Temperature-dependent fluorescence of SiV and NV color centers in micron-sized single crystal diamond needles

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1. Introduction

Micro-diamonds with color centers are promising objects for various applications spreading from micro-electronics to quantum optics due to their remarkable mechanical, thermal, and optical properties. Photoluminescence (PL) of color centers in diamonds can be also applied for precise temperature sensing at the micro- and nano-scales. Micro-diamonds are chemically inert and biocompatible, widening their application to biophotonics.

Synthesis of micro- crystallites with specific needle shape, controlled localization of color centers and enriched with SiVs may allow increasing accuracy and reliability of all-optical temperature determination and sensitivity of the method.

2. Result and Discussion

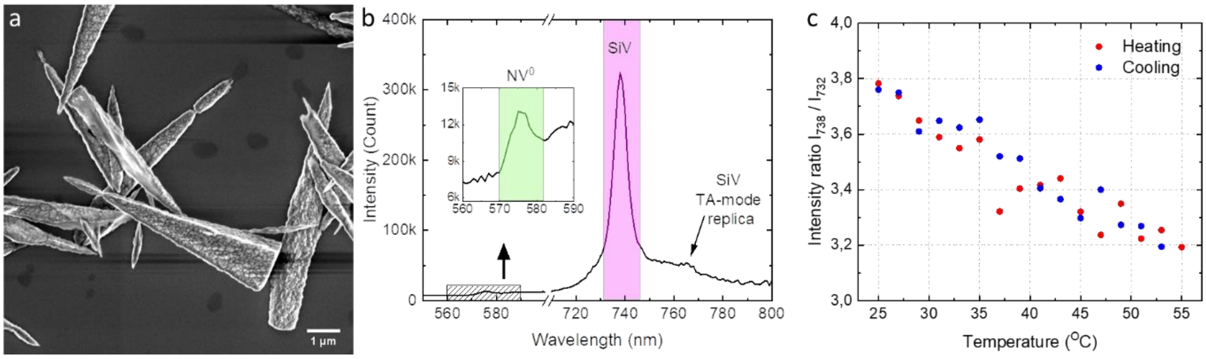

Fig. 1: a) SEM micrographs of D-SCDNs; b) PL spectra of them at room temperature at λ_{ex}=470 nm; c) temperature dependence of the I_{738}/I_{732} fluorescence intensity ratio during heating and cooling.

Dart-like micron-sized single crystal diamonds needles (D-SCDNs) were obtained by CVD-synthesis as described in [1]. D-SCDNs have a pronounced tip (see Fig.1a) and are enriched with both nitrogen-vacancy (NV) and silicon-vacancy (SiV) color centers, which follows from the presence characteristic PL of these centers in spectra (see Fig.1b). However, intensity of zero-phonon line (ZPL) of SiV color centers is several orders of magnitude higher then NVs. The major part of SiVs is concentrated in the tip.

All-optical thermometry was performed in the following way: The PL spectra of SiV color centers of DSCDNs were measured with excitation at 470 nm wavelength during uniform heating followed by cooling in the physiologically significant range (25-55 °C). The dependencies of lifetime, FWHM and peak position of SiV ZPL and its intensity on temperature were investigated. In order to reduce the errors caused by equipment and laser intensity fluctuations and to increase the measurement accuracy, we applied the normalizing of PL intensity measured at the maximum peak position of SiVs' ZPL (λ_{em}=738 nm) on the intensity at the wavelength where it is temperature independent (λ_{em}=732 nm) (see Fig. 1c).

3. Conclusions

Our results open a way towards accurate, non-invasive, precise, and real-time monitoring of temperature variations accompanying endothermic/exothermic processes on the sub-micro-scale, covering possible applications from quantum bioimaging to lab-on-a-chip systems.

4. Acknowledgement

This work was supported by Horizon 2020 RISE DiSeTCom (Project No 823728) and Academy of Finland (Flagship Programme PREIN, decision 320166, and research project, decision 343393).

5. References

[1] S. Malykhin, Y. Mindarava, R. Ismagilov, F. Jelezko, and A. Obraztsov, Diamond and Related Materials, **125**, 109007 (2022)