of the spacer wafer.

18. The method of claim 14 wherein the optics wafer includes through-holes that extend from the upper surface of the optics wafer to its lower surface, the method further including:

after placing the optics wafer on the upper surface of the spacer wafer, dispensing the UV-curable adhesive into the openings in the spacer wafer through the through-holes in the optics wafer; and

subsequently providing the UV radiation through the through-holes in the optics wafer.

19. The method of claim 14 wherein placing the optics wafer on the upper surface of the spacer wafer and providing the UV radiation to cure the UV-curable adhesive are performed in the mask aligner.

20. The method of claim 19 further including removing from the mask aligner the optics wafer attached to the sub-stack after providing the UV radiation to cure the UV-curable adhesive, and placing the optics wafer attached to the sub-stack in an environment with a raised temperature so to cure the first and second thermally-curable adhesives in a location other than in the mask aligner.

21. The method of claim 14 further including separating the stack of wafers into individual modules each of which includes a portion of the substrate, spacer and optics wafers and each of which includes at least one of the light emitting elements and at least one of the light detecting elements.

22. A wafer-level method of fabricating opto-electronic modules, the method comprising:

providing a sub-stack comprising an optics wafer and a spacer wafer, each of which has a respective first surface and second surface, the optics wafer including an array of optical features, the sub-stack including a first thermally-curable adhesive at an interface between the first surface of the optics wafer and the second surface of the spacer wafer;

aligning a substrate wafer with the sub-stack in a mask aligner, the substrate wafer having a first surface and a second surface, wherein the substrate wafer has an array of light emitting and light detecting elements mounted on its second surface;

placing the substrate wafer onto the sub-stack such that the second surface of the substrate wafer is on the first surface of the spacer wafer, wherein a second thermally-curable adhesive is present at an interface between the first surface of the spacer wafer and the second surface of the substrate wafer;

providing ultra-violet (UV) radiation in a direction of the first surface of the substrate wafer to cure a UV-curable adhesive in openings in the spacer wafer and in

contact with portions of the substrate wafer so as to bond the substrate wafer to the sub-stack at discrete locations;

subsequently moving the substrate wafer attached to the sub-stack to another location; and

subsequently heating the substrate wafer attached to the sub-stack so to cure the first and second thermally-curable adhesives.

23. The method of claim 22 wherein the openings in the spacer wafer are located near its periphery.

24. The method of claim 23 wherein each of the openings in the spacer wafer is a through-hole that extends from the first surface of the spacer wafer to its second surface, wherein the UV-curable adhesive substantially fills the openings.

25. The method of claim 23 wherein the UV radiation reaches the UV-curable adhesive by passing through UV-transparent windows in the substrate wafer, wherein the windows are substantially aligned with the openings in the spacer wafer.

26. The method of claim 25 further including:

prior to placing the substrate wafer on the sub-stack, dispensing the UV-curable adhesive into the openings of the spacer wafer;

subsequently placing the substrate wafer on the first surface of the spacer wafer; and

providing the UV radiation through the UV-transparent windows in the substrate wafer after placing the substrate wafer on the first surface of the spacer wafer.

27. The method of claim 23 wherein the substrate wafer includes through-holes that extend from its upper surface to its lower surface, the method further including:

after placing the substrate wafer on the first surface of the spacer wafer, dispensing the UV-curable adhesive into the openings in the spacer wafer through the through-holes in the substrate wafer; and

subsequently providing the UV radiation through the through-holes in the substrate wafer.

28. The method of claim 23 wherein placing the substrate wafer on the first surface of the spacer wafer and providing the UV radiation to cure the UV-curable adhesive are performed in the mask aligner.

29. The method of claim 28 further including removing from the mask aligner the substrate wafer attached to the sub-stack after providing the UV radiation to cure the UV-curable adhesive, and placing the substrate wafer attached to the sub-stack in an environment with a raised temperature so to cure the first and second thermally-curable adhesives in a location other than in the mask aligner.

30. The method of claim 23 further including separating the stack of wafers into individual modules each of which includes a portion of the substrate, spacer and optics wafers and each of which includes at least one of the light emitting elements and at least one of the light detecting elements.

31. A wafer stack comprising:

a first wafer having an upper surface and a lower surface;

a second wafer having an upper surface and a lower surface;

a first thermally-cured adhesive at an interface between the upper surface of the first wafer and the lower surface of the second wafer;

a third wafer having an upper surface and a lower surface,

a second thermally-cured adhesive at an interface between the upper surface of the second wafer and the lower surface of the third wafer;

UV-cured adhesive disposed in the second wafer and in contact with portions of the second and third wafers, wherein the UV-cured adhesive is disposed at discrete locations near the periphery of the second wafer.

32. The wafer stack of claim 31 wherein the third wafer includes UV-transparent windows each of which is substantially aligned with a respective one of the locations in the second wafer that contains the UV-cured adhesive.

33. The wafer stack of claim 31 wherein the UV-cured adhesive also is disposed in the third wafer at locations each of which is substantially aligned with a respective one of the locations in the second wafer that contains the UV-cured adhesive.

34. The wafer stack of claim 31 wherein the discrete locations near the periphery of the second wafer have a diameter in the range of 2-4 mm.

35. The wafer stack of claim 31 wherein each of the discrete locations near the periphery of the second wafer is approximately equally spaced from adjacent ones of the discrete locations.

