Hot Carrier Semiconductor Plasmonic Mid-infrared Photodetector

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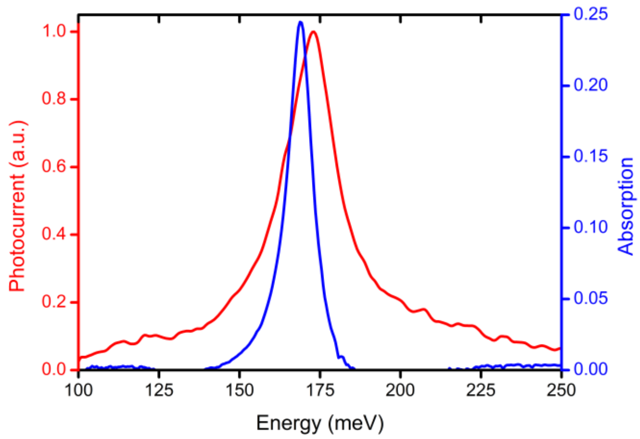
Plasmonic nanostructures have recently been used to enhance the light-matter interaction and to improve the quantum efficiency of internal emission Schottky photodiodes [1]. When the plasmonic mode is used to both enhance the electric field and absorb the radiation, the device is termed a hot carrier photodetector [2]. Hot carrier plasmonic photodetection has so far been reported for nanostructures which support surface plasmon modes [3].

Here we demonstrate a semiconductor plasmonic hot carrier detector in the mid-infared which uses a volume plasmon mode, the well-known Berreman mode [4], as the absorbing medium. The Berreman mode is a collective electronic resonance supported by an electron gas in a slab with thickness smaller than the plasma wavelength. The semiconductor acts as a quasi-monochromatic perfect absorber for a critical coupling angle [5]. We detect a resonant photocurrent signal at the frequency of the plasmon mode when a small DC bias is applied to the device. We demonstrate that the same device emits radiation at the plasmon frequency under the excitation of a modulated electric pulse.

Our system is an ideal platform to study the long-standing problem of the interaction of a single particle current with a collective electronic excitation [6]. Importantly, the mature InP platform used in this study allows for the engineering of the band structure which may help to elucidate the microscopic processes involved in the energy transfer between the collective mode and the single particle electrons.



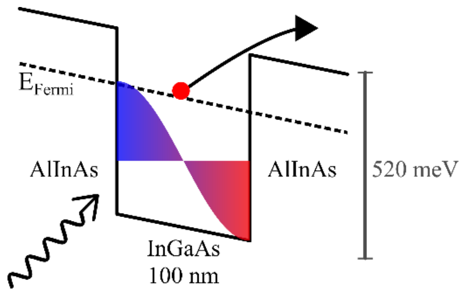


Fig. 1: The normalized absorption (300K) and photocurrent spectra (7K) for a 100 nm InGaAs layer doped with an electronic density of 2e19 cm^{-3}. The collective dipole associated with the Berreman mode is sketched with the electronic band structure.

References:

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