Novel Fabrication and Implementation of Copper and Silver Plasmonic Nanostructure-Coated Foil as a Spectrally Selective Absorber in Highly Efficient Solar Steam Generation Under One Sun Illumination

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Solar thermal energy is an extremely viable solution to solve the global issue of clean water and fossil fuel depletion. However, current methods of solar thermal power generation are expensive and burdensome due to limitations of optical concentration. In this investigation, a novel fabrication method of copper- and silver- nanoparticle-coated foils as a promising spectrally selective absorber (SSA) was investigated. In a galvanic displacement reaction involving the immersion of zinc foil into a copper(II) sulfate or silver nitrate solution, copper and silver nanoparticles were deposited onto zinc foil to create a plasmonic nanostructure-coated foil (PNF). SEM and XRD analyses were conducted on the synthesized PNF's to confirm the existence of nanoparticles. Moreover, extensive optical and thermal analyses show significant surface plasmon resonance and demonstrate a high solar absorption and low thermal emittance. Finally, this scientist programmed and conducted photonic simulations utilizing the finite-difference time-domain method to quantify prototypes and test for alternative configurations, such as iron and nickel nanoparticles. The nanoparticle-coated zinc substrates were then implemented in a novel design for a portable yet highly efficient and cost-effective solar steam generator. From materials such as bubble wrap, extruded polystyrene foam, and cotton twine, an inexpensive and floatable solar steam generator was constructed. The generator consistently reached 100 degrees Celsius under one sun illumination, without the need for cumbersome lenses for optical concentration. For a mere few dollars per square meter, record steam production efficiencies three times that of conventional models were easily attained, with substantial potential for scalability.

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