CLAIMS

1. A photodiode detector comprising:

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

a GeSn absorption layer; and

a multiplier layer disposed adjacent to the 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 overlying light-receiving portion is configured to receive light to be detected by the photodiode detector, and

the optical cavity is configured to confine the received light in the GeSn absorption layer in a form of a standing wave propagating between the overlying light-receiving portion and the underlying mirror along a longitudinal axis of the optical cavity.

2. The photodiode detector as claimed in claim 1, wherein the GeSn absorption layer and the underlying mirror are wafer-bonded with each other.

3. The photodiode detector as claimed in claim 1 or 2, wherein the photodiode detector is an avalanche photodiode detector.

4. The photodiode detector as claimed in any one of claims 1 to 3, wherein the underlying mirror is a distributed Bragg reflector, and the overlying light-receiving portion comprises a passivation layer.

5. The photodiode detector as claimed in any one of claims 1 to 3, wherein the underlying mirror is a first distributed Bragg reflector, and the overlying light-receiving portion is a second distributed Bragg reflector.

6. The photodiode detector as claimed in claim 5, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise same number of material pairs.

7. The photodiode detector as claimed in claim 5, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise different numbers of material pairs.

8. The photodiode detector as claimed in claim 5, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise same type of material pairs.

9. The photodiode detector as claimed in claim 5, wherein the first distributed Bragg reflector and the second distributed Bragg reflector comprise different types of material pairs.

10. The photodiode detector as claimed in any one of claims 4 to 9, wherein the distributed Bragg reflector comprises a dielectric distributed Bragg reflector or a semiconductor distributed Bragg reflector.

11. The photodiode detector as claimed in any one of claims 1 to 10, wherein the multiplier layer comprises a Si multiplier layer.

12. The photodiode detector as claimed in any one of claims 1 to 11, 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.

13. The photodiode detector as claimed in any one of claims 1 to 12, 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.

14. The photodiode detector as claimed in any one of claims 1 to 13, 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.

15. The photodiode detector as claimed in any one of claims 1 to 14, wherein the GeSn absorption layer has a Sn content of near 0% to about 11%.

16. The photodiode detector as claimed in claim 15, wherein the GeSn absorption layer has the Sn content of 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.

17. The photodiode detector as claimed in any one of claims 1 to 16, wherein the GeSn absorption layer has a thickness of more than 100 nm.

18. The photodiode detector as claimed in any one of claims 1 to 17, 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.

19. A method of fabricating a photodiode detector as claimed in any one of claims 1 to 18, the method comprising:

forming a first wafer comprising an underlying mirror;

growing a multiplier layer over the underlying mirror using reduced pressure chemical vapour deposition;

forming a GeSn absorption layer over the first wafer; and

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

20. The method as claimed in claim 19, wherein forming the GeSn absorption layer over the first wafercomprises

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.

21. The method as claimed in claim 20,

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.

22. The method as claimed in claim 21, further comprising after chemical mechanical polishing the GeSn absorption layer, preparing the overlying light-receiving layer via ion-implantation.

23. The method as claimed in claim 19, wherein forming the GeSn absorption layer over the first wafer comprises growing the GeSn absorption layer and a p++ GeSn top contact layer over the first wafer using reduced pressure chemical vapour deposition.

24. The method as claimed in any one of claims 19 to 23, 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.

25. The method as claimed in any one of claims 19 to 24, further comprising prior to the step of forming the first wafer, fabricating the underlying mirror using a double-SOI process.

26. The method as claimed in any one of claims 19 to 25, 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.

27. The method as claimed in claim 26, further comprising prior to the step of forming the two metal contacts, patterning a mesa on at least portion of the photodiode detector.

28. The method as claimed in claim 20 or 21, further comprising prior to the step of wafer-bonding, atomic layer depositing a semiconductor material on the first wafer and the second wafer.