INFLUENCE OF THERMOELECTRICITY ON CONVERSION EFFICIENCY OF SOLAR CELLS

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Efficiency of a single-junction solar cell is limited by the Shockley-Queisser theory which assumes that only photons having energy close to a semiconductor forbidden energy gap are used effectively. Photons of higher energy create electron and hole pairs, and the excess energy turns the photogenerated carriers into the hot carriers, with a nonequilibrium distribution temperature higher than the lattice. A solar cell loses about 30% of incident solar energy when the hot carriers thermalize, i.e., dissipate the excess energy to the lattice. Ross and Nozik proposed the idea of a hot carrier solar energy convertor in which the photogenerated hot carriers are extracted over a narrow range of energies at a rate faster than they dissipate energy to the lattice. Theoretically, the conversion efficiency of such a device can reach 66%. A large number of theoretical and experimental works devoted to the development of hot carrier solar cells werecarried out. However, no hot carrier solar cell valuable for practical applications is built yet. The hot carriers stipulate thermoelectromotive force formation across p-n junction. The polarity of thermoelectromotive force of hot carriers is opposite to that of classical photovoltage. Furthermore, thermalization of hot carriers leads to heating of the crystal lattice. The thermoelectromotive force caused by lattice heating also has polarity opposite to the classical′ one. Thus, carriers and lattice heating reduces the efficiency of a solar cell. In the presentation we demonstrate that photovoltage induced by a 1.06 micron laser pulse across GaAs p-n junction is composed of three components resulting from hot carrier and lattice heating, and electron-hole pair generation phenomena. The first one is very fast and shows polarity of thermoelectromotive force of hot carriers. The second one, resulting from thermalisation loss of hot carriers, has the same polarity and is slower. The third one, respectively, is the classical photovoltage arising due to two photon absorption with polarity opposite to that of the first two. Lattice heating and hot carriers thermoelectromotive force may be the reason of experimentally unattainable Shockley-Queisser limit