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Using inverse analysis to optimize nanoscale radiative surface patterns and enhance solar cell performanceÂ

Abstract: Surface patterning at the nanoscale has been shown to enhance coherent radiative emission and absorption by inducing localized plasmon polariton generation on the surface. For example, previous work has demonstrated that applying closely spaced metal (silver or gold) nanowires across the upper surface of a solar panel composed of thin film amorphous silicon (a-Si) can increase total normal photon absorption by more than 50%. The work presented here uses a comprehensive optimization approach for designing nanoscale surface geometries to meet desired spectral-directional absorption properties. Near field radiation and surface interactions are solved using the Finite Difference Time Domain (FDTD) method to obtain spectral and directional radiative properties. Global and local optimization methods (simulated annealing, tabu search, and quasi-Newton optimization) are then employed and compared for solving the inverse near field radiation problem. The method is applied to solar panel optimization, and up to four geometric parameters are considered for optimizing performance of a thin film a-Si solar panel over daily and seasonal variations of direct solar radiation. Typical performance enhancements in comparison with non-patterned cells are shown.

Biography: Professor Jack Howell pioneered the use of the Monte Carlo method for analysis of radiative heat transfer in complex systems that contain absorbing, emitting and scattering media. His textbook Thermal Radiation Heat Transfer (coauthored with Robert Siegel and Pinar Menguc), has been translated into German and Russian. Its fifth US edition appeared 2010. He has concentrated his research on computational techniques for radiative transfer and combined-mode problems for over 45 years. Recently he has adapted inverse solution techniques to combined-mode problems and radiation at the nanoscale.Â Along with many awards in heat transfer, he was elected a member of the National Academy of Engineering and a foreign member of the Russian Academy of Sciences.