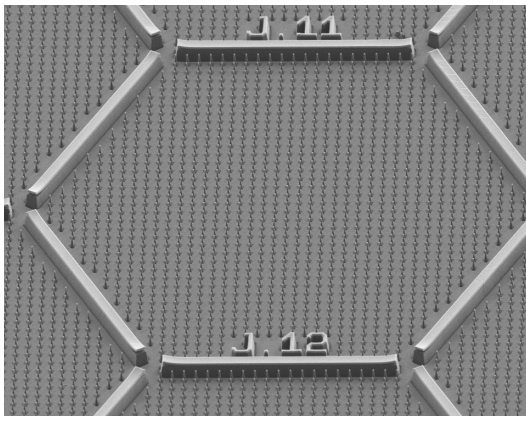
Qnami

the quantum wave



Quantum Foundry

NV Diamond for quantum sensing

NV diamond for quantum sensing

Diamond with embedded nitrogen-vacancy(NV) centers has applications in different fields ranging from global navigation to quantum communications to healthcare.

Quantum sensing using NV diamond enables various applications :

- **Nano-NMR**
  in measuring nuclear magnetic resonance spectra of tens of zeptoliter sample volumes [1]
- **Ultra-sensitive analyte detection in biologic samples**
  single molecule detection [2]
- **Neural signal imaging**
  in investigation of signal propagation in neural networks [3]
- **High sensitivity magnetometry in materials science**
  room temperature imaging of anti-ferromagnetic materials [4,5]

Performance of NV sensors depend directly on the spin properties of the NV centers. Coherence is a fragile property and can be easily damaged by fabrication processes and impurities introduced in the diamond. In general, the sensitivity of an NV quantum sensor is proportional to the collected photons that the NV center emits (√(counts)). In bulk diamond, this collection is quite poor due to the high refractive index of diamond. However, sensitivity can be greatly improved by placing NV centers in photonic structures, such as nano-pillars, that help to guide emitted photons towards collection optics. **Typically, diamond struturing improves photon collection by 10-20 times (Fig. 1), thus sensitivity increases by a factor of 3-5x as compared to diamon bulk.**

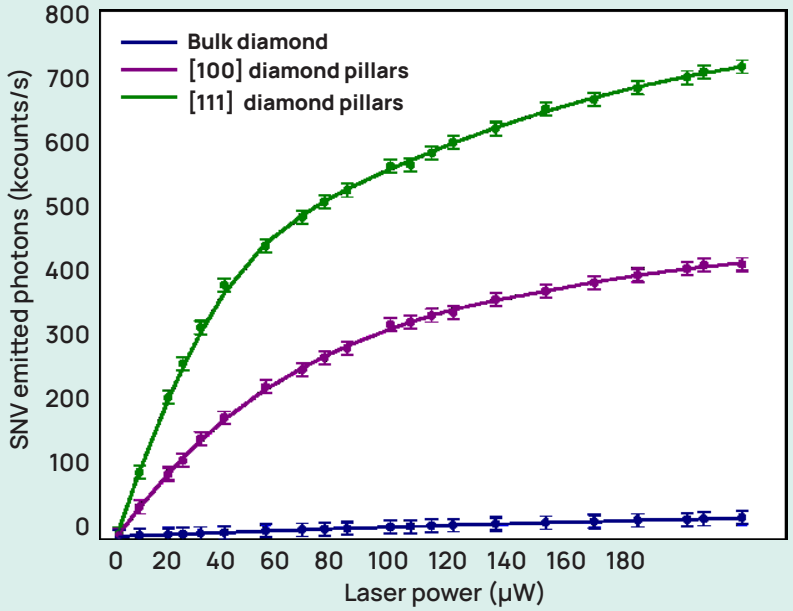


Fig. 1 Comparison of photoluminescence (PL) emission of single NV centers as a function of laser excitation power (measured after the objective lens) for different orientation of the NV center. All measurements were performed on a custom-built confocal microscope composed of a 515 nm green excitation laser, a 650 nm LP filter and an 800 SP filter for collection purposes, and a 0.8 NA air objective.

Boost in sensitivity by Qnami

Qnami provides sensitivity-boosted NV diamonds for multiple applications.

Our proprietary processes allow us to offer diamond with standardized NV layer depths and densities, from single NVs to ensembles with supreme coherence.

We can develop custom diamond chips for specific applications and we advise on chip design, NV diamond selection and signal read-out implementation.

Our experts can guide you from proof of principle demonstration to launching a pilot product production. As an example, a biosensing chip composed of diamond nanopillar arrays is shown in Fig. 2. The pillars contain single NV centers located at the very apex of the pillar, allowing close NV-analyte interaction and high efficiency collection of NV fluorescence.

