NANODIAMONDS – SCIENCE & TECHNOLOGY

NEWS: *Scientists have successfully recorded the Berry phase by the rotation of spin qubits inside the nanodiamonds at ultra-high speeds.*

WHAT'S IN THE NEWS?

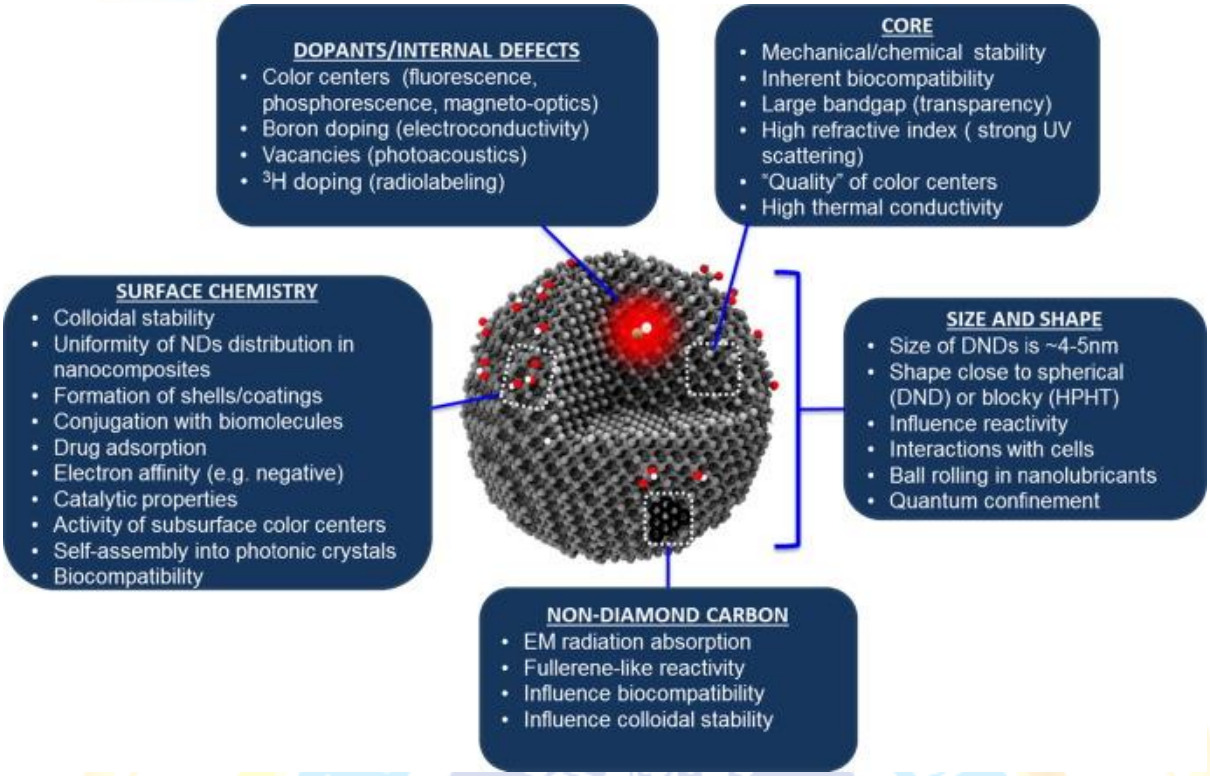
Nanodiamonds (NDs)

Nanodiamonds (NDs) are **carbon nanomaterials with a size of a few nanometers to micrometres that have many potential applications.**

- They are produced in a high-temperature and high-pressure process.
- They **can be doped with nitrogen atoms to form nitrogen-vacancy (NV) centres, which host electron spin qubits.**
- Just like a binary bit is the basic unit of information in classical (or traditional) computing, a **qubit (or quantum bit) is the basic unit of information in quantum computing.**

Properties of NDs:

- **Fluorescence and non-blinking**
- Fluorescence is the **property of some materials to emit light of a lower frequency when irradiated with light of a higher frequency.** But unlike many other nano-scale fluorescent materials, NDs don't blink when irradiated for a long time.
- **Stability**
- Their fluorescence **lifespan is greater than 10 nanoseconds (ns), a relatively long duration, which makes them better than quantum dots.**
- They are stable under light, non-toxic, and capable of maintaining fluorescence for long periods.



Quantum dots

They are **tiny particles or nanocrystals of a semiconducting material with diameters in the range of 2-10 nanometers (10-50 atoms).**

- They are nanoparticles **made from semiconducting materials. The dots show quantum effects because of their small size.**
- This means that electrons inside the dot are trapped and can only occupy defined energy levels.
- They were first discovered in 1980.

Quantum Spin

- Spin is **one of the basic features of the building blocks of matter, like electrons and nuclei.**
- At any given moment, its value is a combination of two states called up and down.
- If the down component is zero, the spin will be up, and vice versa.

A computer can map these values to 0s and 1s and use the electrons to encode information. Manipulating the spin forms the basis of quantum computing.

Berry Phase

- The Berry phase concept was **introduced by physicist Michael Berry in 1986, following earlier work by Indian physicist S. Pancharatnam.**
- The Berry phase is a **geometric phase acquired throughout a cycle when a system's parameters are varied and then returned to their original values.**

- Electrons exhibit both particle and wave characteristics. As waves, they possess properties such as frequency, wavelength, and phase, which can change depending on external conditions.
- **The Berry phase reflects changes in an electron's wave phase when cycled through different quantum states.**

Electrons can be manipulated by altering energy levels through magnetic fields. **This allows researchers to create a cycle of states, which helps in the measurement of the Berry phase.** The Berry phase generated by the rotation of the FNDs could be applied to create a gyroscope for rotation sensing.

Applications

- NDs are **stable under light and aren't toxic to living things, so they have many applications in high-resolution imaging, microscale temperature sensing, and correlative microscopy, among others.**

Progeny tracking

- In biology, scientists use NDs to track cells and their progeny over long periods.

Biomedicine

- NDs are biocompatible and can be used for cell labelling and imaging, targeted drug delivery, and cancer therapy.

Electronic applications

- NDs are used in thin-film electronics, photovoltaic devices, energy storage devices, and electrochemical sensors.

Quantum engineering

- NDs are used in quantum optics and nano-magnetometry.

Quantum optics: It is the study of the **quantum properties of light.**

- **Nano-magnetometry:** It is a technique that uses AC sensing schemes to measure magnetic fields at the nanoscale.

Source: https://epaper.thehindu.com/ccidist-ws/th/th_international/issues/101913/OPS/G4DDDKS8F.1.png?cropFromPage=true