High performance InP/InGaAs single-photon detectors and applications

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InP/InGaAs shortwave infrared single-photon avalanche diodes (SPADs) have the advantages of high sensitivity, small size, easy installation and portability. Furthermore, it is easy to fabricate large-area single-photon focal plane arrays based on the conventional semiconductor chip processing. The InP/InGaAs SPADs can not only detect the weak irradiation, it can also perform the three-dimensional digital imaging of the targets in the cm level accuracy. Therefore, the InP/InGaAs SPADs is widely used in quantum communication, lidar, biofluorescence detection, etc

By adopting the ternary collaborative design engineering of the energy band-electric field-process, the InP/InGaAs material structure design is optimized, and the innovative chip process is used to establish a uniform avalanche electric field. Based on the above optimizations, the SPADs operated at room temperature with the dark count rate 6.82 kHz and the photon detection efficiency 20%. Compared with the currently reported SPADs at room temperature, the dark count rate is one order of magnitude lower for the same detection efficiency. Meanwhile, the cooled SPADs was also investigated and fabricated by the different processing, the detection efficiency was 51.4% and the dark count rate is less than 5.4 kHz at temperature -30°C. The prepared chips were successfully applied to laser ranging and lidar. Furthermore, the 128×128 single-photon array was developed with the integrated InP microlens, which achieved clear grayscale imaging and three-dimensional imaging of the target, with a temporal resolution of 1 ns.

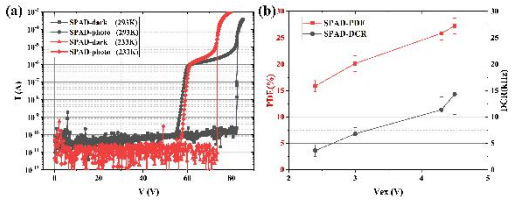

FIG. 1. (a) Measured photo-current (-photo, round and diamond) and dark current (-dark, squares and triangle) of SPAD at 293 and 233 K. (b) Dependence on excess voltage Vex of the measured photon detection efficiency (red squares) and the dark count rate (black round) of SPAD

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References

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