thermophotonic) mid-infrared LED operating at low bias at 167°C. This energy per bit is comparable to recently reported semiconductor diode laser technologies [18]. State of the art vertical-cavity surface-emitting lasers operate around 56 fJ/bit [19] while photonic crystal nanocavity lasers have been reported to operate with as little as 4.4 fJ/bit [20]. Recent results using modern nanophotonic techniques have demonstrated 0.25 fJ/bit communication with a single mode photonic crystal nanocavity LED [21]. However, we note that our approach to efficient communication is fundamentally different and scales with bitrate differently as a result. The aforementioned devices demonstrate a low energy per bit by achieving high modulation speeds of 10 Gb/s or higher while consuming microwatts of input power. Our device is able to achieve a comparable energy per bit despite transmitting at just a few kilobits per second because it only consumes picowatts of input power. For a low-bias LED, the electrical power consumption scales linearly with the bitrate as the latter is reduced toward zero. This contrasts with channels using laser sources where there is a fixed electrical power required to achieve laser threshold. Such operating performance may be of particular benefit for battery-powered sensors. We have considered idealized LEDs and detectors, and extrapolated from our data to find that the energy per bit in such channels could be on the order of the Landauer limit. Based on these results, we believe that this LED based communication channel can serve as a platform to explore the theoretical bounds of energy efficient communication.

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