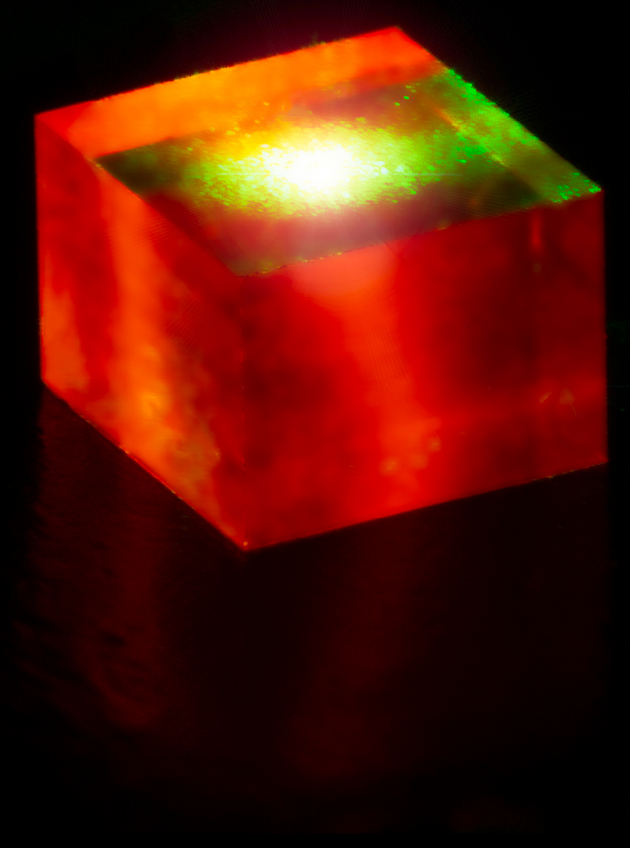
DNV™ **Series**

DNV™ B1 and DNV™ B14

Unlocking next generation quantum technologies

Perfectly imperfect diamonds, uniquely designed for quantum applications



elementsix™

DE BEERS GROUP

DNV™ B1 and DNV™ B14

Advancing diamond quantum technologies

As part of our diamond portfolio grown by chemical vapour deposition (CVD), Element Six offers two quantum grades of single-crystal diamond that contain deliberate and controlled levels of nitrogen-vacancy (NV) centres, fabricated using our patented processes.

The resulting diamond NV (DNV) centres provide researchers with a unique solid-state platform with spin qubits that can be initialised and read out with long qubit lifetimes at room temperature. These properties stem from diamond's structure and strong covalent bonds.

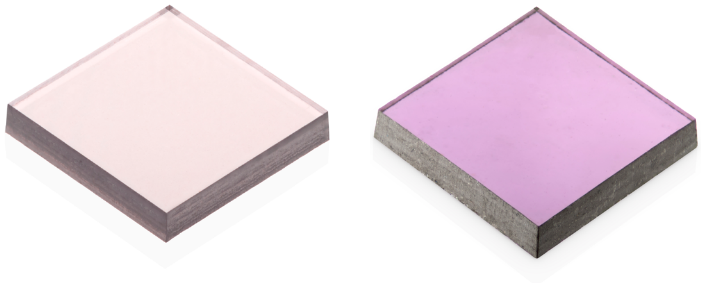


Figure 2: DNV B1 (left) and DNV B14 (right) CVD diamond samples

DNV™ B1 and DNV™ B14

Element Six's DNV™ B1 and DNV™ B14 products are ideal for those interested in employing NV ensembles for DC & AC magnetic field sensing, masers, RF detection, gyroscopes and quantum demonstrators.

These grades of diamond are designed to provide the end-user with a uniform distribution of NV spin centres, in a small chip that may be readily integrated into a quantum device or employed in research experiments.

Due to the differing levels of [NV] and residual [N] the two types of material have varying spin characteristics. The typical inhomogeneous transverse coherence time (T_2*) is of order 1 μs for DNV B1, which is reduced to 0.5 μs for DNV B14 (see Figure 3). Hahn echo measurements measure a factor of 20 higher T_2 in DNV B1 samples (of order 200 μs vs 10 μs).

