

Radiative Thermal Rectifier Using a Phase-Change Material

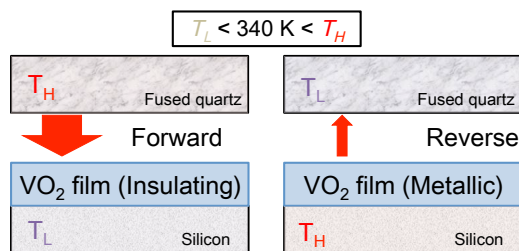
Kota Ito (PhD student from Toyota CRDL)

A radiative thermal rectifier (diode) with a phase-change material (VO_2) is demonstrated for the first time to achieve a rectification contrast ratio of as large as 3:1.

Introduction

Thermal rectifier is a device analogous to an electrical diode with thermal conductance that depends on the direction of heat flow. It is a vital element for intelligent thermal management for a case where temperature gradient changes periodically.

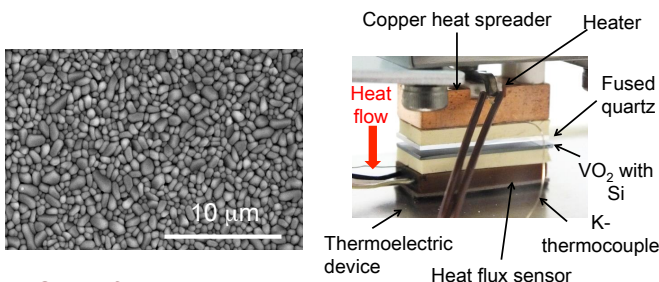
The rectification is realized by the phase-change of vanadium dioxide (VO_2), which behaves as metal at high temperature (> 340 K) and insulator at low temperature (< 340 K).



Experimental setup

The sputtered vanadium film on a silicon substrate is annealed in an oxygen flow at 600°C to achieve the thin film of VO_2 .

A steady-state measurement system in vacuum is developed for the characterization of the rectifier. The temperature of the two substrates are regulated by the heater and the thermoelectric device.

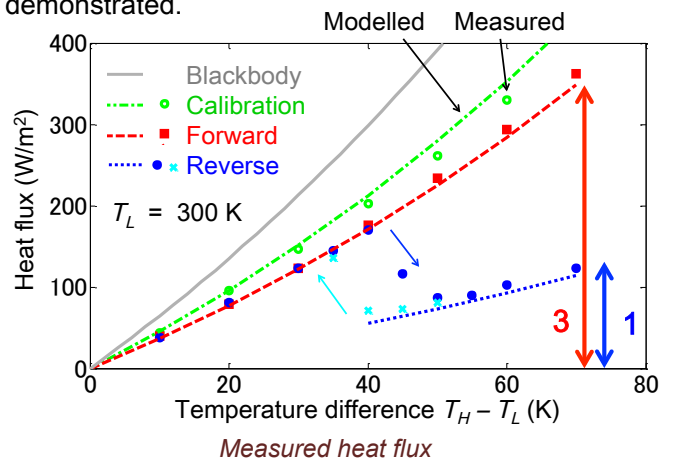


SEM of the deposited thin film VO_2

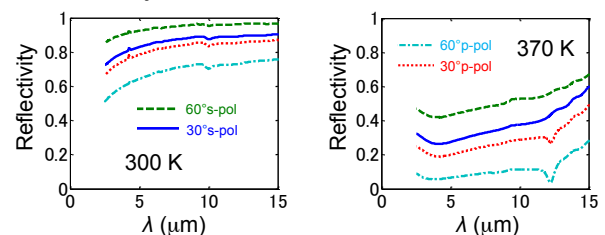
Measurement system

Results

The heat flow through the rectifier is characterized in the forward or reverse scenario. A high heat flux contrast (3:1) is successfully demonstrated.



The experimental results are well explained by an analytic model based on fluctuational electrodynamics, with the optical permittivities of VO_2 determined by FTIR.



Measured FTIR spectra

Conclusion

K. Ito et. al, APL 2014

A radiative thermal rectifier with a high heat flux contrast (3:1) is demonstrated thanks to the phase-change of VO_2 . The rectifier would be applied to various thermal management situations.

Contact: kotaito0@iis.u-tokyo.ac.jp