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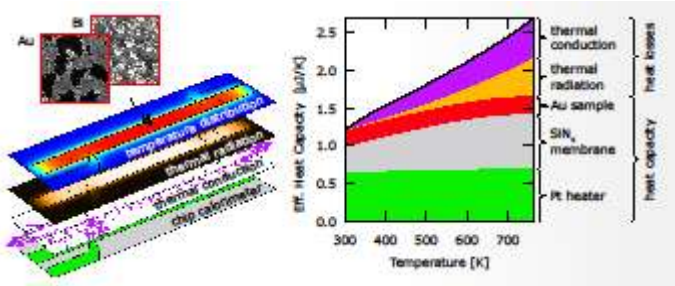
Quantifying DC Differential Scanning Nanocalorimetry for Determining Heat Capacities

Emanuel Franke[1], David A. LaVan[2], Cynthia A. Volkert[1]

[1]*Institute of Materials Physics, Georg-August-University Göttingen, 37077 Göttingen, Germany*

[2]*Material Measurement Laboratory, National Institute of Standards and Technology, Gaithersburg, Maryland, USA 20899*

Graphical abstract



Highlights

- Nanocalorimetry of specimens with different emissivities and thermal conductivities.
- Comparison of measured heat capacity with detailed finite element analysis.
- Quantification of the heat loss mechanisms during nanocalorimetry.
- Strong impact of size effects on thermal radiation.

We investigate the accuracy of a MEMS-based nanocalorimeter for determining specific heat in the temperature range from 300 K to 800 K. By comparing DC differential scanning measurements of materials of known specific heat capacities with detailed finite element studies, the dominant sources for heat losses and inaccuracies have been identified. The main source of error comes from radiative losses at elevated temperatures, but even near room temperature thermal gradients and thermal conductivity in the specimen lead to moderate discrepancies. Furthermore, studies on de-wetted Au films and Bi particles show that specimen emissivities differ strongly from literature values, presumably due to effects associated with the specimen dimensions being smaller than the thermal wavelength. By including the emissivity as a fitting parameter in the simulations, specimen heat capacities can be obtained to an accuracy of better than 7 % over the entire temperature range.

Keywords: nanocalorimeter; calorimetry; thermal analysis; chip calorimetry; specific heat capacity; emissivity

1. Introduction