

THE PROPERTIES OF NITROGEN-VACANCY CENTRES IN NANODIAMOND

By

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A THESIS SUBMITTED TO MACQUARIE UNIVERSITY
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
DEPARTMENT OF PHYSICS AND ASTRONOMY, ARC CENTRE OF EXCELLENCE
FOR ENGINEERED QUANTUM SYSTEMS,
MACQUARIE UNIVERSITY, NSW 2109, AUSTRALIA
FEBRUARY 2012



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To my Family, my dad Stanislav, my mum Laura and my sister Kristina

To Melanie

To all my Friends

Abstract

Diamond is unique. Whether mechanical, thermal, electrical or optical, its properties are within the most extreme compared to those of any other material. This, together with the fact that in the last fifty years the synthesis of artificial diamond has become a reality, makes it very attractive for engineering and technological purposes. The range of diamond-based applications is very diverse and, among the others, includes its use in mechanical machining, high-power high-frequency electronics and high transmissivity optics.

Diamond is also host to a wide variety of crystallographic defects. Appropriately controlled, they can be used to tune the characteristics of the material, but even more interestingly they often possess attractive optical properties on their own. In particular, nitrogen-vacancy (NV) centres in diamond have been the subject of extensive study in the last few years. They possess unique room-temperature optical and spin properties which make them promising systems for solid-state qubits in quantum information technologies and for emerging applications in biotechnology, nanomedicine and high resolution magnetometry, such as drug delivery, fluorescent biomarking and spin imaging.

This thesis is focused on NV centres in diamond. I first present an extensive review on diamond as a material, describing in detail its physical properties, the methods that have been developed to synthesise it and some of its possible applications. I then move the attention specifically to NV centres in nanodiamonds (NDs), i.e. diamond crystals in the

nanometre size range (0-100 nm). They are a potential candidate for emerging technologies including high-resolution magnetometry and biomedical imaging. For these applications, specific material requirements, such as the small size of the diamond nanocrystals and the optical stability of the hosted NV centres, are crucial. The NV stability with respect to the nanodiamond size and surface is the central theme of this thesis. I analyse the optical behaviour of NV centres in nanodiamond while varying a number of key parameters such as size, surface termination and diamond origin. Based on the measurements, I conclude whether the nanodiamond size and the NV surface proximity are factors that must be taken into consideration in order to control the material and realise nanotechnologies based on NV centres in nanodiamonds.

Declaration

I certify that the work in this thesis has not been submitted for a degree nor has it been submitted as part of requirement for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the presentation of the thesis itself has been acknowledged.

I certify that all information sources and literature used are indicated in the thesis.

Carlo Bradac

Acknowledgments

I would like to thank my supervisor James R. Rabeau, for being a constant source of motivation, a point of reference and, most of all, a good friend.

Special thanks go to Torsten Gaebel who has been a true mentor for me, always willing to share his experience and satisfy my insatiable eagerness for knowledge.

I would also like to thank my associate supervisor Jason Twamley for suggesting stimulating ideas and for our constructive discussions.

I have been fortunate to work with many good people. Andrei V. Zvyagin, Amanda S. Barnard, Mike J. Steel, David Inglis, Louise Brown, Ben F. Johnston, Nishen Naidoo, Varun Sreenivasan (my irreplaceable lab-buddy for long working-hours during the week-ends), Jana M. Say and Faraz A. Inam. I thank them all with whom I have enjoyed collaborating and working over the past few years.

I wish to thank my Family, my dad Stanislav, my mum Laura, my sister Kristina and my uncle Enrico. Despite living in Milan (IT), 16545.52 km away from Sydney (AU), they have always been very supportive with my decision of moving “not exactly behind the corner”. I would also like to thank all my Friends in Italy and in particular Daniele S., Daniele C., Davide, Marco, Claudio, Sara, Ilaria, Michela, Valentina, Giulia, Claudia, Manuel, Lucia, Angelo, Alessandra and “The Bovinda Company”. They have always thought that Peschiera Borromeo (Milan, IT), my little hometown, was too small to realise my dreams and convinced me to pursue them somewhere else, on the other side of the planet.

Thanks go to Giovanni Consolati and Ezio Puppini. They are the professors who first passed on me the love for Science.

I would also like to thank some of my good Friends here in Australia, in particular Boris, Niraj, Matthias and Renan. A very special thank goes to my Friend Yichuan Jin with whom I have shared training and sparring sessions, endless chats and our common love for Martial Arts. I wish to thank Ron Claassens. He employed me for several casual jobs at university all at very early or late hours to make a living without clashing with my PhD research. Ron is also the most passionate Martial Arts Master I have ever met, but most of all is a very good Friend.

Finally, I wish to thank Melanie. She has been by my side every moment along the way in writing this thesis. Thanks Mel for being the amazing person you are.