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EMISSION CHARACTERISTICS OF SOLID-STATE COLOR CENTERS COUPLED TO PLASMONIC ANTENNAE & WAVEGUIDES

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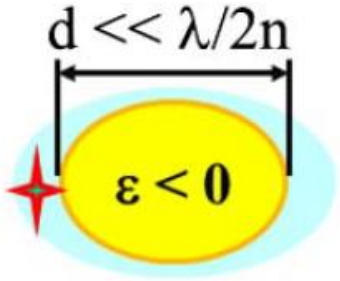
Plasmonics for controlling quantum emitters

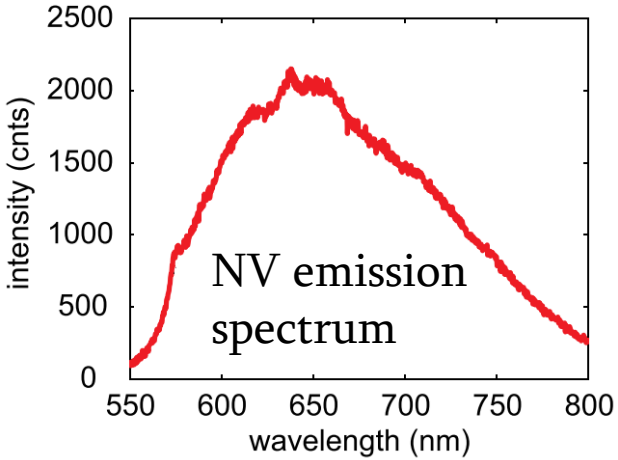
1. Emission rate enhancement 100 times higher than in dielectric cavities



$V/V_0 \sim 10^{-5}$-10^{-6}

more details: Bozhevolnyi, Khurgin, Optica 2016

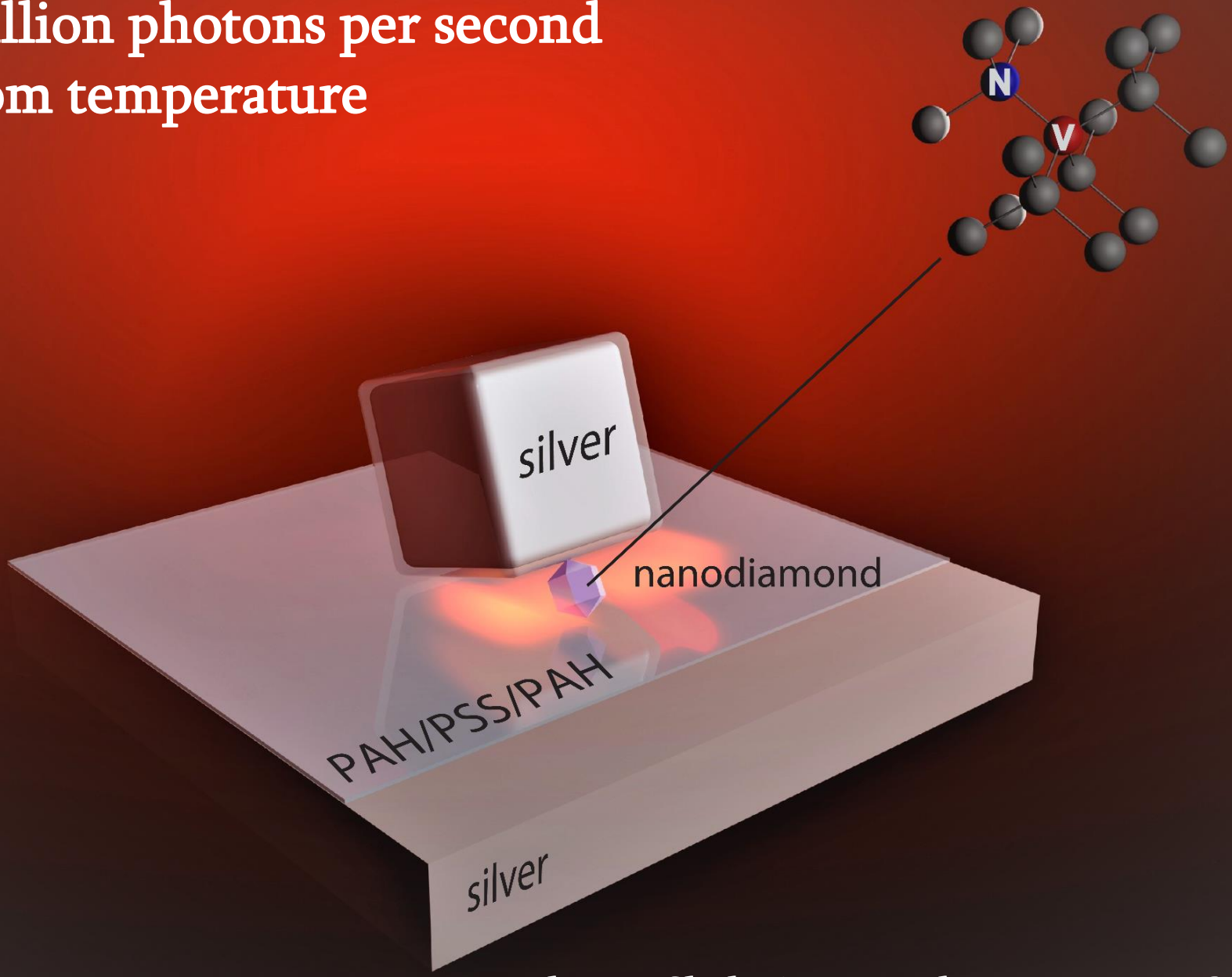
2. Match broad emission spectra of room-temperature emitters



