Towards a wearable magnetometer

Juan Luis Sánchez Toural, Ramón Bernardo Gavito, Daniel Granados, José Luis Pau Vizcaino

Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA Nanoscience), Universidad Autónoma de Madrid, Cantoblanco, 28049, Madrid, España.
E-mail: jl.sanchez.toural@gmail.com

Magnetoencephalography (MEG) is a technique for studying brain activity by measuring the magnetic fields induced by electrical currents generated in neurones. Currently, the devices that allow MEG have strong limitations such as their operation, size, ambient conditions and cost. The project pursues the development of an integrated magnetometer using the properties of diamond color centers, in particular, the negatively charged nitrogren-vacancy centers or NV centers [1][2][3][4]. They are especially interesting because of their unique properties for high resolution magnetometry. The spin of the electron that is enclosed within the defect can be manipulated at room temperature. Leveraging its properties, the goal is to develop a wearable magnetometer, that allows high spatial and time resolution and operates at room temperature.

The long-lived spin states and optically detected magnetic resonance allow a high sensitivity with nanometer scale spatial resolution.

We have demonstrated, using a diamond single crystal, manipulation of the electron spin, polarization and read out using a microwave antenna. The microwave field is used to manipulate the orientation of electron spins through the electron-spin resonance tuned by an external magnetic field. The electron spin is optically initialized using laser radiation and the photoluminescence spin-readout return from NV centers provides the information about the applied magnetic field.
As part of the roadmap to an integrated device, in the next steps we will miniaturise the device and investigate the way to fabricate the material using annealing and irradiation of a polycrystalline diamond wafer.

References

1. N. B. M. Marcus W. Doherty, "The nitrogen-vacancy colour centre in diamond," School of Physics, University of Melbourne, VIC 3010, Australia, Tech. Rep., 2013.
2. P. K. Kasper Jensen, "Magnetometry with nitrogen-vacancy centers in diamond," Niels Bohr Institute, University of Copenhagen, Denmark, Tech. Rep., 2017.
3. S. A. L. J. Rogers, "New infrared emission of the nv centre in diamond: Zeeman and uniaxial stress studies," Laser Physics Center, Australian National University, Canberra, Tech. Rep., 2008.
4. J. W. F. Jelezko, "Single defect centres in diamond: A review," DPhysikalisches

Figures

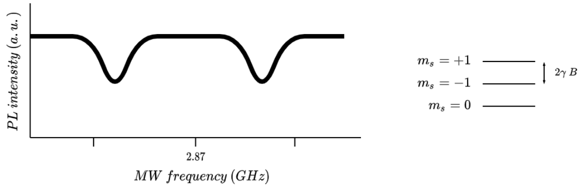

Figure 1: Due to the Zeeman effect, under an external magnetic field, the energy level splits resulting in the shifting of the PL in the optically detected magnetic resonance (ODMR) spectrum.

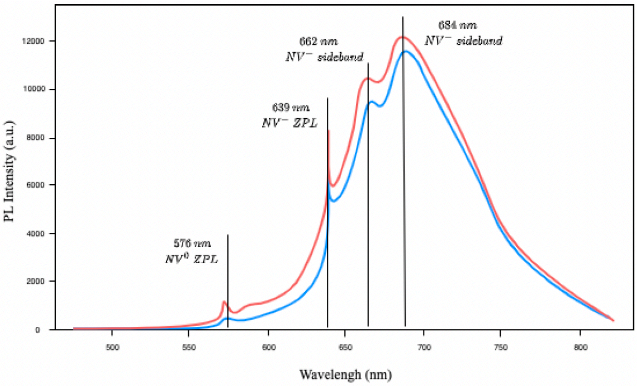

Figure 2: Photoluminescence spectra for an NV spin ensemble embedded in a single crystal diamond (red) and a polycrystalline diamond (blue). The typical luminescence curve representing the intensity as a function of the wavelength with the zero phonon lines (ZPL) and the phonon sidebands.