Engineering Germanium-Vacancy Center Arrays in Diamond Nanopillars for Quantum Applications

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Among the color centers in diamond, germanium-vacancy (GeV) centers, are gaining attention for their potential in quantum technologies. These defects exhibit strong zero-phonon line (ZPL) emissions at 603 nm, even at room temperature, short excited-state lifetimes, and high optical coherence due to their inversion-symmetric (D3d) structure [1].
In this study, we fabricated GeV centers in electronic-grade diamond using a Focused Ion Beam (FIB) with a liquid metal alloy ion source. FIB implantation offers precise, mask-free fabrication of GeV centers, ensuring accurate spatial positioning with minimal ion straggling [2].
Implantation was performed at 35 keV and 70 keV with Ge ion doses from 10 to 1000 ions per beam spot. Post-implantation, the samples underwent thermal annealing in ultra-high vacuum at 1000°C for two hours.
To enhance emission efficiency, nanopillar structures (20 nm in diameter) were precisely fabricated at the sites of the single-photon emitter arrays using electron-beam lithography and plasma etching. This process led to a significant improvement of a factor 8 in photon collection, emphasizing the effectiveness of this nanoscale engineering approach for quantum photonics applications.
Photoluminescence (PL) measurements together with antibunching measurements, revealed that up to 33% of the fabricated nanopillars contained single emitters, with the exact percentage depending on ion implantation parameters.

References

[1] C. Bradac, et al., Nat Commun. 10 (2019), 5625
[2] Y. Zhou, et al. New J. Phys. 20 (2018), 125004

Figures

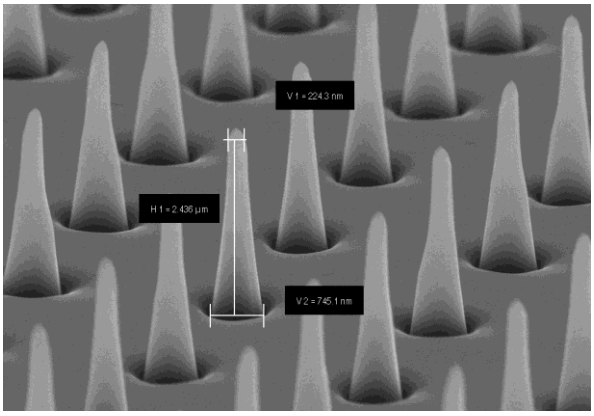

Figure 1: SEM image of the array of diamond nanopillars