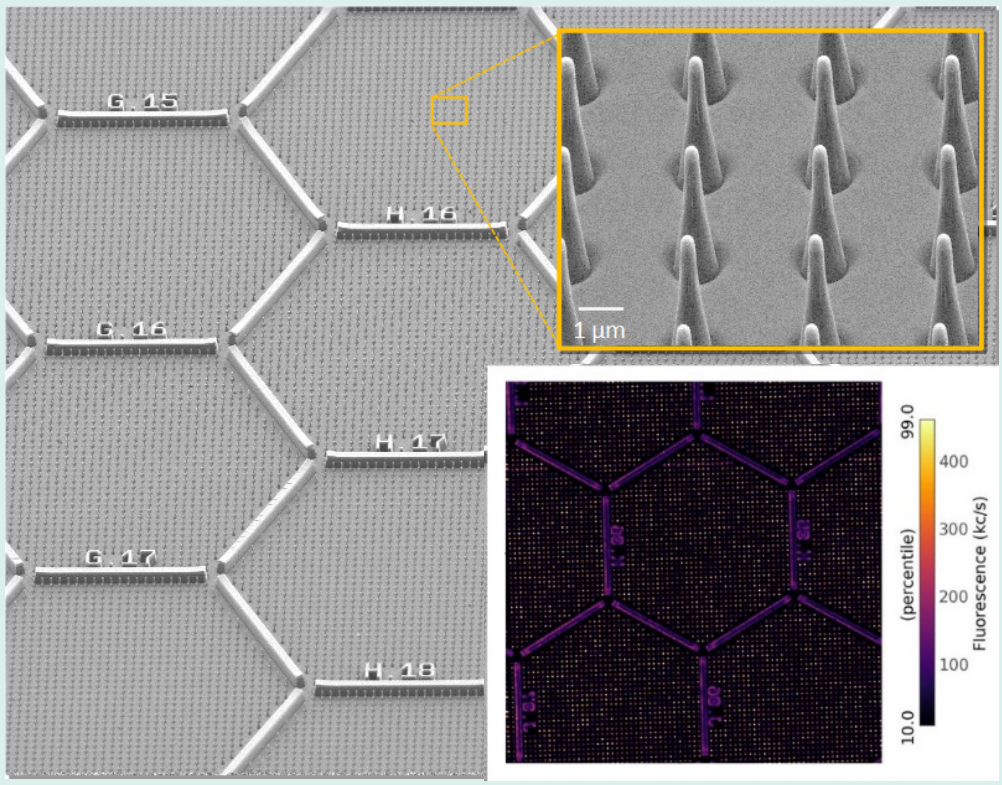


Fig. 2 Scanning electron micrograph showing large area diamond pillar arrays for high sensitivity analyte detection. The photoluminescence map in the inset indicates high photon emission counts from single NV centers.

Standard specifications*

Diamond material characteristics

- **Diamond grade:** quantum grade (residual [N] and [B] ~ppb range)
- **Diamond cut:** [100] or [111]
- **Polished surface roughness:** ~1 nm RMS
- **Diamond chip lateral dimensions:** 3 mm x 3 mm (standard); others upon request*
- **Thickness:** 40±10 µm; others upon request*

Nanofabrication of pillar arrays

- **Patterned area** of up to 2 mm x 2 mm (on 3 mm x 3 mm diamonds)
- **Flexible design** (pillar spacing, diameter and arrangement)

NV center characteristics

- **NV distance from the surface (layer)**: from 10 nm to 500 nm
- **NV density:** from 1 to 500 NVs per pillar
- **Average increase in photon count-rates** of 10-20x higher compared to bulk
- **Spin properties** unaffected by fabrication process

Diamond shipped on custom holder ready for operation at room and low temperature applications.

**diamonds with specifications outside the standard range can also be provided for custom projects*

CONTACT US

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References

[1] Aslam, N, et al. "Nanoscale nuclear magnetic resonance with chemical resolution." Science 357.6346 (2017): 67-71.
[2] Lovchinsky, I, et al. "Nuclear magnetic resonance detection and spectroscopy of single proteins using quantum logic." Science 351.6275 (2016): 836-841.
[3] Hanlon, L, et al. "Diamond nanopillar arrays for quantum microscopy of neuronal signals." Neurophotonics 7.3 (2020): 035002.
[4] Haykal, A., et al. "Antiferromagnetic textures in BiFeO 3 controlled by strain and electric field." Nature communications 11.1 (2020): 1-7.
[5] Chauleau, J-Y., et al. "Electric and antiferromagnetic chiral textures at multiferroic domain walls." Nature materials 19.4 (2020): 386-390