Optimization of the Efficiency of Photovoltaic Cells for Laser Light: An Application to Laser Power Beaming

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In a vastly increasing energy dependent society, there is need for the transportation of energy quickly and efficiently. Laser power beaming and transferring energy with fiber optic cables are two methods that accomplish this. The low efficiency of converting laser light energy to electrical energy via photovoltaic cells is a problem. This project aims to optimize the efficiency of a PV cell for laser light using a theoretical approach. Shockley's and Queisser's methods of a optimizing a photovoltaic cell for sunlight were used, and the blackbody spectrum of the sun was replaced with a laser spectrum. The mathematical calculations were done for this laser-PV cell system given the condition that a photon with an energy above the band gap of the PV cell may create an exciton with energy equivalent to the band gap. The "ultimate efficiency" equation was found as a function of the laser frequency, the laser linewidth, and the band gap frequency. It was used to calculate the efficiencies of over 600 laser-PV cell combinations and to create a color map representing the three dimensional ultimate efficiency function. Most efficiencies were low. However, when the laser frequency was only slightly over the band gap frequency, efficiencies of over 98% were reached. Although there are limiting factors preventing efficiencies this high in real life, high efficiencies can still be achieved. These findings can be the start of experimentation using laser-cell combinations highlighted in the paper and can result in a new era of energy transfer.

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