$Q \sim 1$-100

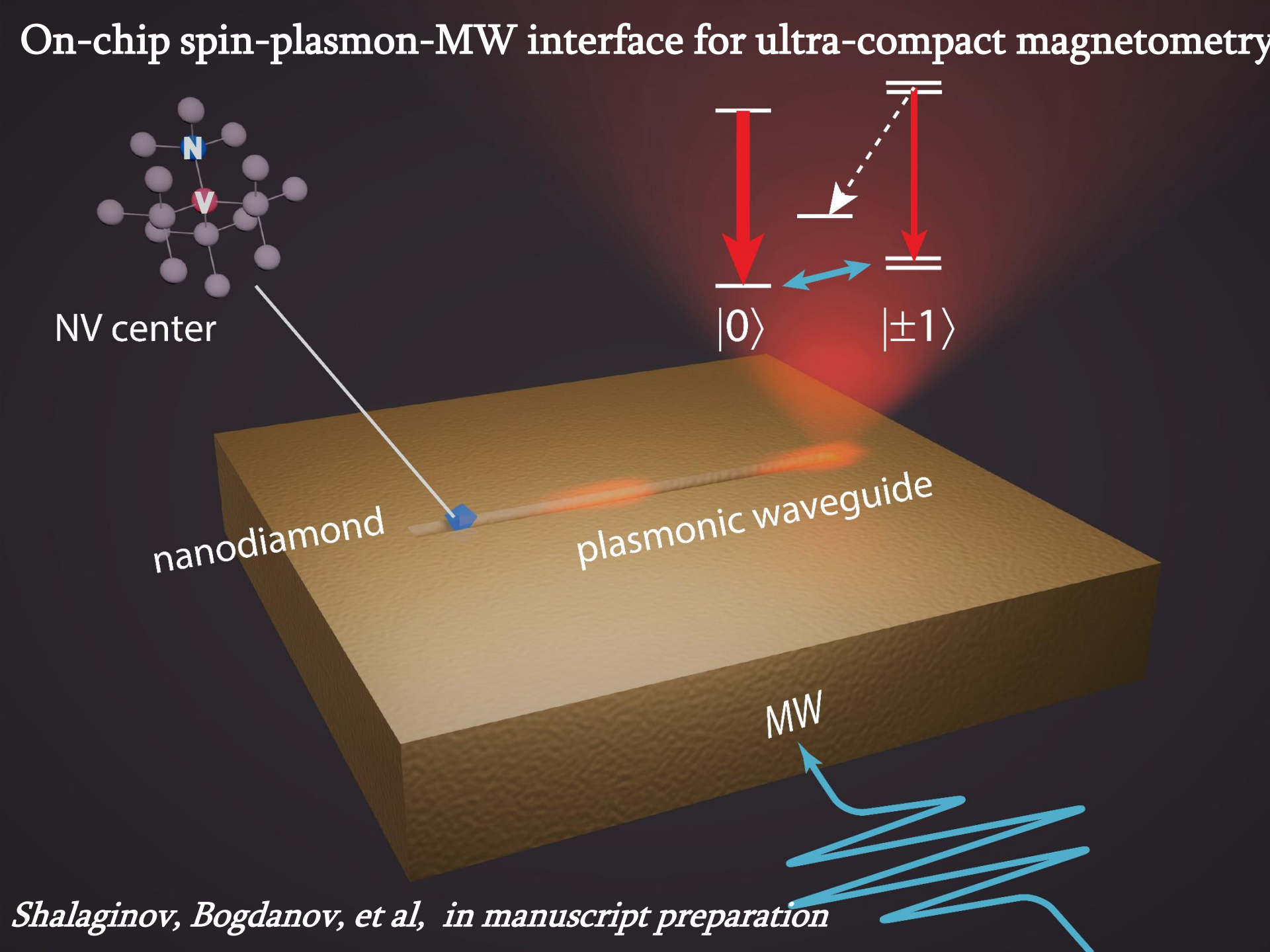
3. Made of conductive materials, which can also guide electrical signals

