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The Greenhouse Photonic Management Improves Solar Energy Conversion

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ABSTRACT

Bio-inspired greenhouse photonic management of a solar cell made of materials with high quantum efficiencies strongly reduces the radioactive emission from the cell shifts the absorption emission detailed balance in favor of absorption, and enhances the conversion efficiency beyond the detailed balance limit. In a Perovskites solar cell, the greenhouse filter establishes a sharp absorption edge and reduces conversion losses related to wide distribution of photovoltaic band gaps in a perovskite material. For power beaming applications, such as charging of unmanned aircrafts by laser beam, the greenhouse filter is the tool of choice to prevent emission inthe rangebetween the semiconductor bandgap andthe energy of laser quanta.

Keywords: Photovoltaicsolar energyconversion, Greenhouse effect, Perovskites, Earth's surface

DESCRIPTION

The Sun provides Earth with a huge amount of energy, which heats Earth's surface, warms the atmosphere, and supports plant growth. In 1827 Joseph Fourier applied his analytical theory of heat transfer to investigations of the balance between the incoming solar energy and the outgoing energy of emitted radiation [1,2]. He calculated Earth's average temperature, which turns out to be near 0°F. To get the real average temperature of approximately 60°F, Fourier proposed the atmospheric process similar to the way a greenhouse traps the heat. A greenhouse's glass or plastic film transmits visible light, which is absorbed by plants and soil. The absorbed solar energy is naturally converted into two forms of energy heat and biochemical energy. Then, plants and soil emit the heat energy as infrared (IR) radiation. The greenhouse glass/plastics reflect significant part of IR radiation back into the greenhouse. Both atmospheric greenhouse effect and actual greenhouse trap IR radiation and shift the absorption emission energy balance in the favor of absorption. The trapped IR radiation stimulates photosynthesis which leads to the growthand bloom and, at the same time, increases the Earth temperature which results in dangerous changes of climate.

The photovoltaic (PV) conversion is another way of solar energy transformation, which allows us to convert sunlight directly intoelectricity via generation of electrons and holes separated by the photovoltaic band gap. The photo carriers transfer a part of theirenergy to crystalline lattice and relax to the states near band edges. Electrons and holes accumulated near the band edges can recombine with emission of the band gap IR photons (radioactive recombination) or without emission (non-radioactive recombination). The nonradioactive processes convert the energy of photo carrier into the heat and should be suppressed. As i t was proposed by Shockley and Queisser in 1960, a fundamental limit of the photovoltaic conversion efficiency is determined by the detailed balance between the absorbed solar flux and emitted flux of IR photons [3]. Initially, the paper was rejected as unrelated to real semiconductors, which had significant nonradioactive losses [4]. Today, a number of traditional and emerging PV materials demonstrate negligible nonradioactive recombination (high intrinsic quantum efficiency) and the Shockley-Queisser limiting efficiencies are considered as the most fundamental benchmarks in solar light conversion [5,6]. Recently, researchers from the Army Research Laboratory wondered, if the greenhouse filter added to the traditional solar cell can shift the detailed balance between absorption and emission in favor of absorption [1]. In traditional cell design, the absorption emission balance is controlled by the Kirchhoff's law, according to which the emitted radiation is exactly given by the absorbed ration reversed in time. However, the Kirchhoff's law is not a thermodynamic law. According to fundamental Onsager-Casimir reciprocity relations, the time-reversal asymmetry in absorption emission processes may be generated by magnetic field, intrinsic magnetization, time-modulation of optical properties, and by various non-equilibrium conditions [7]. The innovative design of PV cell mimics the greenhouse effect and corresponding no equilibrium greenhouse processes, such as trapping of IR radiation and its re-use by plants [1]. The greenhouse filter placed at the front surface of a cell establishes photonic photovoltaic band gap above the semiconductor band gap and traps the photons with energies below the photonic band gap. The greenhouse filter strongly enhances PV conversion in materials with fast cooling of photo carriers, such as A3B5 semiconductors, doped grapheme, and many others. In particular, in A3B5 semiconductors hot electrons cool very fast due to the interaction with heavy holes [8]. Fast cooling of photoelectrons significantly reduces the population of photo carriers above the photonic photovoltaic band gap. Reduced population of hot photoelectrons directly decreases generation of photons with energy above the photonic band gap. The emission from the converter is strongly suppressed, because only such photons can leave the cell with the greenhouse filter. In the same way the greenhouse design can also enhance thermo photovoltaic conversion [1,9]. For power beaming applications, such as charging of unmanned aircraft systems, the greenhouse filter is the tool of choice to prevent emission in the range between the semiconductor band gap and the energy of laser quanta and, in this way, it strongly increas es the conversion efficiency of laser radiation [10].To avoid solar cell heating, the greenhouse design requires photovoltaic materialswith low nonradioactive losses, i.e. high quantum efficiencies. GaAs demonstrates internal quantum efficiency of 99. 7% which allows the greenhouse cell to overcome the Shockley and Queisser limit [1,11]. Perovskites are very promising low-cost photovoltaic materials, which also demonstrate quantum efficiencies close to 100% in very wide spectral ranges [12]. At the same time, perovskite solar cells suffer with very smooth absorption edge, which significantly reduces the conversion efficiency [12]. The greenhouse filter solves this problem by establishing the photovoltaic band gap above the spectral range with low absorption. Thus, the greenhouse photonic management of photovoltaic conversion has a strong potential to enhance conversion efficiencyof PV cells made of traditional and emerging materials.

REFERENCES

1. Sablon,K., et al. US Patent. **2021**;152(11):888
2. Baron Fourier, JB. Théorie analytique de la chaleur. Chez Firmin Didot, père et fils. **1822**.
3. Shockley,W., et al. *J Appl Phys.* **1961**;32(3):510-519.
4. Marx,W. AnnPhys. **2014**; 526(5):A41-5**.**
5. Green,MA.,et al.*Nature Material.* **2017**;16(1):23-34.
6. Sergeev, A., et al. Phys Rev Appl. **2018;**10(6):064001.
7. Caloz,Ch., et al. *Phys Rev Appl.* **2018**;10(4):047001**.**
8. Hohenester,U., et al. *Phys Rev B.* **1993**;47(20):13233.
9. A. Sergeev et al. J. Photonics for Energy. **2020**;10(3):0355010.
10. Sergeev,A., et al. *MRS Advances*. **2019**;4(16):897-903.
11. Schnitzer,I., et al. *Appl. Phys. Lett.* **1993**;62(2):131-133.
12. Green,MA.,and Ho-Baillie,AW. *Energy Lett*. **2019**;4(7):1639-1644.