UNIVERSITY NAME

DOCTORAL THESIS

Thesis Title

Author:
John SMITH

Supervisor:
Dr. James SMITH

A thesis submitted in fulfillment of the requirements
for the degree of Doctor of Philosophy

in the

Research Group Name
Department or School Name

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Declaration of Authorship

I, John SMITH, declare that this thesis titled, "Thesis Title" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

UNIVERSITY NAME

Abstract

Faculty Name
Department or School Name

Doctor of Philosophy

Thesis Title

by John SMITH

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgments and the people to thank go here, don't forget to include your project advisor…

Physical Constants

Speed of Light $c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

For/Dedicated to/To my…

Chapter 1

Motivation and Background

1.1 Quantum info processing and Qubit candidates

1.2 Silicon vacancy as a Qubit candidate

1.3 Silicon vacancies in nanodiamonds

1.4 Motivation of the thesis, unsolved problem

Chapter 2

Experimental approach of surpressing the spectral diffusion

2.1 sample preparation

2.1.1 preparation of the substrate

IIa diamond as substrate Our choice of substrate is based on the principle of low background fluorescence, low refractive index and high thermal conductivity at low temperature (4K) and no misleading spectral features.

here is a paragraph dedicate to the expended explanation of requirements of substrate

here is a paragraph describing that based on the mentioned principles, Uwe Jantzen and coworkers has compared several different materials and in the end type IIa diamond rised as the most fitting candidate.

FIB In order to make it more convenient to trace the nanodiamonds, markers were curved onto the surface of the IIa type diamond substrate, this work was done by Uwe Jantzen during his master's thesis period. As is shown in the fig.[], the focues ion beam bombards the surface of diamond away and leaves behind markers that are visible in optical microscopy images and SEM images, as well as confocal microscopy images.

here is a sketch of how Ga-ion bombards the surface of substrate

here insert image of markers, optical, sem and confocal

fig. ?.

2.1.2 spin-coating of the sample

theory of spin coating

Spin coating is the method that spreads the liquid evenly across the surface of

thickness $\sim \frac{1}{\sqrt{\omega}}$, time of evaporation, single time or multiple times. Surface condition and liquid spreading. Importance of clean room. Before and after optical image.

Acid cleaning

To make sure that the NDs dispension can evenly spread and eventually settled on the substrate, a smooth, cleaned and hydrophilic surface is important.

Tri acid boiling is a very practicle way of substrate cleaning.

here insert a sketch of how we do acid cleaning the strongly acidic and oxidic mixture can remove most of the contaminations, leaving a clean hydrphilic surface covered with carboxyl and hydroxyl groups.

here insert image of before and after cleaning substrate, optical image, confocal image Tri Acid boiling blabla. Expectation of the surface. Before after cleaning. Optical image. Confocal image.

fundamental of spin coating thickness $\sim \frac{1}{\sqrt{\omega}}$, time of evaporation, single time or multiple times. Surface condition and liquid spreading. Importance of clean room. Before and after optical image.

2.2 development of a technology to estimate the spectral diffusion

Setup In order to resolve the fine structure of ZPL of SiVs, we need to observe the sample at low temperature, thus a cryogenic setup must be applied. Our setup is a typical confocal micropscopy setup connects with a cryostat, which cools the sample with liquid Helium flow.

here inserts a picture of our flow cryostat, from out and in side. This is the flow cryostat, whose main body is a vaccum chamber with

here insert a sketch of the cryo4 setup Confocal + Cryostat, Green laser + Red laser, spectrometer, apd, pic

PL green laser + spectrometer. Instrumental limitation fo resolution from spectrometer. See the sum of all Emission over exposure time. Observing ZPL and phonon side band.

PLE resonance excitation of optical transition. Rsésolution limited by scanning step of laser. Observing phonon side band with apd. range of scanning: limited by laser, small.

time resolved PL spectra Tracing PL spectra over time, show the diffusing behaviour of lines, characterisation methods: excitation polarisation: width of diffusion. Cross- correlation over time.

We recorded and noticed that the diffusion, whose range can up to 1nm, is far beyond the capability of PLE.

2.3 Oxidation

Effect of Oxidation Size reducing, surface group changing, removal of Sp2 carbon

2.3.1 first Oxidation

method According to the paper[Elka Neu], condition: . With the help from Markus Mohr. Setup : tube furnace, pic.

Before Oxidation Confocal image, SEM image, PL, time resolved PL, PLE. Power dependence.

After Oxidation dirty surface: Optical image, Confocal image, time resolved PL. Power dependence.

Analysis Reason for getting dirty surface. Behaviour of the lines: brighter, broader...

2.3.2 second Oxidation

method According to [] paper, higher temperature - total removal of Sp2 carbon. Improvement of setup: to prevent contamination: cleaner tube, clean He flow when cooling. Improvement of characterisation: added in excitation polarisation, record the time resolved PL with 2 differently polarised incident beam. Samller nanodiamonds: a earlier batch.

Before Oxidation optical image after spincoating, excitation polarisation: confocal image, histogram of the distribution of peaks. SEM image.

After Oxidation Confocal image of bright back ground. Gr1 center everywhere. Can't see pois.

Analysis Comparasion if possible: different behaviour pre treatment between two batches Possible reason: losing NDs due to Helium flow while cooling, GR1 getting closer to the surface due to oxidation caused size/thickness reduction.

2.4 H termination

Effect of H termination NEA, band structure of diamond. Reduction of surface.

method Plasma treatment, setup, apparatus.

why no pre characterisation Conditions for Plasma treatment.

After H termination Confocal image, optical image, excitation polarisation, time resolved PL with different incident polarisation.

Analysis Within the instrumental limit of spectrometer, the spectral diffusion has been significantly suppressed. Possible reason.

Chapter 3

Conclusion and outlook

3.1 The road so far

Initial motivation

Development of a method to estimate the spectral diffusion

Surface treatments and their effects

3.2 Probabilities in the near future

PLE

life time measurement

comparasion of different surface group

better method for size selection

relation between surface geometry and spectral behaviour

Appendix A

Appendix Title Here

Write your Appendix content here.

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