Applications of Quantum Sensing

Quantum Technologies workshop

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Present developments of Quantum Technology

Quantum sensing based on NV centers in diamond

Place of Europe compared to its global competitors

Prospective applications

Conclusion
Present technology involving quantum information

Secure communications
- Symmetric encryption
- Quantum cryptography
  - Field implementation
  - Secure distance: 80 km
  - QKD key rates: 2 kbits/sec

Cs beam atomic clock
- Precision: $10^{-12}$ at 1 s
- Cold atoms on a chip
- Clock based on entangled ions

Quantum information has impact on present technology
Nitrogen Vacancy color centers in Diamond

« artificial atom » nestled in the crystal

- Solid-state
- Room-temperature

Optically controlled quantum system

- Single photon source for quantum cryptography
- Quantum bit (Qubit)
- Quantum gate with two NV’s
- High sensitivity magnetic field sensors

NV centers are solid-state magnetic-field sensors
Europe is at the forefront of research on NV centers:

- Strong level of publication
- Competition and collaboration with US, Australian, Japan teams

Integrate the efforts of the European Community on NV centres in order to keep Europe’s prominent position.
Scanning probe magnetometer

- single nitrogen-vacancy (NV) defect in diamond
- high sensitivity (< $10 \text{nT/Hz}^{1/2}$) and spatial resolution (< 10 nm)

Applications:
- high-density magnetic storage disks characterization
- Single electron and nuclear spin imaging
Objective 2

Wide field imaging magnetometer

- Ultra-thin diamond sample with high density on NV centers
- Spatial resolution of 300 nm and sensitivity < 1 nT/Hz^{1/2}.

Applications:

- Wide-field imaging of neuronal networks
- Imaging of electron spin density in graphene and carbon nanotubes

A non invasive, room temperature, enabling technology.
Applications

- High capacity storage disks (3 Tbit per square inch) required for intense computing
  - calibration and optimization of magnetic heads

- Next generation of electronic components based on spintronics,
  - imaging of electron-spin in graphene and carbon nanotubes

- Understanding of brain function,
  - non-invasive investigation of living neuronal networks

- Single protein imaging for medical research.
  - demonstration of magnetic resonance imaging of single spins
Conclusion

- Quantum information already has impact on present technology,
- Quantum sensors with unprecedented resolution and sensitivity based on NV centers in diamond,
- Applications with high impact on society,
- Integrate the efforts of the European Community in order to keep Europe’s prominent position.