Photocurrent detected two-dimensional spectroscopy of InP nanowire array solar cell

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Photocurrent detected two-dimensional spectroscopy is used to study the effect of excitations in InP nanowire array solar cell. Results show instantaneous changes in the band structure of the semiconductor material due to the excitation of electrons into the conduction band. Possible mechanisms that lead to the changes are discussed.

The measured band gaps of semiconductors decrease when the conduction bands are populated by electrons.[1] Recent, studies indicate that the change in the band gap occurs in sub femtosecond time scale preceding lattice relaxation.[2] However, the reasons behind this reduction in the band gap have not been well understood. We have used photocurrent detected two-dimensional spectroscopy[3] to investigate this phenomenon. Our experiments on InP nanowire array solar cells also indicate that the band gap reduction is instantaneous at high excitation densities. We also observe modulation in the band structure, which indicates the prevalence of dynamic Franz-Keldysh effect in such solar cells. The results show that different nonlinear field matter interactions in photoactive devices can have effects in the photocurrent from the device, and such effects could be used to investigate the changes in the electronic structure of the devices under different operating conditions.

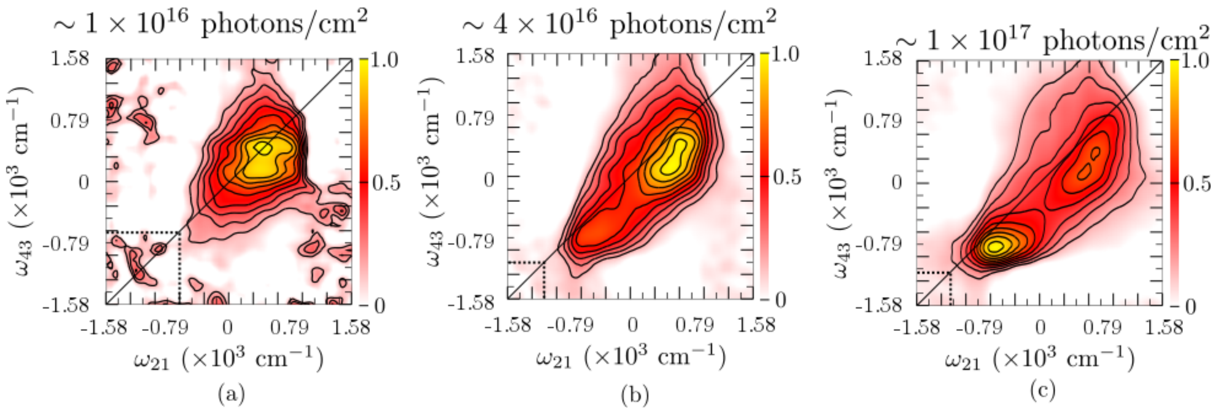

Fig.1 Photocurrent detected two-dimensional spectra at zero population time of InP nanowire array solar cell at different excitation densities (a, b and c). The frequency axes are labeled relative to the reference frequency at 12675 cm^{-1} (788 nm). The band gap at low excitation density as estimated from (a) is at 12042 cm^{-1} (830 nm). At high excitation densities (b and c), the band gap decreases to 11561 cm^{-1} (865 nm). We also observe strong modulation of the band structure in (b) and (c) owing to dynamic Franz-Keldysh effect.

[1] J. Noffsinger *et al*., Phys. Rev. Lett. **108,** 167402 (2012).
[2] M. Schultze *et al*., Science **346,** 1348 (2014).
[3] K. J. Karki *et al.*, Nat. Commun. **5**, 5869 (2014)