



PhD Thesis Defense MICHAEL GEISELMANN 'All Optical Manipulation of a Single Nitrogen-Vacancy Centre in Nanodiamond'

MICHAEL GEISELMANN

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Thursday April 10, 11:00. ICFO Auditorium

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Plasmon Nano-optics

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The efficient interaction of photons with single quantum emitters like nitrogen vacancy (NV) centres is essential for the elaboration of future integrated quantum optical devices. A promising strategy towards this goal capitalizes on the latest advances of nano-optics to boost the interaction with single emitters as well as strengthen coupling between several of

them. However, fully exploiting the capabilities of this marriage between NV centres and optical nanostructures requires suitable tools to accurately control their interaction.

In this thesis, we use optical manipulation to trap and manipulate in 3D individual nanodiamonds containing a single NV.

We first demonstrate the use of optical tweezers as a tool to achieve deterministic trapping and three-dimensional spatial manipulation of individual nanodiamonds hosting a single NV spin. Remarkably, we find that the NV axis is nearly fixed inside the trap and can be controlled in situ by adjusting the polarization of the trapping light. By combining this unique spatial and angular control with coherent manipulation of the NV spin and fluorescence lifetime measurements near an integrated photonic system, we demonstrate individual optically trapped NV centers as a novel route for both three-dimensional vectorial magnetometry and sensing of the electromagnetic local density of states.

In a second step, our manipulation technique is further developed to deterministically position a single nanodiamond into the hotspot of a plasmonic antenna. The gradient force of electromagnetic field of the excited plasmon acts as localized optical tweezers to drive the functionalized nanodiamonds to the regions of largest field enhancement of the antenna, where they are adsorbed. The proximity of the immobilized NV to the nano-antenna is corroborated by the observed decrease in its fluorescence lifetime.

Last but not least, we observe a NV fluorescence decrease upon near-infrared (NIR) illumination. We identify the promotion of the excited electron to a so far unknown dark band with a fast decay channel as the origin of the fluorescence decrease. This assumption is verified by the excellent agreement between our simple rate equation model and the experiment.

With this mechanism we demonstrate that a single NV can operate as an efficient and fast

optical switch controlled through an independent NIR gating laser. Furthermore the hybrid system formed by a single NV coupled to a gold gap antenna enhances the modulation depth.

The results presented in this thesis show the ability to manipulate and position NV centres in nanodiamond with optical tweezers. This paves the way towards spin based magnetic field and temperature sensing in liquid environment. Furthermore, the control of positioning and coupling to photonic and plasmonic nanostructures may play a role for potential applications in all-optical circuits or quantum optical devices.

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