Single NV centers produce 30 million photons per second at room temperature



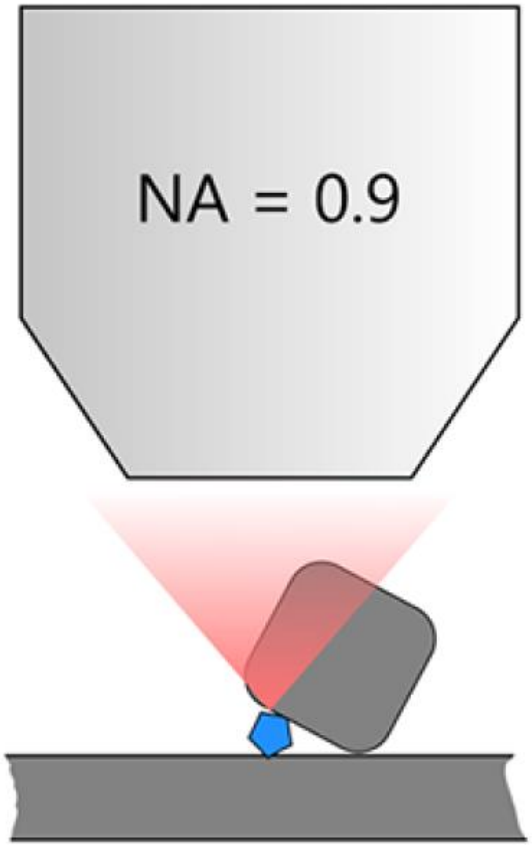
Bogdanov, Shalaginov, et al, Nano Letters 2018

On-chip spin-plasmon-MW interface for ultra-compact magnetometry



Shalaginov, Bogdanov, et al, in manuscript preparation

Electromagnetic waves simulations in frequency domain



Layout for collecting signal from an NV coupled to nanopatch antenna (NPA)

