Experimental Demonstration of Tunable Near-field Radiative Heat Transfer Exceeding Blackbody Limit with VO₂ Thin Film

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Abstract
The objective of this research is to experimentally show tunable near-field radiative heat flux that exceeds the blackbody limit by a near-field radiative thermal metrology. The material used will be vanadium dioxide (VO₂), which is a phase-change material between metallic and insulating phases around temperature of 68°C.

Methods
The theoretical modeling of forward-biased and reverse-biased heat flux was conducted for a variety of vacuum gaps between SiO₂ and VO₂. The goal of this modeling was to replicate the results from a recent study measuring the rectification factor between phase-change materials [2]. The experimental setup can be seen in Figure 2 along with modeled results in Figure 3.

Background
The focus of this experiment is dealing with the phenomenon of near-field radiation as the primary source of heat transfer. The primary theory being investigated in this experiment is that near-field radiation generates greater heat flux than conventional radiation governed by Planck’s law with maximum for blackbodies.

Heat flux due to near-field radiation has been shown by other researchers to be 11 times as high as the blackbody limit when two parallel plates are separated by 200 nm vacuum gap [1]. More simply, this means that near-field radiation can absorb much more light than traditional methods of radiation which has a wide variety of implications for enhancing energy conversion and thermal management.

Discussion & Results
Initial testing and validation experiments were performed on doped silicon samples. The results can be seen below in Figure 4. Future work will use the existing experimental set-up to test VO₂ samples to create a tunable near-field radiative heat transfer device.

References

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