Machine learning Assisted Selective Emitter design for Solar Thermophotovoltaic System

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Abstract : Solar thermophotovoltaic systems (STPV) have emerged as a promising solution to overcome the Shockley-Queisser limit, a significant impediment in the direct conversion of solar radiation into electricity using conventional solar cells. The STPV system comprises essential components such as an optical concentrator, selective emitter, and a thermophotovoltaic (TPV) cell. The pivotal element in achieving high efficiency in an STPV system lies in the design of a spectrally selective emitter or absorber. Traditional methods for designing and optimizing selective emitters are often time-consuming and may not yield highly selective emitters, posing a challenge to the overall system performance. In recent years, the application of machine learning techniques in various scientific disciplines has demonstrated significant advantages. This paper proposes a novel nanostructure composed of four-layered materials (SiC/W/SiO2/W) to function as a selective emitter in the energy conversion process of an STPV system. Unlike conventional approaches widely adopted by researchers, this study employs a machine learning-based approach for the design and optimization of the selective emitter. Specifically, a random forest algorithm (RFA) is employed for the design of the selective emitter, while the optimization process is executed using genetic algorithms. This innovative methodology holds promise in addressing the challenges posed by traditional methods, offering a more efficient and streamlined approach to selective emitter design. The utilization of a machine learning approach brings several advantages to the design and optimization of a selective emitter within the STPV system. Machine learning algorithms, such as the random forest algorithm, have the capability to analyze complex datasets and identify intricate patterns that may not be apparent through traditional methods. This allows for a more comprehensive exploration of the design space, potentially leading to highly efficient emitter configurations. Moreover, the application of genetic algorithms in the optimization process enhances the adaptability and efficiency of the overall system. Genetic algorithms mimic the principles of natural selection, enabling the exploration of a diverse range of emitter configurations and facilitating the identification of optimal solutions. This not only accelerates the design and optimization process but also increases the likelihood of discovering configurations that exhibit superior performance compared to traditional methods. In conclusion, the integration of machine learning techniques in the design and optimization of a selective emitter for solar thermophotovoltaic systems represents a groundbreaking approach. This innovative methodology not only addresses the limitations of traditional methods but also holds the potential to significantly improve the overall performance of STPV systems, paving the way for enhanced solar energy conversion efficiency.

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