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Terahertz quantum cascade lasers and video-rate THz imaging

Qing Hu

Department of EECS, MIT, Cambridge, MA/USA, qhu@mit.edu

The terahertz frequency range (1-10 THz) has long remained undeveloped, mainly due to the lack of compact, coherent radiation sources. Semiconductor electronic devices (such as transistors) are limited by the transient time and RC roll-off to below 1 THz. Conventional semiconductor photonic devices (such as bipolar laser diodes) are limited to above 10 THz even using small-gap lead-salt materials. Transitions between subbands in semiconductor quantum wells were suggested as a method to generate long wavelength radiation at customizable frequencies. The recently developed THz quantum-cascade lasers (QCL) hold great promise to bridge the so-called "THz gap" between conventional electronic and photonic devices.

Based on two novel features, namely resonant-phonon-assisted depopulation¹ and metal-metal waveguides for mode confinement,² we have developed many THz QCLs with strong performance. The highlights include by not limited to: a maximum pulsed operating temperature of ~ 186 K and a maximum cw operating temperature of 117 K,^{3,4} and ~ 250 mW power level.⁵ Using the high-power THz QCL and a 240×320 focal-plane array camera, we are now able to perform real-time THz imaging at video rate, that is, taking movies in "T-rays".⁶ These rapid developments indicate great potentials for THz QCLs in various applications. We will present more detailed results and our perspective at the workshop.

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