Solar-thermal Energy Conversion Using Nanomaterials

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Presenter's Biography

Dr. Ming-Tsang Lee received his Ph.D. degree from the Department of Mechanical Engineering at University of California, Berkeley, in 2008. After graduated, he had been a Postdoctoral Researcher in the University of California at Berkeley and as a Visiting Scientist in Lawrence Berkeley National Lab. He specialized in energy and mass transport phenomena in micro- and nanoscales, solarthermal-hydrogen productions, and laser assisted micro- and nanoscale fabrications. Dr. Lee has served as a faculty in the Department of Mechanical Engineering at National Chung Hsing University, Taiwan, since 2011. His current research interests include: Heat and mass transport phenomena in small-scale thermalfluidic systems, Laser assisted micro/nanoscale additive manufacturing and material processing, and Multiphysics analysis (thermal-fluid-solid mechanics) for advanced energy device and machinery systems.

ABSTRACT

This presentation composes two studies on the photo-thermal energy conversion enhancement and effective utilization with applying nanomaterials. The first section is emphasized on the development of a microscale solar-thermal reformer for hydrogen production with nanocatalyst. Water is a significant source of the hydrogen gas that produced from steam-reformers. The solar thermal steam-methanol reformer is thus an effective way of producing energy from renewable resources. In the reformer section an essential consideration is the surface between the catalyst and the reactants and it is noted that a desirable morphology and structure is compatible with a heterogeneous nanoporous catalyst. The fabrication and investigation of heterogeneous nanoporous catalysts for solar-thermal reformer is then reported. Preliminary experiments were conducted to investigate the performance of the nanocatalytics matrix integrated in a solar thermal reformer. Specifically, CuO/ZnO nanowire catalyst for hydrogen production by solar thermal steam-methanol reforming was fabricated. Such nanowire catalyst is more durable than the conventional nanoparticle catalysts by avoiding agglomeration, and it exhibits ideal optical properties. A solar simulator was used as a heat source for the demonstration of the steam methanol reformer. Gas chromatograph measurements confirmed significant production of hydrogen with irradiated solar energy. The nanocatalytic matrix was then fabricated and tested on a large area glass plate substrate demonstrate scaling-up. [1, 2]

The second example is a study on solar-drying of porous thin plates with the assistance of nanowire matrix in an attempt on enhancing the solar energy harvesting and utilization. Experiments and analysis were conducted to understand the transport phenomena of the micro-porous thin plate drying processes. It was noted that a significant amount of the energy provided to the drying system was lost and not utilized for drying. Therefore, to utilize the solar energy on drying the porous thin plate more effectively, the usage of a nanomaterial-based solar absorber, silicon nanowires, was investigated. The significantly reduced spectral reflectivity of silicon nanowire to visible light makes it attractive in solar energy applications. The benefit of its use for solar thermal energy harvesting was investigated. Spectral hemispherical reflectivity and transmissivity of the black silicon nanowire array on silicon wafer substrate were measured. It was observed that the reflectivity is lower in the visible range but higher in the infrared range comparing to the plain silicon wafer. A drying experiment and a theoretical calculation were carried out to evaluate the effects of the trade-off between scattering properties at different wavelengths. It is shown that silicon nanowires can significantly improve the solar thermal energy harnessing. [3, 4]

References

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