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Terahertz Semiconductor Detectors: Designs to Applications

UNIL PERERA, Georgia State University

The work describes terahertz photon detectors based on semiconductor micro- and nano-structures using homojunctions, and heterojunctions. A Homojunction or HEterojunction Interfacial Workfunction Internal Photoemission (HIWIP or HEIWIP) infrared detector, formed by a doped emitter layer, and an intrinsic layer acting as the barrier followed by another highly doped contact layer, can detect Terahertz photons due to intraband transitions. The threshold can be tailored by adjusting the band offset between the emitter and the barrier. This principle can be used with any semiconductor material combination. HIWIPs have the same material (doped and undoped) in the emitters and barriers, while HEIWIPs have different band gap material in the two layers. The detection mechanism involves free carrier absorption in the emitter, followed by the internal photoemission of photoexcited carriers across the junction barrier, and then the collection of carriers by the applied electric field at the contacts. Utilization of nanoplasmonic resonances to enhance the terahertz absorption using engineered and self-assembled metal nanostructures on HEIWIP detectors will also be discussed. The metal nanostructures will act as enhanced frequency couplers, which will allow more efficient absorption of terahertz radiation as it is converted into surface plasmons. The near field of SPs will affect the electron gas in the photodetectors the same way as the far-field does. Thus the local field enhancement known for other phenomena and devices could be achieved. Work supported in part by US NSF and US Airforce.