A New Approach for Quantum Infrared Detection at Room Temperature

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ABSTRACT

Performance of quantum LWIR/MWIR photo-detectors is limited by dark-thermal current. Common approach is to reduce the thermal current by cooling the devices to cryogenic temperatures, preventing dark-thermal excitation of carriers disturbing the IR detection process. Sirica presents a new approach enabling quantum IR detection at room temperature. Instead of cooling the device, the free carriers are heated. Once their temperature is much higher than that of the device material lattice, heat transfer from the cold lattice to the hot free carriers is not possible due to thermodynamic laws. Heat transfer from hot carriers to the lattice is prevented by selecting a media where free carriers remain hot for long enough time (longer than their expected recombination lifetime). Thus, the device material lattice and hot free carriers are thermodynamically uncoupled and the device appears “cool” at room temperature. The hot carriers are then excited by IR photons to generate electron–hole pairs which are further converted to visible or NIR photons detectable by commercial visible CMOS/CCD sensors, a process known as “energy up-conversion”. The energy required for up conversion is provided by an external low power light source. The new media required for effective light conversion is made of all silicon-based materials and offers the following benefits: (a) essentially non-equilibrium free carriers; (b) strong free carrier absorption of IR radiation; and (c) effective visible/near IR luminescence originating from the IR excited carriers. The theoretical model underlying the device and experimental results showing photo-induced free carrier IR absorption and IR-induced photoluminescence are presented.

Keyword list

Uncooled; Photon; IR detector; Energy up-conversion, Silicon