CLAIMS

1. A photodiode detector comprising:

an optical cavity comprising an overlying light-receiving portion and an underlying mirror; and

a GeSn absorption layer;

wherein the GeSn absorption layer is disposed within the optical cavity and arranged between the overlying light-receiving portion and the underlying mirror,

the GeSn absorption layer and the underlying mirror are wafer-bonded with each other, and

the overlying light-receiving portion is configured to receive light to be detected by the photodiode detector.

2. The photodiode detector as claimed in claim 1, wherein the overlying light-receiving portion is a surface of the GeSn absorption layer, and the underlying mirror has a refractive index different from a refractive index of the GeSn absorption layer surface.

3. The photodiode detector as claimed in claim 2, wherein the underlying mirror comprises a Al_2O_3 layer.

4. The photodiode detector as claimed in claim 1, further comprising a multiplier layer disposed adjacent to the GeSn absorption layer, wherein the photodiode detector is an avalanche photodiode detector.

5. The photodiode detector as claimed in claim 4, wherein the underlying mirror is a distributed Bragg reflector, and the overlying light-receiving portion comprises a passivation layer.

6. The photodiode detector as claimed in claim 4, wherein the underlying mirror is a first distributed Bragg reflector, and the overlying light-receiving portion is a second distributed Bragg reflector.

7. The photodiode detector as claimed in claim 6, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise same number of material pairs.

8. The photodiode detector as claimed in claim 6, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise different numbers of material pairs.

9. The photodiode detector as claimed in claim 6, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise same type of material pairs.

10. The photodiode detector as claimed in claim 6, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise different types of material pairs.

11. The photodiode detector as claimed in any one of claims 5 to 10, wherein the distributed Bragg reflector comprises a dielectric distributed Bragg reflector or a semiconductor distributed Bragg reflector.

12. The photodiode detector as claimed in any one of claims 4 to 11, wherein the multiplier layer comprises a Si multiplier layer.

13. The photodiode detector as claimed in any one of claims 4 to 12, wherein the overlying light-receiving portion and the GeSn absorption layer are arranged adjacent to each other, and the underlying mirror and the multiplier layer are arranged adjacent to each other.

14. The photodiode detector as claimed in any one of claims 4 to 13, wherein an anode of the photodiode detector comprises a first metal contact for external electrical connection, the first metal contact overlying at least part of a positively doped p region of

the GeSn absorption layer; and a cathode of the photodiode detector comprises a second metal contact for external electrical connection, the second metal contact overlying at least part of a negatively doped n region of the multiplier layer.

15. The photodiode detector as claimed in any one of claims 1 to 14, further comprising a substrate having a planar surface, wherein the optical cavity is arranged extending upwardly from the planar surface, with the underlying mirror being adjacent to the substrate or with the substrate forming an integrated part of the underlying mirror.

16. The photodiode detector as claimed in any one of claims 1 to 15, wherein the GeSn absorption layer has a Sn content of near 0% to about 11%.

17. The photodiode detector as claimed in claim 16, wherein the GeSn absorption layer has the Sn content of about 3 % to 4% to enhance absorption coefficient at a wavelength of 1550 nm, or about 10% to enhance absorption coefficient at a wavelength of 2000 nm.

18. The photodiode detector as claimed in any one of claims 1 to 17, wherein the GeSn absorption layer has a thickness of more than 100 nm.

19. The photodiode detector as claimed in any one of claims 1 to 18, wherein the underlying mirror has a thickness sufficient to provide about 0.5 reflectivity or more at a wavelength of 1550 nm or 2000 nm.

20. A method of fabricating a photodiode detector as claimed in any one of claims 1 to 19, the method comprising:

forming a first wafer comprising an underlying mirror;

forming a GeSn absorption layer over the first wafer; and

forming an overlying light-receiving portion over the GeSn absorption layer,

wherein forming the GeSn absorption layer over the first wafer comprises wafer-bonding the GeSn absorption layer and the underlying mirror.

21. The method as claimed in claim 20, wherein wafer-bonding the GeSn absorption layer and the underlying mirror comprises

forming a second wafer comprising the GeSn absorption layer; and

wafer-bonding the first wafer and the second wafer, wherein the GeSn absorption layer on the second wafer is facing toward the first wafer.

22. The method as claimed in claim 21,

wherein the step of forming the second wafer comprises depositing the GeSn absorption layer over a temporary substrate; and

wherein after wafer-bonding, the method further comprises

removing the temporary substrate by grinding and/or wet etching; and

chemical mechanical polishing the GeSn absorption layer.

23. The method as claimed in claim 22, further comprising after chemical mechanical polishing the GeSn absorption layer, preparing the overlying light-receiving layer via ion-implantation.

24. The method as claimed in claim 20, wherein wafer-bonding the GeSn absorption layer and the underlying mirror comprises growing the GeSn absorption layer and a p++ GeSn top contact layer over the first wafer using reduced pressure chemical vapour deposition.

25. The method as claimed in any one of claims 20 to 24, further comprising prior to the step of forming the GeSn absorption layer over the first wafer, growing a multiplier layer over the underlying mirror using reduced pressure chemical vapour deposition.

26. The method as claimed in claim 25, wherein after growing the multiplier layer, the method comprises doping a charge sheet layer with ion implantation with boron acceptors; and performing rapid thermal annealing of the charge sheet layer and the multiplier layer.

27. The method as claimed in any one of claims 20 to 26, further comprising prior to the step of forming the first wafer, fabricating the underlying mirror using a double-SOI process.

28. The method as claimed in any one of claims 20 to 27, further comprising after forming the overlying light-receiving portion over the GeSn absorption layer, forming two metal contacts for external electrical connections of the photodiode detector, using a metal deposition process, or a process comprising photolithography, electron-beam deposition, and subsequent lift-off process.

29. The method as claimed in claim 28, further comprising prior to the step of forming the two metal contacts, patterning a mesa on at least portion of the photodiode detector.

30. The method as claimed in claim 21 or 22, further comprising prior to the step of wafer-bonding, atomic layer depositing a semiconductor material on the first wafer and the second wafer.