36. The wafer stack of claim 31 wherein the wafers are made of materials substantially non-transparent to UV-radiation.

CLAIMS

1. A method of forming a stack of wafers for an opto-electronic module, the method comprising:

providing a sub-stack comprising a first wafer (PW; OW; PW) and a second wafer (SW), each of which has a respective upper surface and lower surface, the sub-stack including a first thermally-curable adhesive (102) at an interface between the upper surface of the first wafer (PW; OW; PW) and the lower surface of the second wafer (SW);

placing a third wafer (OW; PW) on the upper surface of the second wafer (SW), the third wafer (OW; PW) having an upper surface and a lower surface, wherein a second thermally-curable adhesive (104) is present at an interface between the upper surface of the second wafer (SW) and the lower surface of the third wafer (OW; PW);

providing ultra-violet (UV) radiation in a direction of the upper surface of the third wafer (OW; PW) to cure a UV-curable adhesive (124) in openings (122) in the second wafer (SW) and in contact with portions of the third wafer (OW; PW) so as to bond the third wafer (OW; PW) to the sub-stack at discrete locations; and

subsequently heating the third wafer (OW; PW) and the sub-stack so to cure the first and second thermally-curable adhesives (102, 104).

2. The method of claim 1 wherein the openings (122) in the second wafer (SW) are located near the periphery of the second wafer (SW).

3. The method of claim 2 wherein each of the openings (120) in the second wafer (SW) is a through- holes that extends from the upper surface of the second wafer (SW) to its lower surface, wherein the UV-curable adhesive (124) substantially fills the openings (122).

4. The method of claim 1 wherein the UV radiation reaches the UV-curable adhesive (124) by passing through UV-transparent windows (122; 130) in the third wafer (OW; PW).

5. The method of claim 4 further including:
prior to placing the third wafer (OW; PW) on the upper surface of the second wafer (SW), dispensing the UV-curable adhesive (124) into the openings of the second wafer (SW); subsequently moving the third wafer (OW; PW) onto the upper surface of the second wafer (SW), wherein the UV-transparent windows (120; 130) in the third wafer (OW; PW) are substantially aligned over the openings (122) in the second wafer (SW) containing the UV-curable adhesive (124); and
providing the UV radiation through the UV-transparent windows (120; 130) in the third wafer (OW; PW) after moving the third wafer (OW; PW) onto the upper surface of the second wafer (SW).

6. The method of claim 1 wherein the third wafer (OW; PW) includes through-holes (120) that extend from the upper surface of the third wafer (OW; PW) to its lower surface, the method further including:
after moving the third wafer (OW; PW) onto the upper surface of the second wafer (SW), dispensing the UV-curable adhesive (124) into the openings (122) in the second wafer (SW) through the through-holes (120) in the third wafer (OW; PW); and
subsequently providing the UV radiation through the through-holes (120) in the third wafer (OW; PW).

7. The method of claim 1 wherein moving the third wafer (OW; PW) onto the upper surface of the second wafer (SW) and providing the UV radiation to cure the UV-curable adhesive (124) are performed in a mask aligner.

8. The method of claim 7 further including removing from the mask aligner the third wafer (OW; PW) attached to the sub-stack after providing the UV radiation to cure the UV-curable adhesive (124), and heating the third wafer (OW; PW) attached to the sub-stack so to cure the first and second thermally-curable adhesives (102, 104) in a location other than in the mask aligner.

9. The method of claim 1 further including separating the stack of wafers into individual modules each of which includes a portion of the first, second and third wafers (PW, SW, OW).

10. The method of claim 1 wherein the wafers (PW, SW, OW) are made of materials substantially non- transparent to UV-radiation.

11. The method of claim 1 wherein the first wafer (PW) includes an array of light emitting and light detecting elements (E, D) mounted on its upper surface, and wherein the third wafer (OW) includes an array of optical features (15, 16), or wherein the first wafer includes an array of optical features, and wherein the third wafer includes an array of light emitting and light detecting elements mounted on its upper surface.

12. A wafer stack for an opto-electronic module comprising:
a first wafer (PW; OW) having an upper surface and a lower surface;
a second wafer (SW) having an upper surface and a lower surface;
a first thermally-cured adhesive (102) at an interface between the upper surface of the first wafer (PW; OW) and the lower surface of the second wafer (SW);
a third wafer (OW; PW) having an upper surface and a lower surface,
a second thermally-cured adhesive (104) at an interface between the upper surface of the second wafer (SW) and the lower surface of the third wafer (OW; PW);
UV-cured adhesive (124) disposed in the second wafer (SW) and in contact with portions of the second and third wafers (SW, OW; SW, PW), wherein the

UV-cured adhesive (124) is disposed at discrete locations near the periphery of the second wafer (PW).

13. The wafer stack of claim 12 wherein the third wafer (OW; PW) includes UV-transparent windows (120; 130) each of which is substantially aligned with a respective one of the locations in the second wafer (SW) that contains the UV-cured adhesive (124).

14. The wafer stack of claim 12 wherein the UV-cured adhesive (124) also is disposed in the third wafer (OW; PW) at locations each of which is substantially aligned with a respective one of the locations in the second wafer (SW) that contains the UV-cured adhesive (124).

15. The wafer stack of claim 12 wherein the wafers (PW, SW, OW) are made of materials substantially non- transparent to UV-radiation.