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HgCdTe APDs for low photon number IR detection

HgCdTe APDs have opened a new horizon in photon starved Infra-Red (IR) applications due to their exceptional performance in terms of high linear gain, low excess noise and high quantum efficiency which have enabled single photon detection with high efficiencies from the uv up to the mid-IR range [1]. These properties, which enables the detection of a few number of photons, down to single photon detection, with an ultra-low loss of the information contained in the photon flux, equivalent to an effective quantum efficiency of 70 to 80 %, combined with a large linear dynamic range offers an unique observation window of low photon number temporal and/or spatial information in the IR range. The performances of HgCdTe APDs, such as quantum efficiency, gain, dark noise, excess noise, response time will be discussed as a function of the spectral sensitivity of the APD that can be tuned by varying the composition of the compound semi-conductor [2-4] in order to achieve down to single photon detection for wavelengths ranging from the uv up to cut-off wavelengths varying between 2.5 and 10 µm.
HgCdTe APD prototype detectors have been developed for applications such as time of flight 3D imaging, astrophysics, free space optical telecommunications, photoluminescence or fluorescence life time measurements, gas LIDAR and singe photon detection. The presently achievable detector performance will be illustrated through a number of such application demonstrations made with prototype imaging arrays and single element detectors dedicated to extract the spatial and/or temporal information low photon number IR flux.

[1] J. Rothman et. al., HgCdTe APDs for space applications, Proc. ICSO, 2014.
[2] Perrais et. al., Study of the Transit-Time Limitations of the Impulse Response in Mid-Wave Infrared HgCdTe Avalanche Photodiodes, J. Electron. Mater., 38, 1790, 2009
[3] J. Rothman et. al., Short-wave Infrared HgCdTe Avlanche Photodiodes, J. Electron. Mater., 41, 2928, 2012.
[4] J. Rothman et. al., Response time measurements in Short-Wave Infrared HgCdTe e-APDs, J. Electrons Mater., 43, 2947, 2014.

Summary

HgCdTe avalanche photodiode enables the detection of a low number of photons from the uv to the mid-IR range with a close to negligeable degradation in signal quality. In this communication we will detail the physical principels of HgCdTe APDs and present the performance of already developped detectors and the perspectives for imaging and/or temporal analysis of weak IR photon signals.

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