# As systems and scanning tips, since resistivity

As the arrangement of carbon gives diamond having robust properties, disruptions of its lattice are equally unique.

Intrinsic defects in the bulk lattice of diamond particles show a number of useful properties that are appropriate for a number of applications. Optically active defect centers exist in natural and synthetic grown diamonds, but their concentration is typically needed to be increased for practical use. These defects can be formed at higher concentrations via either additional doping or high energy ion, neutron, or electron irradiation to produce vacancies. At the current time, the highest technological interest is the production of stable defect centers composed of substitutional nitrogen and vacancies (NV centers).

The NV center can exist in two forms, NV0 and NV? i. e neutral and negatively charged states, respectively. The NV? center is formed when local substitutional nitrogen donates an electron to induce a negative charge state on the defect center.

The ability of optically observed magnetic resonance and stable photoluminescence of the NV? center make it an appealing candidate for nanoscale sensing, quantum computing, and bio-imaging in vivo and in vitro applications. NV and NVN(H3) centers are also favorable candidates for invigorating emission depletion (STED) imaging18, 93. As these are present within the bulk of the diamond lattice and are secured from the surrounding environmental agents (such as strong chemicals), fluorescent defect centers in diamond provide infinitely stable fluorescence with no photobleaching or blinking. The long fluorescent lifetimes of NV centers in nanodiamonds (?

20 ns in water) make them useful for background-free imaging, which is mandatory when tissue autofluorescence is present, particularly in vivo applications. In total, there are over 500 optically active defect centers within a diamond, so there is potential for a huge number of applications not yet realized.

Another important technologically optical center in diamond is the Silicon-Vacancy (SiV) center, which emits in the NIR region. SiV centers can be particularly useful for in vivo imaging through tissue as their excitation and emission lie in the NIR window with low absorption94. In addition to optically active fluorescent defect centers, doping with boron formed electrically conductive nanodiamond of high technological importance.

The use of boron doped nanodiamond as a seed crystal for the growth of conductive thin film diamond is of very high interest for the formation of nano-electromechanical systems and scanning tips, since resistivity which is originating from “ regular” diamond seeds is harmful to the devices. Boron-doped nanodiamond also useful in the energy community due to their enhanced oxidation resistance, as applied to novel electrodes in fuel cells. Moreover, boron doped diamond can also exhibit phosphorescence, which gives some novel chances related to niche imaging applications. A number of properties originate from optically active defect centers and boron doping for induced electrical conductivity explain the versatility imparted upon nanodiamond by bulk defects and foreign atoms. Doping of nanodiamond core with tritium is another exciting opportunity that gives highly stable radiolabeled nanodiamonds for bioimaging applications with surface available for further functionalization with targeted proteins and for drug uploading11.