Controlled heat flux measurement across a closing nanoscale gap and its comparison to theory

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Abstract

We present here a controlled measurement of heat flux across a closing gap that is initially less than 10 nm wide between two solid surfaces at different temperatures. The measured heat transfer is compared with our published theoretical analyses of this phenomenon that show thermal radiation dominates the heat transfer for gaps wider than about 1-2 nm, but phonon conduction dominates between 1-2 nm and contact. The experiments employ a thermal actuator (TA) mounted on a rocking base block for coarse positioning that supplies Joule heating to an embedded element to cause thermal expansion of a localized region for less than 10 nm spacing control, together with an embedded near-surface resistive thermal sensor (TS) to measure its temperature change due to the heat flux across the gap. The measured results are in general agreement with the theoretical predictions, and they also agree with common sense expectations. This paper not only shows nanoscale heat transfer measurement across a closing gap, it also lends additional strong support to the validity of the referenced theoretical developments.