SAND2019-11187C

Design of an Experimental Platform for In-Situ Single Photon Source Detection

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Motivation

Why Solid-state Single Photon Sources?

- Applications range from quantum enhanced sensing to quantum information transfer and quantum computing
- To make use of the quantum nature of light, need on demand high purity single light quanta, i.e. single photons
- Color centers are ideal candidates for high density and long coherence time quantum platforms

Key CINT capability:

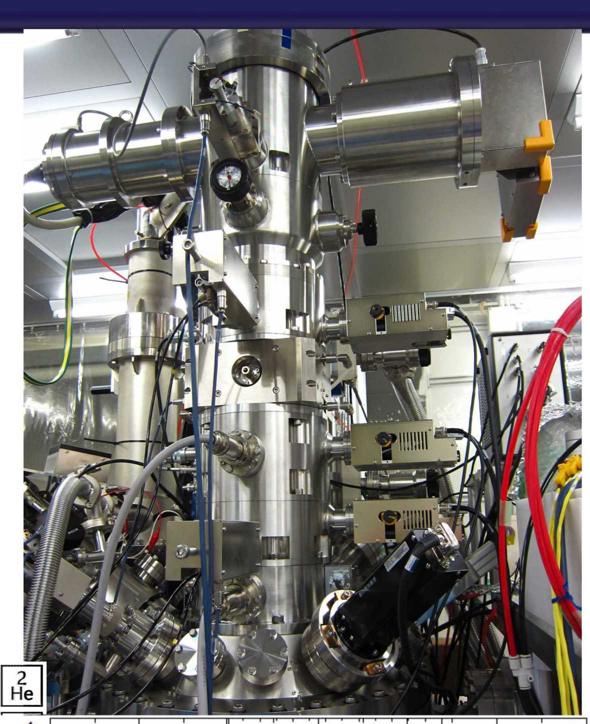
High-resolution implantation of defects in virtually any material and donors in materials such as diamond, SiC, hBN, etc… enabling the placement of color centers where we need it.

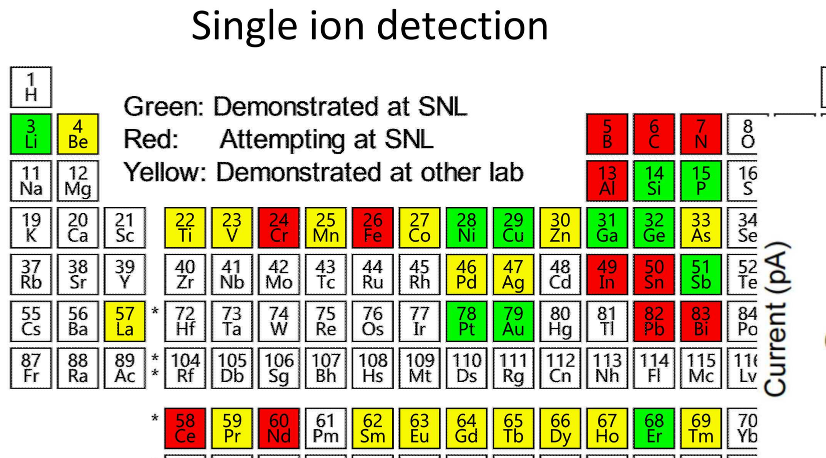
A. Sipahigil et al., Science 354 (6314) 847 (2016)

