$In_{0.53}Ga_{0.47}As/Al_{0.85}Ga_{0.15}As_{0.56}Sb_{0.44}$ Single Photon Avalanche Diodes

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Near-infrared Single Photon Avalanche Diodes (SPADs) are used as single photon detectors in laser-ranging, quantum gas sensing, and quantum communication networks. Compared to other single photon detectors, SPADs have relatively high operation temperature (≥200K), so they do not require costly and complex cryogenic systems. For applications that require portable detector modules and can tolerate a higher Dark Count Rate (DCR), operating passively cooled SPADs can minimize cost, size, weight, and power consumption. Such SPADs require avalanche materials with excellent temperature stability. A promising avalanche material on this aspect is $Al_{0.85}Ga_{0.15}As_{0.56}Sb_{0.44}$, whose thermal coefficient of avalanche breakdown voltage is significantly lower than that of commercial InP-based SPAD (~10-20mV/K[1], c.f. 100'smV/K in InP).

In this work, we report Single Photon Detection Efficiency (SPDE) of InGaAs/AlGaAsSb SPADs at 1550nm wavelength between 300 and 200K. SPDE and DCR data were obtained from multiple devices covering three diameters (15, 35, and 55µm). For a given diameter, as operating temperature reduces, the peak SPDE increases (14 to 28%), as shown in Fig.1(left). Such temperature dependence is in line with more established SPADs (e.g. InGaAs/InP and InGaAs/InAlAs). Operating the InGaAs/AlGaAsSb SPADs at room temperature without active thermal stabilisation yielded DCR density versus time characteristics shown in Fig.1(right). In these measurements, an overbias of ~2.5V was applied to the SPADs, corresponding to dark count probabilities of ~0.2. The DCR density for both diameters remained stable over a 2-hour period, confirming the device's thermal stability and its relevance to optical applications where low weight and power consumption are desired.

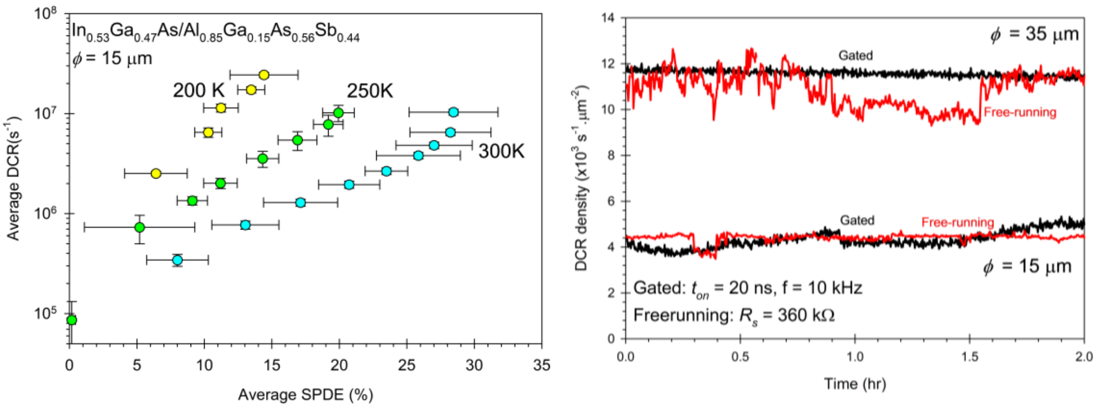

Fig. 1. *DCR density versus SPDE data for Ø = 15 µm devices at 300, 250, and 200 K(left). DCR density versus time data for Ø = 15 and 35 µm devices operated without active temperature stabilization in both gated and free-running modes (right).*

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References

[1] J. Taylor-Mew, *et al*, *IEEE Trans. Electron Devices*, 71(3), Mar. 2024, doi: 10.1109/TED.2024.3354698.