Kolloquium Energie- und Halbleiterforschung

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Dienstag, 08.05.2018, 16.15 Uhr in W0 0-001

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EHF- EPKoS

The effect of the apparent barrier height on the heat transfer in the near-field scanning thermal microscope

Radiative heat transfer can largely exceed the black body limit at sub-micrometer distances as evanescent modes start to contribute at gap sizes smaller then the dominating thermal wavelength. One instrument to experimentally access this near-field heat transfer is the near-field scanning thermal microscope (NSThM), a modified scanning tunneling microscope (STM) which utilizes a self-built tip as a thermocouple and can therefore measure heat fluxes at distances in the range from 0.2 nm to several tens of nanometers[1].
Our previous works on the NSThM have found a heat transfer between a gold sample and a gold coated tip which is three orders of magnitude larger then theoretical predictions by the conventional theory of fluctuational electrodynamics[2]. Other authors using a similar setup suggest in a recent publication that this large deviation can be attributed to surface contamination effects and propose the apparent barrier height as a signature of cleanliness[3].
To examine the claimed reduction of thermal conductivity with an increased apparent barrier height, gap size dependencies of both the heat flux and the tunneling current in the NSThM are measured simultaneously. The tunneling currents exponential decay allows for accessing the apparent barrier height and correlating it with an increase of the heat flux. The distinct correlation described in ref. [3] is not reproduced in our setup. Additionally, other indicators of the sample's cleanliness, such as the STM imaging quality, are considered and the NSThM setup is changed from cooling the sample to heating it, which not only changes the sign of the temperature difference and, therefore, the direction of the heat flux but also would be expected to reduce surface contamination effects on the sample.

[1] Wischnath, Uli F., et al.: *The near-field scanning thermal microscope.* Review of scientific instruments 79.7 (2008): 073708.
[2] Kloppstech, Konstantin, et al.: *Giant heat transfer in the crossover regime between conduction and radiation.* Nature communications 8 (2017).
[3] Cui, Longji, et al.: *Study of radiative heat transfer in Ångström-and nanometre-sized gaps.* Nature communications 8 (2017).