

博士論文（要約）

Optimal design of spectrally selective photonic structures for thermal radiation applications

（熱輻射応用のための波長選択的フォトニック構造の最適デザイン）

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Summary

Thermal radiation is a fundamental phenomenon which is associated with nearly all the heat transfer process. ‘Graybody’ like thermal radiation by natural exist materials leads to low energy utilization efficiency, such as solar thermal, solar photovoltaics, radiative cooling and so on. Thermal photonic structure can tailor radiative property in demand, but currently inverse design of thermal photonics is still highly relying on human’s experiences and often by trial and error which is low efficiency. Materials informatics which combines the materials design and machine learning informatics algorithm are proposed to efficiently design thermal photonics with tailored radiative property for various thermal radiation-based applications in this thesis.

Chapter 2 introduce the numerical simulation method for optical simulation and the machine learning method for optimization. Chapter 3 presents the thermal photonics design for radiative cooling application including the highly wavelength selective thermal radiator is designed by hybrid grating and multilayer structure via Bayesian optimization, metamaterial composite discovered accelerated by quantum annealing combined with factorization machine, color compatible radiative cooler for both transmissive and reflective color designed by Bayesian optimization. Chapter 4 explores using Bayesian optimization for the highly selective solar absorber and emitter molybdenum nanophotonic design with hafnium dioxide coatings for high temperature

solar thermophotovoltaics application. Chapter 5 presents the rapid design strategy of tunable ultra-narrowband thermal emitter by Monte Carlo tree search.

The current exploration work of materials informatics implantation in thermal radiation applications may accelerate the inverse design of thermal emitter with high energy conversion efficiency. The physical mechanism founded by the abnormal optimized photonic structures can further deepen people's understanding about light and matter interaction. Current photonic design is still only assisted by machine learning algorithm, the fully automatic design strategy should be studied in the future.