Interband Cascade Infrared Photodetectors for High-speed Applications

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Emerging areas such as high-precision frequency comb spectroscopy, light detection and ranging (LIDAR) and free-space optical communication demand for high-speed detectors in the mid-infrared. Fast detectors have proven to be invaluable tools to reconstruct the waveform of mode-locked lasers and measure the phase-coherence and timing jitter of frequency combs [1,2]. Here we present our latest progress on studying the high-speed performance of interband cascade infrared photodetectors (ICIPs) based on a type-II InAs/GaSb superlattice. ICIPs combine interband optical transitions with fast intraband transport achieving high-frequency and broad-wavelength operation at room temperature. We study limitations of the high-speed performance, employing varying superlattice absorber thicknesses. In addition to the fundamental carrier transport time scales, the electronic detector speed can further be limited by parasitic electronic components.
We furthermore rely on these detectors to push our research on ICL frequency combs allowing us to characterize ICLs emitting at various wavelengths due to the broad spectral response of the ICIP ranging from 1.8 to 4.5 µm (Fig. 1b), including ICLs performance sweet spot between 3-4 µm. Recently, our fully packaged ICIP, as shown in the inset of Fig. 1a is employed in a free-space communication experiment. The bandwidth of the system, using a directly modulated ICL optimized for RF injection [3] and the ICIP was characterized (Fig. 1c). The electrical bandwidth is heavily influenced by the applied bias on the detector, resulting in a 3-dB bandwidth of 2 GHz at 5V bias. The transmission rate of a full interband free-space communication system is investigated, paving the way towards energy-efficient multi-Gbits/s communication.

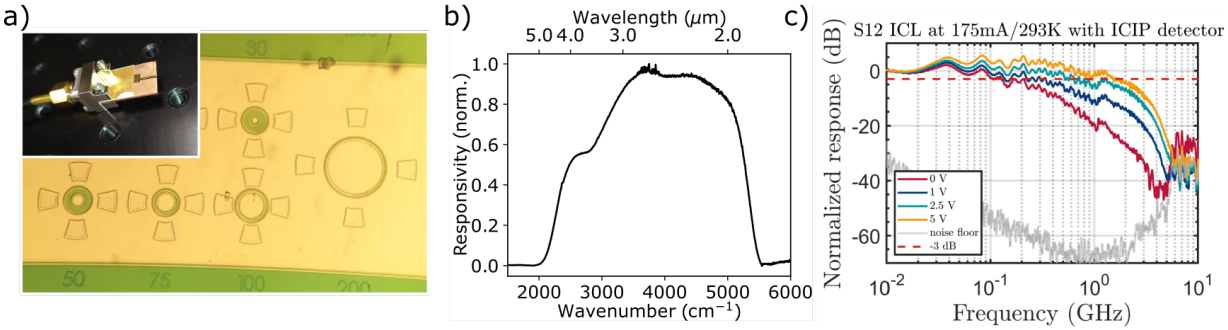

Fig. 1.a) Fabricated ICIP chip. Inset: photograph of a fully packaged ICIP. b) Measured photoresponse of the ICIP. c) Frequency response of a system employing an ICL and an ICIP.

[1] J. Hillbrand, et al., *Optics Express* **29**(4), 5774–5781 (2021)
[2] J. Hillbrand, et al., *Phys. Rev. Lett.* **124**(2), 023901 (2020)
[3] P. Didier, et al., *Applied Physics Letters* **119**, 171107 (2021)