"Virtually Perfect" Photovoltaic Cells: A Novel and Adaptive Approach to Modeling Quantum Dot Templates Optimized for Varied Light Conditions

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The purpose of this experiment was to determine if a modeled, quantum dot photovoltaic cell (QDPC) designed to be optimized for varied light conditions was significantly more efficient (Watt-sec/m2) than Silicon-based (SiO_2) or Gallium-based (GaAs) triple-junction solar cells. The QDPC was designed by utilizing 7 optimizations that collectively yielded the highest efficiency (design patent pending). A novel model was then created to calculate the ideal QDPC design and corresponding power conversion efficiencies, current(mA), and voltage(V) output of the QDPC under any input light condition. The model was constructed by using the Brus Equation, Quantum Yield/Efficiency calculations, and experimental data from professional research articles. It is extensible to newer QD materials, designs, and corresponding efficiency/loss parameters, allowing other scientists in quantum photonics research to use it to predict outputs. The QDPC was modeled under exterior sunlight from 6:00AM to 6:00PM, warm and cool LEDs, F7 and F11 fluorescent spectral irradiance. Results showed that the QDPC had an efficiency of 79.82% and was, on average, 5.98 and 5.16 times more efficient than Si-based cells & Ga-based cells. The significant difference in efficiencies and light conditions was supported by p-values yielded by 2 ANOVA tests and 6 independent 1-tailed t-tests, among other rigorous statistical analysis. Having endless applications, high efficiency QDPC's can ameliorate the energy crisis in developing countries where energy generation and power lines are scarce, circumvent the vulnerability of transporting fuel for military across large distances, and convert many indoor gadgets to charge using only light, all the while accelerating the shift from fossil fuels to green sustainable energy.

Awards Won:

Arizona State University: Arizona State University Intel ISEF Scholarship