A Hybrid Hydrogel-Heat Sink for Enhancing GPU Performance, Solar Panel Efficiency, and Electric Vehicle Range

Wang, Oliver (School: Thomas Jefferson High School for Science and Technology)

Photovoltaic (PV) solar energy is the fastest-growing energy source as its scalability and versatility are unmatched. However, PV panels exhibit low efficiency, which limits their capacity for large-scale energy generation. As artificial intelligence and high-performance computing demands increase, so does the demand for sustainable energy solutions. Currently, the energy grid cannot keep up with the growth of computing power. Hygroscopic hydrogel cooling is a promising solution to increase the efficiency of PV cells by leveraging water's high latent heat of vaporization to dissipate heat while simultaneously harvesting atmospheric water. This study introduces an open-source, experimentally validated model that simulates the cooling effects of hygroscopic hydrogels on PV cells and computational processors. Using the fourth-order Runge-Kutta (RK4) method to solve differential equations, the model enables researchers to evaluate the cooling potential of any hydrogel on any PV or processor. Through model-driven optimization, a hybrid hydrogel-heat sink system was then developed. A metal heat sink, engineered with a Schwarz-D triply periodic minimal surface, maximizes thermal conductivity and surface area for optimal heat dissipation. Experimental testing with Maxeon's industry-leading solar panels, the most efficient commercial cells available, pushed them beyond their limits, achieving a previously unattainable increase in peak performance. This study introduces a novel type of hybrid hydrogel-heat sink system that increases solar panel efficiency while reducing costs. In addition, this research directly allows increased electric vehicle range and improves high-performance computing, allowing CPUs and GPUs to operate at higher power levels.

Awards Won: