3.1 Publishable summary

At the start of the project we have stated that ability to engineer material at atomic scale is the key requirement for building future molecular scale devices. During first year DIAMANT members were able to achieve remarkable progress towards building atomic devices based on implanted dopants in diamond lattice. All groups involved in the project (representing interdisciplinary expertise in material science, quantum optics, theoretical physics and magnetic resonance) were able to reach the highly challenging target of the DIAMANT work programme. The project results were published in high impact journals (among them several papers in Nature). They were presented to the wide public auditorium during EU open days (Budapest 2011) and in numerous lectures of the PIs. Below we list short a summary of the project results divided into work packages. The project website is www.quantenoptik.de.

Work Package 1 – Management (WP1)

DIAMANT consortium was able to start the project according to the schedule and a webpage was created within the domain quantenoptik.de belonging to coordinator. During the first year the project team was able to acquire a new partner (RISSPO-HAS Budapest) as a result of special call for new EU states. DIAMANT kick-off meeting was organized in Ulm, which was attended by all team members.

Work Package 2 - Engineering atomic and artificial molecular and nanophotonic devices in diamond (WP2)

WP2 has been remarkably successful with key milestones. Specifically, diamond material science partners (IMEC, E6) were able to produce ultrapure diamond material (with a concentration of impurities below ppb level)[4] having ultra-flat (subnanometer roughness) surfaces. This material was supplied to the project partners according plan. Synthesis of isotopically pure diamond is in progress and the first ^{12}C crystals are expected to be delivered within next few months. Novel ion implantation techniques based on nano-apertures have been developed for increasing the resolution. A new ion trap showing superior performance for implantation purposes has been designed and built, an important step progress towards deterministic implantation.

Work Package 3 - Atomic sensors and magnetic imaging (WP3)

The progress of the material science work package (WP2) was crucial for the successful development of diamond applications in WP3. Specifically, we have shown that single spin on the surface of diamond can be detected using shallow implanted NV. We have demonstrated that a Heisenberg limited precision scaling of magnetic field measurements can be achieved using coherent control techniques. We have also performed first steps towards novel types of sensing based on optical coupling and Fluorescence Resonance Energy Transfer (FRET).

Work Package 4 - Quantum control theory (WP4)

Initially the theory work package of DIAMANT planned to achieve the following two main goals: develop quantum control tools for manipulating single atoms in ion trap (relevant for ion implantation) and optimization of quantum gates using optimal control techniques. The research in this direction was performed successfully (resulting in optimized ion trap design, WP2) and high performance magnetometry protocols (WP3). RISSPO-HAS team (joined DIAMANT during last

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M. L. Markham, J. M. Dodson, G. A. Scarsbrook, D. J. Twitchen, G. Balasubramanian, F. Jelezko, and J. Wrachtrup, "CVD diamond for spintronics," Diam Relat Mater **20** (2), 134-139 (2011).

year) provided significant theory input on quantum chemistry calculation of diamond defects. This contribution is crucial for understanding the charge dynamics of NV defects.

Work Package 5 - Spintronics and integrated photonics (WP5)

At the starting point of the project, colour centres in diamond were identified as promising candidates for novel photonics platform operating with single photons and enabling the transfer of information between photons and spins. During the first year of DIAMANT such a platform become reality. Project team members were able to develop photonic elements in diamond (solid immersion lenses, photonic crystal cavities). The use of solid immersion lenses enables the single shot readout of individual nuclear spins in diamond.