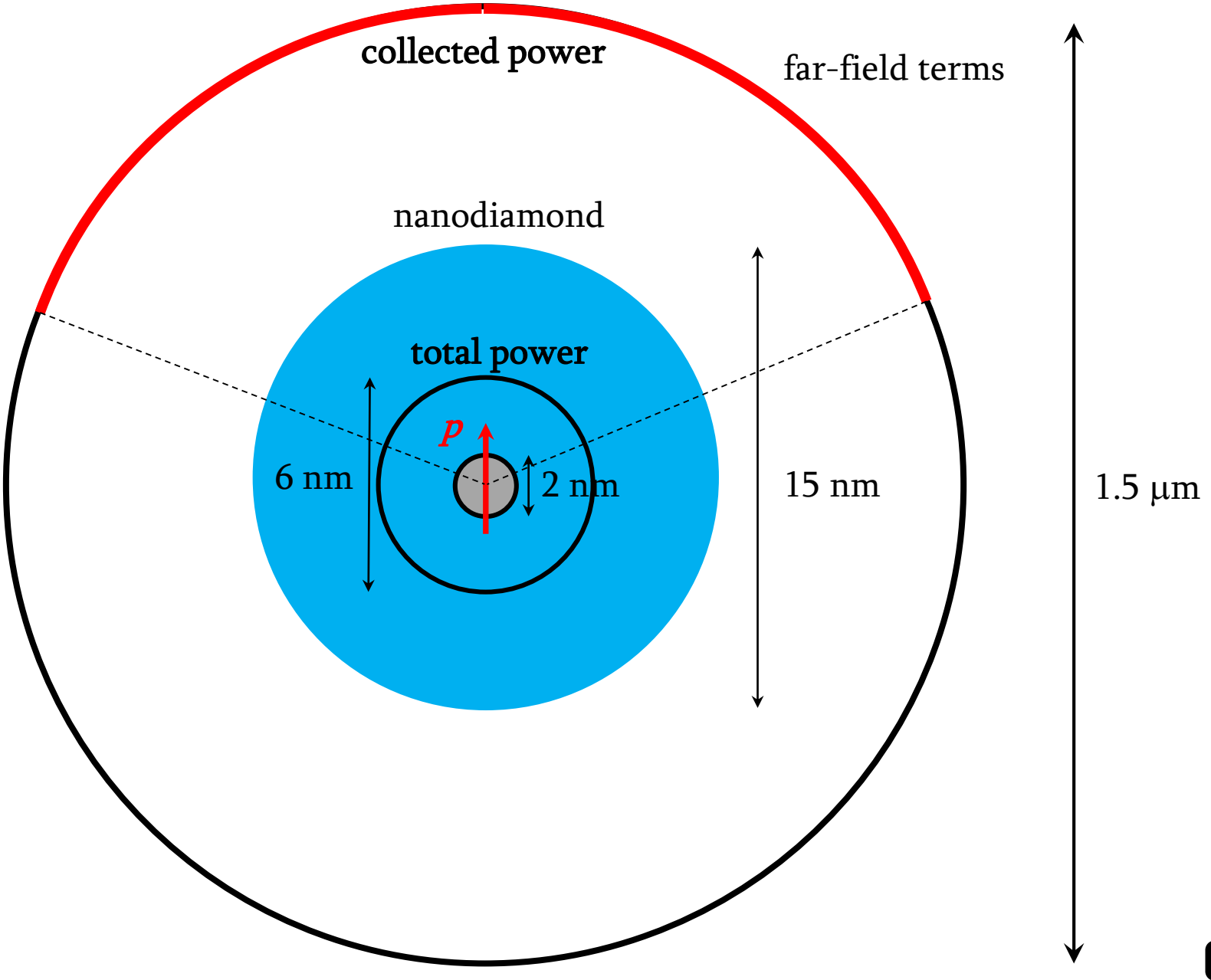
Outputs

- Total released power (decay rate)
- Radiation pattern/collection efficiency

Inputs

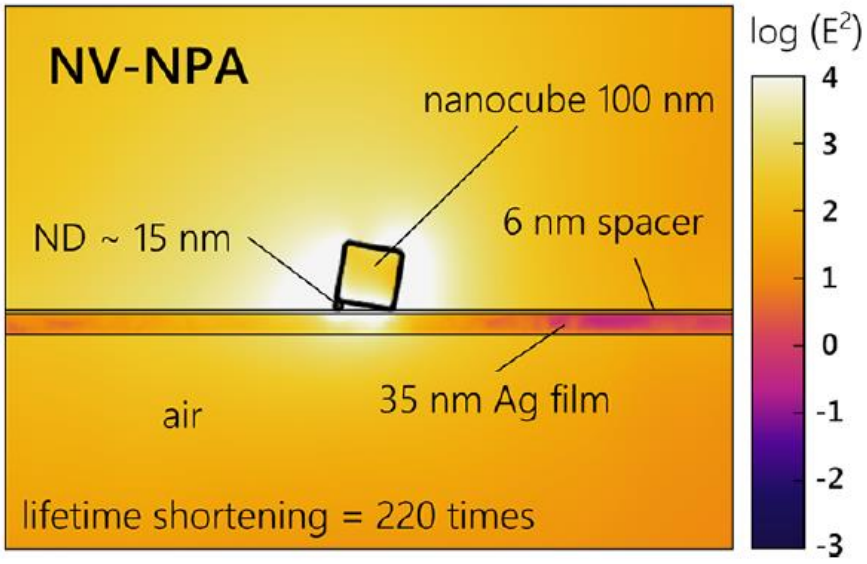
- Geometry: antenna, diamond
- Materials: diamond, silver (from ellipsometry measurements), polymers
- Settings: full-field, wavelength, dipole source, PML boundaries

