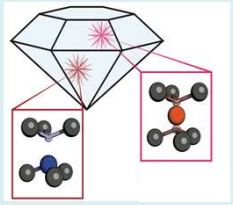
Nanophotonics for telecom quantum networks based on neutral silicon vacancy centers in diamond

Ding Huang, Alex Abulnaga, Sacha Welinski, Brendon C. Rose, Zi-Huai Zhang, Paul Stevenson, Nathalie P. de Leon
Department of Electrical Engineering, Princeton University

Requirements for quantum networks:

- Long lived quantum memory
- Efficient spin-photon interface
- Identical photons
- Telecom wavelength

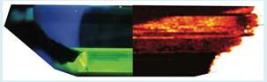
Prior work on color centers in diamond:



NV^- centers have long electron spin coherence, poor optical properties

SiV^- centers have better optical properties, poor spin coherence

Neutral silicon vacancy centers

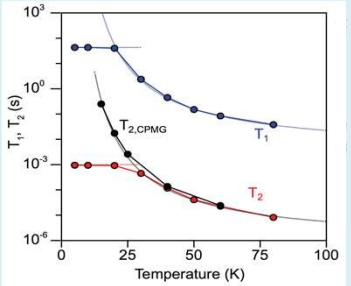


Key idea—Fermi level engineering to stabilize neutral charge state of SiV, access new spin configuration

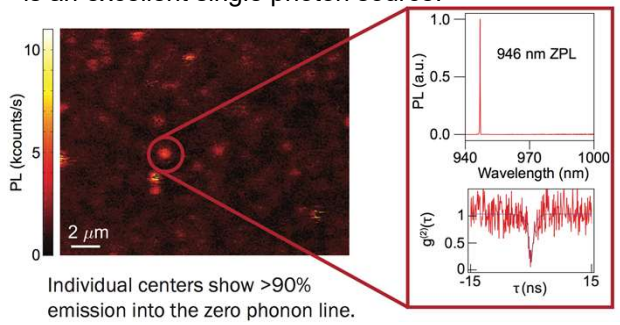
SiV^0 is a long lived quantum memory:

T_1 ~ 1 minute

T_2 ~ 1 second

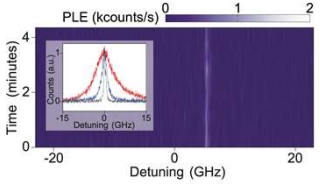


SiV^0 is an excellent single photon source:

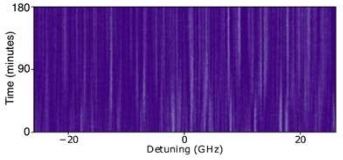


Individual centers show >90% emission into the zero phonon line.

Near-transform-limited linewidth, low saturation power

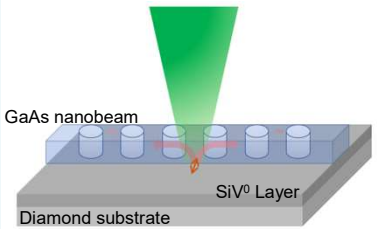


Ensemble PLE shows all centers have narrow lines over hours



"Observation of an environmentally insensitive solid-state spin defect in diamond" - Rose*, Huang*, et al, Science, 361, 60-63 (2018)

Heterogeneously integrated GaAs-on-diamond photonic platform



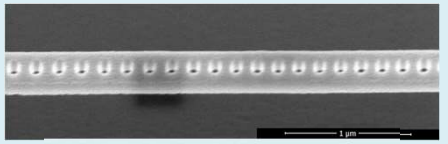
946 nm optical emission allows for use of GaAs, a mature photonic platform

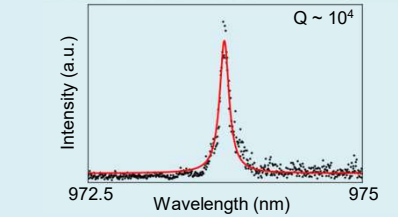
Evanescent coupling to SiV^0 in diamond substrate

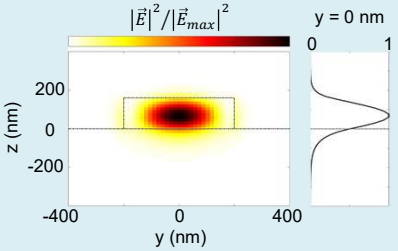
Fully integrated nanophotonic circuit using GaAs-on-diamond

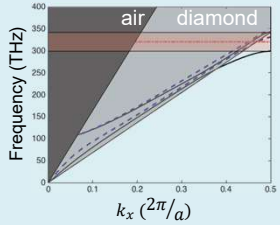
Collaboration with Jeff Thompson, Loren Pfeiffer

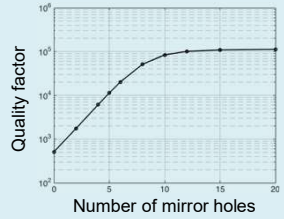
Photonic crystal cavity design





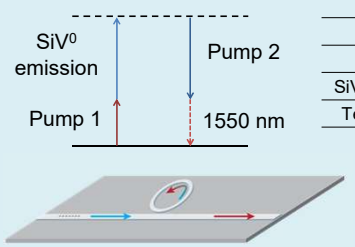




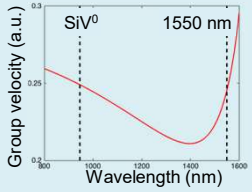


Electric field intensity at SiV^0 layer around 30% of peak value

On-chip quantum frequency conversion scheme



3 dB attenuation distance in single mode fibers	
Yb^+ ions: 370 nm	< 50 m
NV^- center: 637 nm	300 m
SiV^- center: 737 nm	520 m
Rb atom: 780 nm	750 m
SiV^0 center & QDs: ~946 nm	1.5 km
Telecom C-band: 1550 nm	15 km



Experiments with other material platforms:
Srinivasan group, Nat. Photonics, 2016 (SiN); Radic group, PRL, 2010 (SiO_2)

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