Siemens Competition
Math : Science : Technology
Regional Finalist

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High School: Catlin Gabel School
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Project Title: *Novel Automated Designs and Rapid Multivariate Optimization of Next-Generation Multijunction Quantum Dot Solar Cells Using Monte Carlo Modeling* (Computer Science; Electrical Engineering; Materials Science/Nanoscience)

More than 50% of efficiency lost in conventional solar panels comes from intrinsic spectral loss, as maximizing absorbed photon quantity often conflicts with maximizing energy obtained from each photon. Multijunction quantum dot solar cells offer a potential high-efficiency and low-cost solution. Yet, despite clear leading status in quantum dot solar cells (QDSCs), lead sulfide (PbS) quantum dots are rarely studied in multijunction solar cells. This work characterized quantum dot/photon interactions and limiters of efficiency, optimizing multijunction QDSC designs for highest efficiency. Quantum mechanically cloud-computed absorption spectra for PbS quantum dots of 1-5 nm diameter were incorporated into JAVA-programmed stochastic Monte Carlo simulations implementing novel algorithms. Algorithms were developed and executed to maximize photon absorption-electricity conversion synergy. 6,132 simulations spanning design permutations for 1- to 9-junction QDSCs, each assuming 10 million incoming photons, were conducted with QD bandgap standard deviations ranging from 0.01-0.11 eV. Absorptive spectral changes and maximum energy conversion were tracked as photons progressed through junctions. Aggregate results indicated optimized efficiencies of 39.2%, 51.5%, 57.7%, 62.8%, 64.5%, 66.7%, 68.1%, 68.4%, and 68.7% for 1- to 9-junction QDSCs under concentrated sunlight, as compared to the 33.7% Shockley-Queisser limit of conventional solar cells.