Near-Field Radiative Heat Transfer Between a Sphere and a Flat Surface in the Sub-200 nm Regime and Prospects for Energy Harvesting

Mathieu Thomas[1]
Carlos Acosta[1], Pierre-Olivier Chapuis[1]
[1]Univ Lyon, CNRS, INSA-Lyon, Université Claude Bernard Lyon 1, CETHIL UMR5008, F-69621, Villeurbanne, France
Mathieu.thomas@insa-lyon.fr

When the distance between objects decreases below the characteristic wavelength of thermal radiation (few micrometres in the 300-1000 K range), the radiative heat exchanged between these objects is increased beyond the blackbody limit imposed by Planck's law in far field. This increase of thermal radiation, which takes place in the near field and is due to the additional contribution of evanescent waves, can reach several orders of magnitude. This phenomenon can be of interest for thermal-energy harvesting. For instance, thermophotovoltaics (TPV) can take advantage of this enhancement of the radiative heat flux in order to increase the electrical output power density when the emitter is brought closer to the cell [1].
As the radiative flux between objects depends dramatically on distance, it is critical to determine it with extreme precision. We report on our recent efforts to evaluate the stability of our experiment. It involves a heated micrometric sphere as the emitter, which is glued on a Scanning Thermal Microscopy probe cantilever. The emitter is moved towards the cold sample or a pn junction (TPV cell or Light Emitting Diode, LED) using a piezoelectric actuator while the radiative transfer is measured throughout the approach. We analyze the vibrations of our cantilever-based system during the approach with combined means of interferometry, optical deflection and resistive thermometry in order to provide accurate data in the sub-200 nm distance regime. We discuss the prospects for energy harvesting by means of TPV or thermophotonics, a technology close to TPV where the emitter is a hot LED.

References

[1] Near-field thermophotovoltaic conversion with high electrical power density and efficiency above 14%, C. Lucchesi, D. Cakiroglu, J.-P. Perez, T. Taliercio, E. Tournié, P.-O. Chapuis and R. Vaillon, Nano Letters 21, 4524 (2021)

Figures

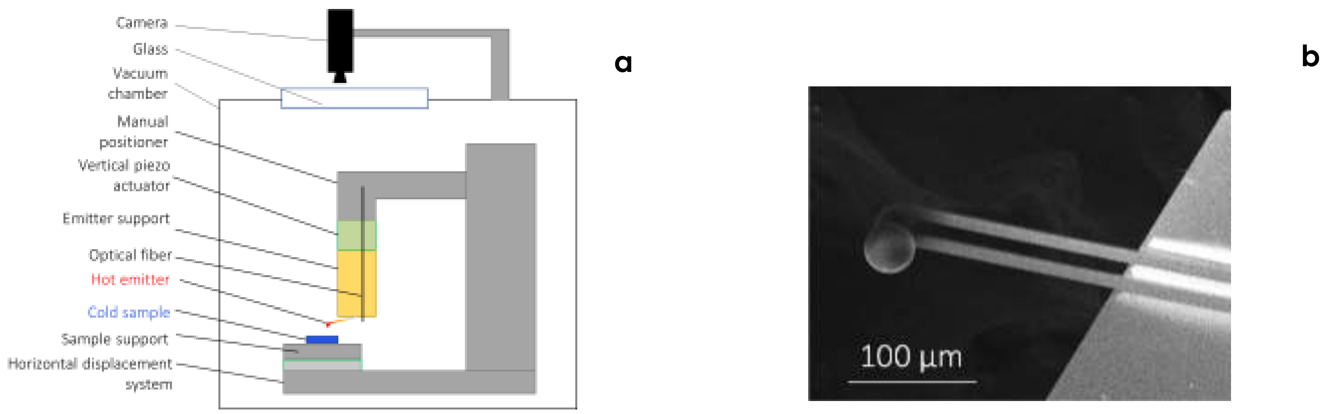

Figure 1: (a) Schematic of the near-field radiative experiment and (b) SEM image of the spherical heated emitter