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Nanoscale scanning thermal imaging using novel diamond scanning probes

R. Tanos[1], F. Favaro de Oliveira[2], G. Seniutinas[2], M. Munsch[2], P. Maletinsky[2], M. Rollo[1], A. Finco[1], V. Jacques[1], and I. Robert-Philip[1]

1 Laboratoire Charles Coulomb, Université de Montpellier and CNRS, Place Eugène Bataillon, 34095 Montpellier, France
2 Qnami AG, Hofackerstrasse 40B, CH-4132 Muttenz, Switzerland

The ability to measure temperature with nanoscale spatial resolution has become key in a broad range of fields like materials science, electronics, chemistry, and life sciences. Several techniques have been used including scanning thermal microscopy (SThM), thermo-reflectance and Raman spectroscopy. However, none of these techniques can simultaneously provide sensitive, and quantitative thermal imaging with a sub-micron spatial resolution under ambient conditions.

In recent years, nanoscale thermometry based on Nitrogen-Vacancy (NV) electronic spins in nanodiamonds has emerged to be a valid alternative to overcome the challenges encountered by other techniques ([1], [2]). Despite such progress, nano-diamonds are typically spread randomly over a sample of interest, which forbids the deterministic acquisition of spatial information during thermometry measurements.

In this talk, we present an extensive, numerical analysis that clearly identifies the limitations in the use of bulk diamonds in nano-thermometry measurements suggesting that engineered heterostructures must be designed to truly achieve non-invasive spatially resolved nano-thermometry. As a solution, present first results related to a novel approach in the fabrication of diamond-based scanning probes containing NV centers that are optimized for nano-thermometry imaging experiments. These devices offer a unique combination of tip robustness, high sensitivity, quantitative sensing, and nanometer resolution to scanning thermometry. Our approach will enable measurements of hot spots that could not be performed before in materials with high thermal conductivity such as metallic feed lines in microelectronic devices.

References:

[1] https://pubs.acs.org/doi/abs/10.1021/nl401216y

[2] https://pubs.acs.org/doi/abs/10.1021/acs.accounts.5b00484