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Optical centres in diamond created by high-resolution ion implantation for single-photon sources and solid-state qubits

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sala Castagnoli, Dipartimento di Fisica, via P. Giuria 1

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Abstract

Hundreds of optical centres are known in diamond. Some of these defects (related to nitrogen, silicon, nickel,…) have been observed at the single level by optical means. Single-photon sources operating at room temperature are already commercially available, based on the emission of single nitrogen-vacancy (NV) centres. Although not the best single-photon source in terms of emission rate and spectral width, the NV centre possesses however unique spin properties. Indeed, the electron spin associated to the negatively charged NV centre can be read out and polarized optically, and shows coherence times as long as a few ms at room temperature. Therefore the NV centre is considered to be the most promising candidate for quantum computing in the solid-state. For such applications, scalable structures of coupled qubits have to be built, in which each qubit can be individually addressed. Ion implantation is the best way to produce such single centres on demand. Recent developments in ion implantation techniques have lead to an improvement of the spatial resolution which is now approaching the nanometer. Moreover, almost any kind of ions can be implanted.

In the last few years, barriers have also been pushed further in diamond growth and optical imaging. Firstly, high-purity diamond substrates are now available. For example, the nitrogen concentration (which is the most common impurity in diamond) of CVD-grown diamonds can be reduced to almost 1 ppb. This gives the opportunity to create, study and manipulate single defects in a very reproducible manner. Secondly, optical microscopy has known a revolution with the invention of new imaging techniques no more limited by diffraction. Using stimulated emission depletion (STED) microscopy, single NV centres can be imaged with a resolution of a few nanometers only.

The talk will give an overview of the field of optical centres in diamond for applications as solid-state qubits and single-photon sources, and the role played by ion implantation.

The Author

Sébastien Pezzagna received his PhD in Physics from the University of Nice-Sophia Antipolis, France, in 2005. He studied the growth and optical properties of group III-nitride semiconductors for applications in nonlinear optics. In 2007 he first joined the Ruhr-University of Bochum as a member of Prof. A. D. Wieck´s group, a renowned expert in focused ion beams. Since 2008, he has been working at RUBION laboratory, where he is involved in the creation of optical centres in diamond by ion implantation and the development of new techniques for high-resolution implantation of single ions and their optical imaging.