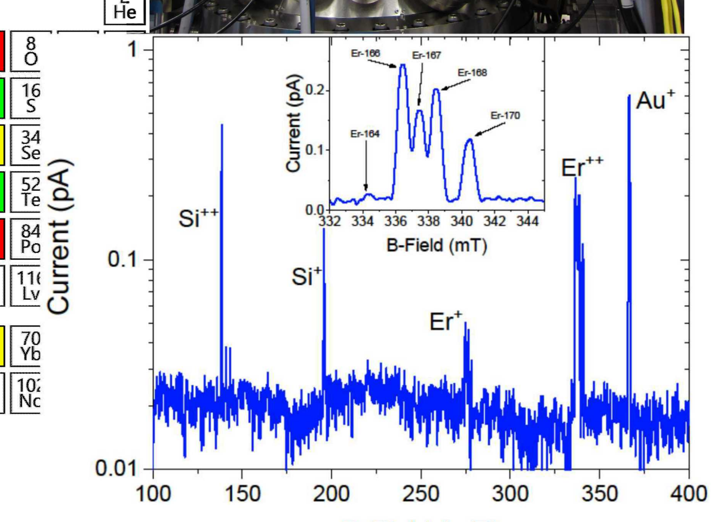
Nanoscale Ion Implantation

nanoImplanter

- Focused ion beam system (FIB)
  nm spot sizes on target
- ExB (Wien) Filter
  Ion and isotope selectivity
- Fast blanking and chopping
  Single ion implantation
- In-situ electrical probes
  Single ion detection