These values of [NV], T_2 and T_2* mean the two materials lend themselves to different sensing modalities/applications. For example, the greatly increased Hahn-echo T_2 for DNV B1 means it is suited to AC magnetometry, whereas the increased [NV] in DNV B14 and only moderate reduction in T_2* results in DNV B14 being applicable for DC-sensing magnetometry experiments.

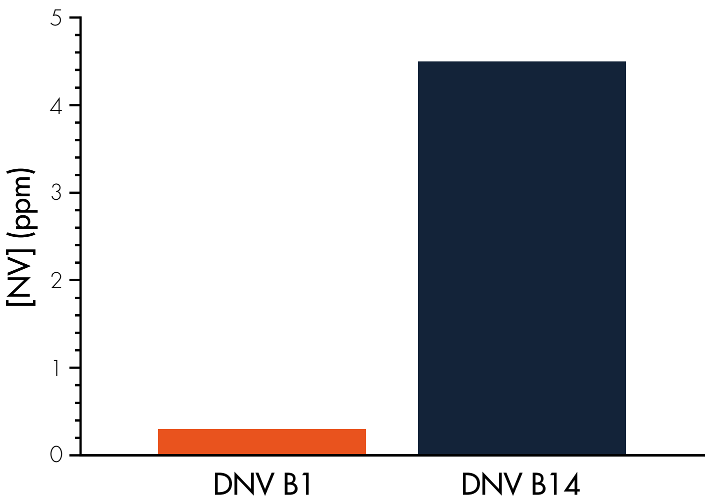


Figure 1: DNV B1 and DNV B14 in terms of [NV]

DNV B14 has a more than10-times higher NV density (refer to Figure 1) compared to DNV B1. This difference in NV concentration ([NV]) is reflected in the contrasting colour of the two materials; DNV B1 samples are light pink, whereas DNV B14 has an intense purple colouration (Figure 2).

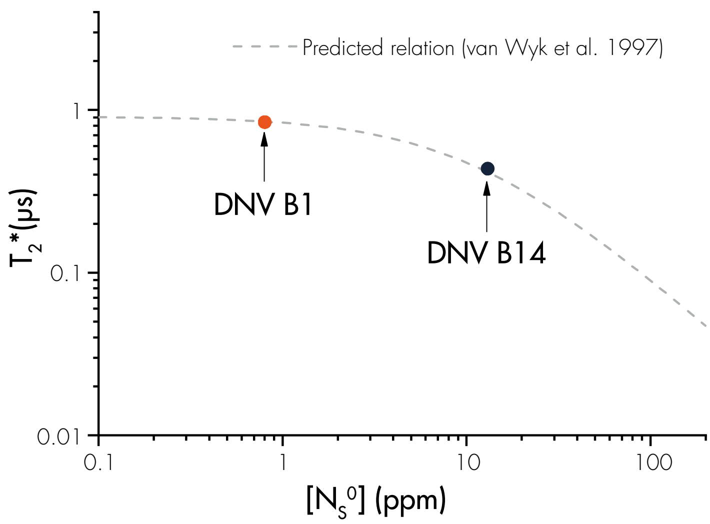


Figure 3: Spin coherence vs. nitrogen concentration (van Wyk et al. (1997). J. Phys. D: Appl. Phys. 30, 1790)

The choice of material also depends on device-design considerations, such as the amount of laser power used or how the microwaves are delivered, due to the differing densities of NV defects.

DNV™ Series
DNV™ B1 and DNV™ B14

Specifications and tolerances	Values
Crystallography	Major {100} polished faces
Crystallographic orientation (miscut)	< +/-3°
Typical dimensions	3 mm x 3 mm x 0.5 mm
Edge features	< 0.2 mm
Roughness, Ra	< 10 nm
^{13}C	1.1%

Quantum properties	DNV B1	DNV B14
Typical [N_S^0] (before treatment)	800 ppb	13 ppm
Typical [NV]	300 ppb	4.5 ppm
Typical spin coherence time T_2*	1 μs	0.5 μs
Typical spin coherence time T_2	200 μs	10 μs

Further reading

1. Markham, M. and Twitchen, D. (2020). The diamond quantum revolution. Physics World 33, 39
2. Zhang, H. et al. (2018). Little bits of diamond: Optically detected magnetic resonance of nitrogen-vacancy centers. American Journal of Physics 86, 225. https://doi.org/10.1119/1.5023389

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