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Title: Design and development of 256x256 linear mode low-noise avalanche photodiode arrays

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Abstract

A larger format photodiode array is always desirable for many LADAR imaging applications. However, as the array format increases, the laser power or the lens aperture has to increase to maintain the same flux per pixel thus increasing the size, weight and power of the imaging system. In order to avoid this negative impact, it is essential to improve the pixel sensitivity. The sensitivity of a short wavelength infrared linear-mode avalanche photodiode (APD) is a delicate balance of quantum efficiency, usable gain, excess noise factor, capacitance, and dark current of APD as well as the input equivalent noise of the amplifier. By using InAlAs as a multiplication layer in an InP-based APD, the ionization coefficient ratio, k, is reduced from 0.40 (InP) to 0.22, and the excess noise is reduced by about 50%. An additional improvement in excess noise of 25% was achieved by employing an impact-ionization-engineering structure with a k value of 0.15. Compared with the traditional InP structure, about 30% reduction in the noise-equivalent power with the following amplifier can be achieved. Spectrolab demonstrated 30-um mesa APD pixels with a dark current less than 10 nA and a capacitance of 60 fF at gain of 10. APD gain uniformity determines the usable gain of most pixels in an array, which is critical to focal plane array sensitivity. By fine tuning the material growth and device process, a break-down-voltage standard deviation of 0.1 V and gain of 30 on individual pixels were demonstrated in our 256x256 linear-mode APD arrays.