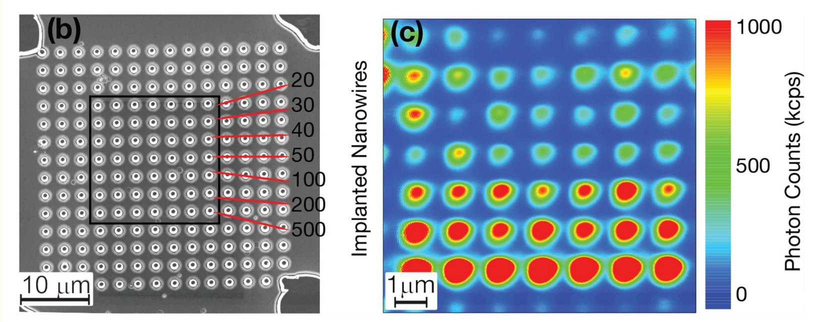




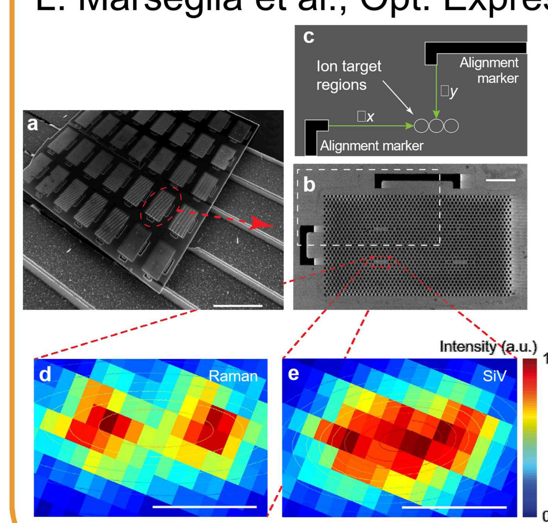


Current Collaborations & Roadmap

Quantum Optics with SiV, GeV

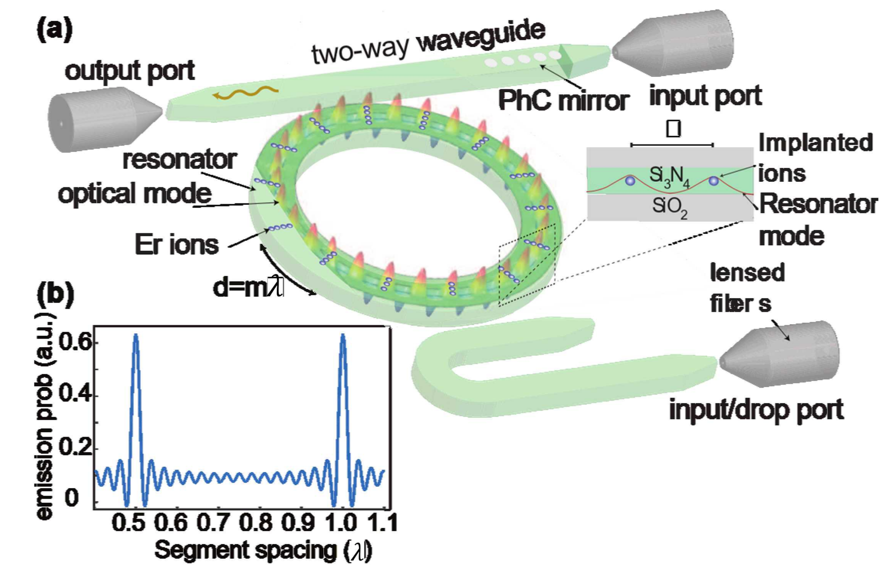


L. Marseglia et al., Opt. Express 26, 1, 80 (2018)



T. Schröder et al., Nat. Commun., 8, 15376 (2017)

Collective resonances in Fiber



A. Nandi et al., arXiv:1902.08898

NV in Diamond

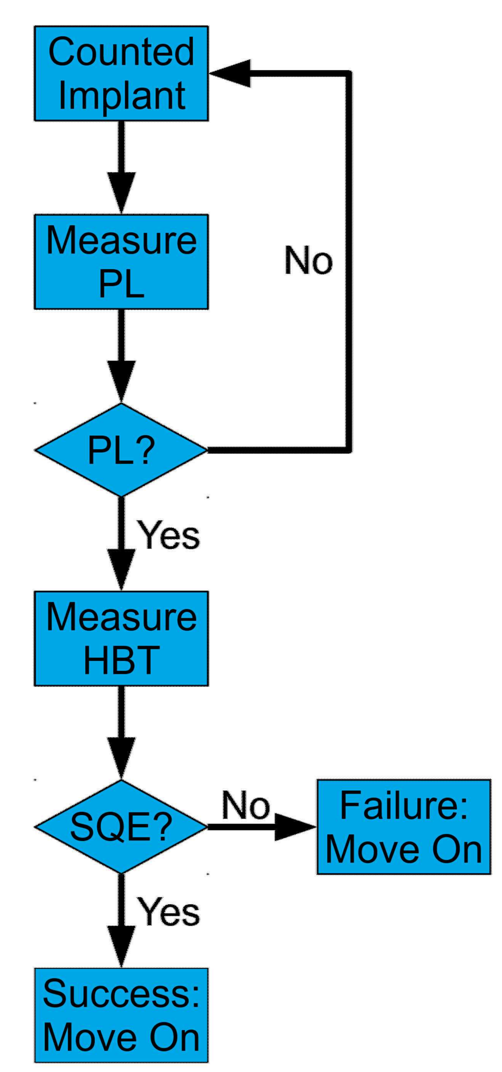
- N source development
  - Ionic Liquid Ion Source (MIT)
  - Implant Liquid Metal Source with N (SNL)
- NV-NMR under development for quantum material characterization (see Ziabari et al.)
- Add in-situ anneal to nanoImplanter
  - Heated implants (MIT)
  - Laser annealing (U Torino, Italy)

High-resolution ion implantation is necessary to enable these experiments, BUT how do we produce a deterministic SPS?

Low Optical Yield – How to Ensure SPS Generation?

Creating optically active defect centers

- Counted implantation to produce single implanted ions
- Photoluminescence (PL) to confirm color center is optically active
- Hanbury-Brown-Twiss (HBT) measurement confirms a single photon source through $g^{(2)}(t)$



SiV, GeV in Diamond

- Only 3% of implanted ions generate optically active defect center
- To detect photoluminescence, need high-temperature anneal after implant

