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High speed and high bandwidth quantum cascade detectors

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In recent years, there has seen an increasing interest in sensitive and high-speed mid-infrared (MIR) detectors for room temperature applications. Quantum cascade detectors (QCD) are very promising candidates due to their fast carrier dynamics and because they operate at zero bias, which results in no dark current. Their use could be beneficial for a wide range of applications, from spectroscopy to highly accurate frequency metrology and free-space data telecommunication. Most applied techniques rely on mapping the optical to the radio frequency (RF) domain by beating the MIR signal on a fast detector. Therefore, there is an increasing demand for MIR photodetectors with bandwidths large enough to detect optical beatings up to the Gigahertz range. We report on high-speed QCDs operating at 4.3 µm wavelength, connected to a microwave coplanar transmission line (CPW) which allows a 3-dB bandwidth larger than 10 GHz. As the responsivity of QCDs is inversely proportional to the number of periods, a single stage QCD was fabricated [1] into a 6 µm wide and 150 µm long ridge waveguide, which is wire-bonded to the 50 Ohm impedance matched transmission line. The devices show a particularly high responsivity of more than 0.8 A/W at room temperature. Microwave rectification and an interband cascade laser (ICL) frequency comb [2] emitting around 3.8 µm are used to characterize the high-speed detection capabilities of the single period QCD. The small area of the narrow ridge waveguide allows a 3-dB bandwidth of several GHz.

[1] Schwarz et al. "The limit of quantum cascade detectors: A single period device." *Applied Physics Letters* 111.6 (2017): 061107.

[2] Schwarz et al. "A monolithic frequency comb platform based on interband cascade lasers and detectors." *arXiv preprint arXiv:1812.03879* (2018).

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