Engineering Diamond Membranes for Color Center-Based Thermometry

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Diamond color centers, such as NV and group-IV centers, are solid-state quantum emitters whose temperature-dependent photoluminescence arises from thermally induced lattice strain and electron–phonon interactions in diamond [1,2]. Combined with diamond's chemical inertness and biocompatibility, these defects provide a robust platform for quantum-enhanced nanoscale thermometry with sub-micron spatial resolution, extending to the single-cell level [3,4].

We present first results toward the development of an all-optical quantum thermometry platform based on a custom AFM-integrated quantum probe capable of single-cell temperature measurements. A ~1 µm-thick diamond membrane hosting optically activated native NV^- centers is prepared by plasma-focused Xenon ion beam (P-FIB) and mounted onto an AFM cantilever, enabling controlled manipulation and deterministic contact with the sample.

Photoluminescence and Raman readout are performed directly within the AFM setup under laser illumination, allowing localized quantum sensing under ambient conditions. A home-built temperature-control system enables in situ calibration, and we present preliminary measurements of the temperature-induced shift of the NV^- zero-phonon line (ZPL).

References

[1] Chen, X-D., et al. "Temperature dependent energy level shifts of nitrogen-vacancy centers in diamond." Applied Physics Letters 99.16 (2011).
[2] Doherty, Marcus W., et al. "Temperature shifts of the resonances of the NV− center in diamond." Physical Review B 90.4 (2014), 041201
[3] Chipaux, Mayeul, et al. "Nanodiamonds and their applications in cells." Small 14.24 (2018), 1704263.
[4] Kucsko, Georg, et al. "Nanometre-scale thermometry in a living cell." Nature 500.7460 (2013), 54-58.

Figures

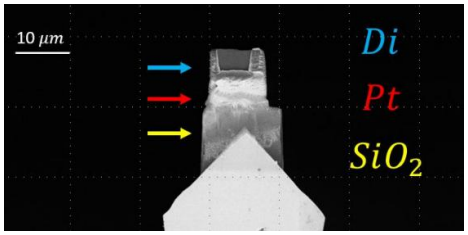

Figure 1: SEM image of the diamond membrane attached to an AFM cantilever.

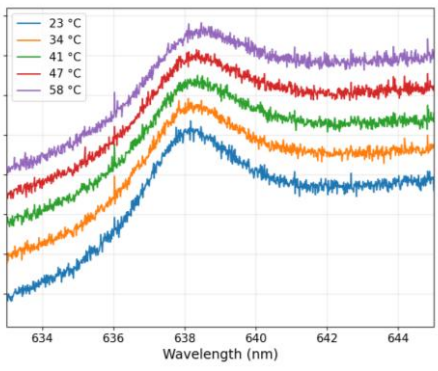

Figure 2: Spectra of NV^- ZPL as a function of the environment temperature.