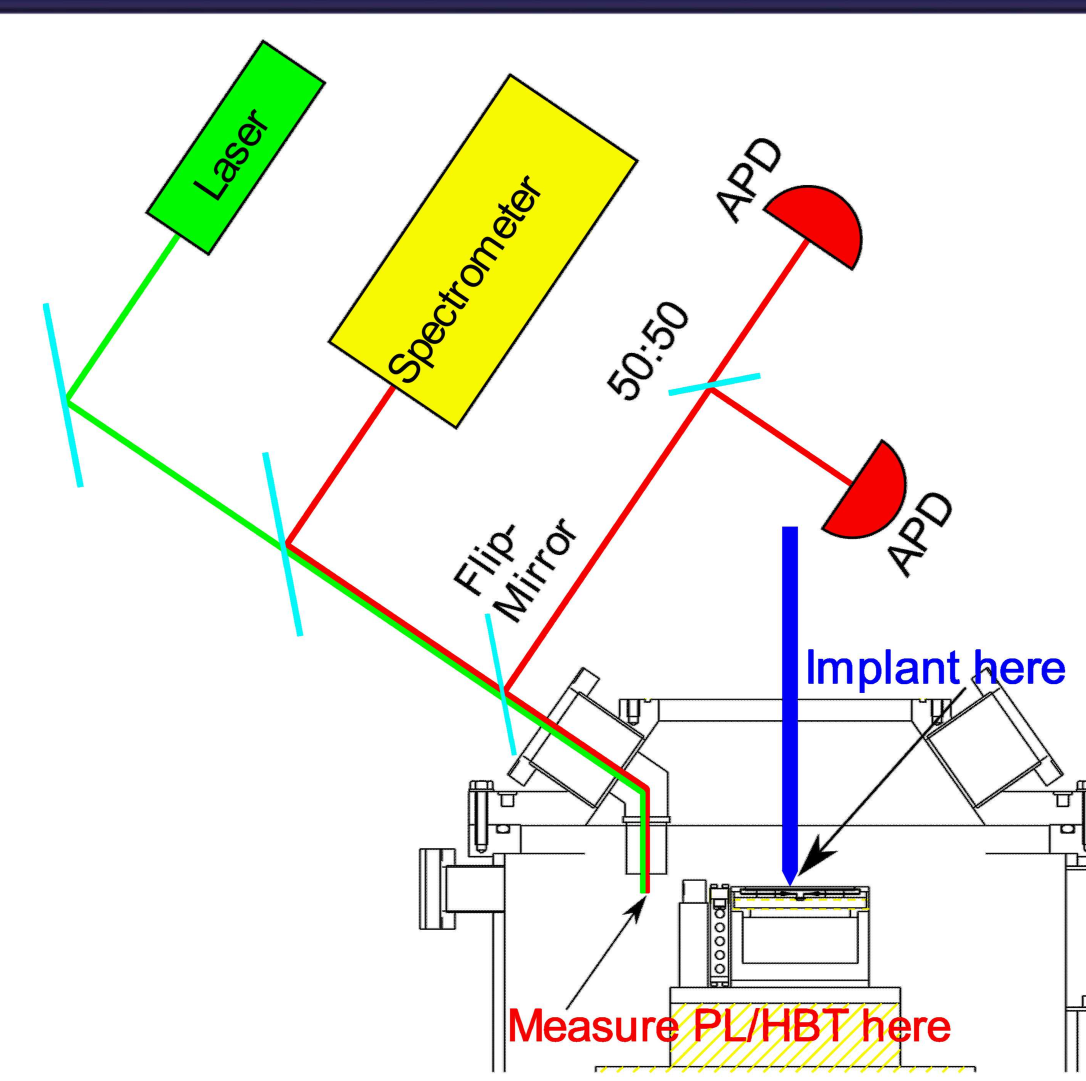
V_{Si} in SiC

- ≥ 5 % yield
- No annealing necessary to see photoluminescence

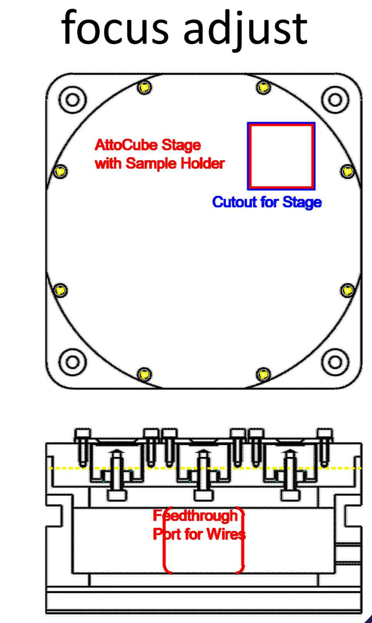
Start with SiC
Then try diamond

Already know how to do counted implants, add in optical measurement

Design of the In-situ Optical Setup



Need new sample holder with focus adjust



Component	Efficiency (%)
SiC Yield	5
50:50 BS (HBT measmt.)	45
NA (Collection)	35
Objective (Transmission)	80

Estimated Efficiency 10 %

Expect 10^4 cps with 1mW pump

This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science. Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. DOE's National Nuclear Security Administration under contract DE-NA-0003525. The views expressed in the article do not necessarily represent the views of the U.S. DOE or the United States Government.

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