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Increasing production yield of sensing diamond nanoneedles

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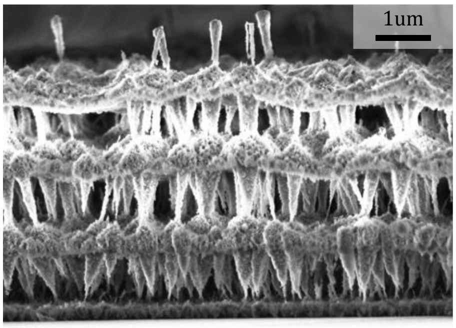

Fig. 1 Multi-layer diamond needles grown on silicon substrate after oxidation

Colour centres in diamond are atomic-sized crystal defects and room-temperature quantum sensors [1]. For nanoscale sensing, diamond microneedles of pyramidal shape and nanometre tip size was fabricated using plasma enhanced chemical vapor deposition (PECVD) followed by selective oxidation [2]. The PECVD technique allows *in situ* control of geometry and colour centre distribution [3].

One bottleneck toward application of CVD-grown diamond structures in biomedicine arena is their production, in comparison to HPHT and detonation [4]. In this work, we tested different substrate treatment methods to optimize nucleation density of diamond upon silicon, to about $10^{10-11}/cm^2$ by seeding substrate with nanodiamond particles. Further, we tested a novel growth technique, where multiple layers of diamond needles can be grown in a single process, potentially allowing a $\sim mg/cm^2$ production yield (Fig.1).

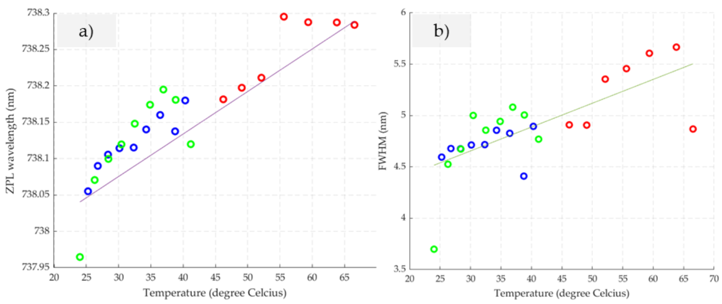

Fig. 2 Dependencies of a) ZPL position and b) FWHM of SiV PL in nanoneedles with size of 600-700 nm. (SiV in cell and Layered growth SEM).

Our fabricated needles contained silicon-vacancy (SiV) centers, which are atomic scale temperature sensors. The nanoneedles could be taken up by cells by endocytosis and the SiV photoluminescence exhibited robust penetration through biological samples. Preliminary tests showed a linear dependence of spectral features of SiV in diamond nanoneedles upon temperature.

Spin-properties of the nitrogen-vacancy (NV) center will be explored in the future, with the aim of expanding the functionalities of the diamond nanoneedle platform, e.g. sensing of concentration of radicals, electromagnetic field and local stress.

REFERENCES

[1] N. Nunn, M. D. Torelli, A. Ajoy, A. I. Smirnov, and O. Shenderova, Reviews and Advances in Chemistry 2022 12:1, vol. 12, no. 1, pp. 1–21, Apr. 2022, doi: 10.1134/S2634827622010044.

[2] A. N. Obraztsov, P. G. Kopylov, A. L. Chuvilin, and N. V. Savenko, , Diam Relat Mater, vol. 18, no. 10, pp. 1289–1293, Oct. 2009, doi: 10.1016/J.DIAMOND.2009.05.001.

[3] S. Malykhin, Y. Mindarava, R. Ismagilov, F. Jelezko, and A. Obraztsov, Diam Relat Mater, vol. 125, 2022, doi: 10.1016/j.diamond.2022.109007.

[4] O. A. Shenderova, A. I. Shames, N. A. Nunn, M. D. Torelli, I. Vlasov, and A. Zaitsev, Journal of Vacuum Science & Technology B, Nanotechnology and Microelectronics: Materials, Processing, Measurement, and Phenomena, vol. 37, no. 3, 2019, doi: 10.1116/1.5089898.