Waves & Optics Module: power flow integrals

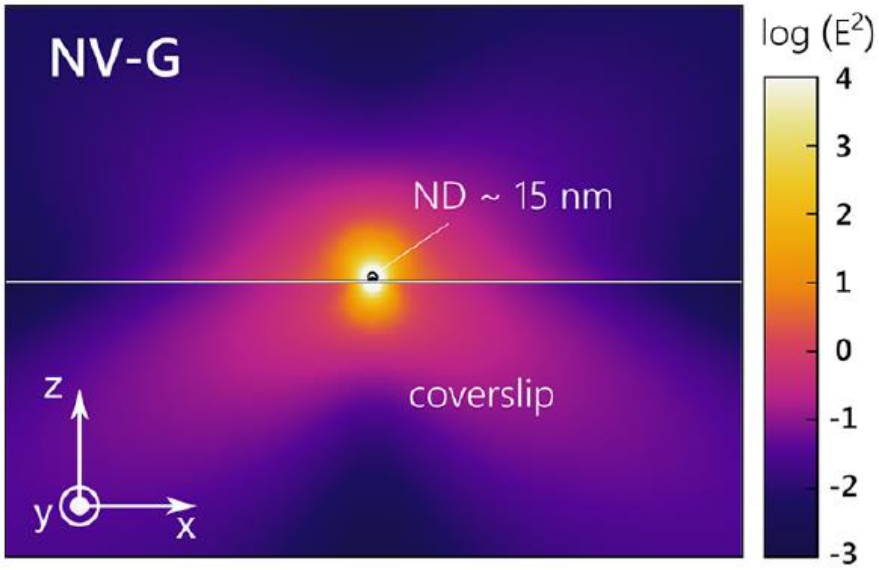


Results of electro-magnetic simulations

NV nanodiamond with NP antenna (NPA)



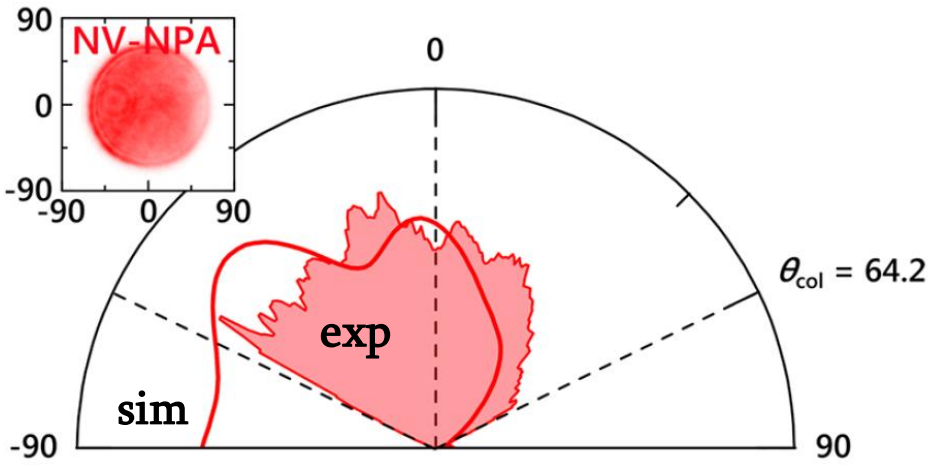
NV nanodiamond on glass (G) - reference



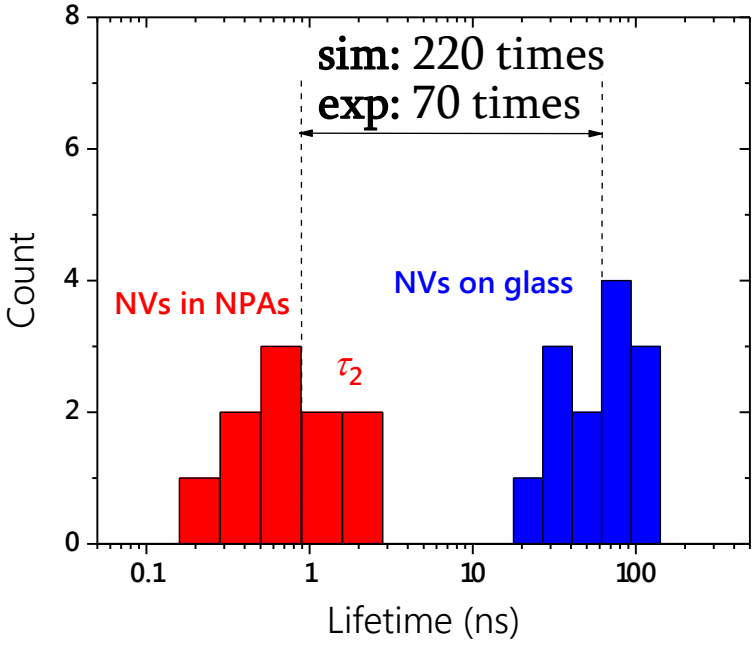
	NV-NPA	NV-G
total decay rate, ns^{-1}	0.39^{-1}	84.5^{-1}
collection efficiency, %	45	85

rate enhancement (Purcell factor) – 220; collection efficiency – 45%

Comparison with experimental results



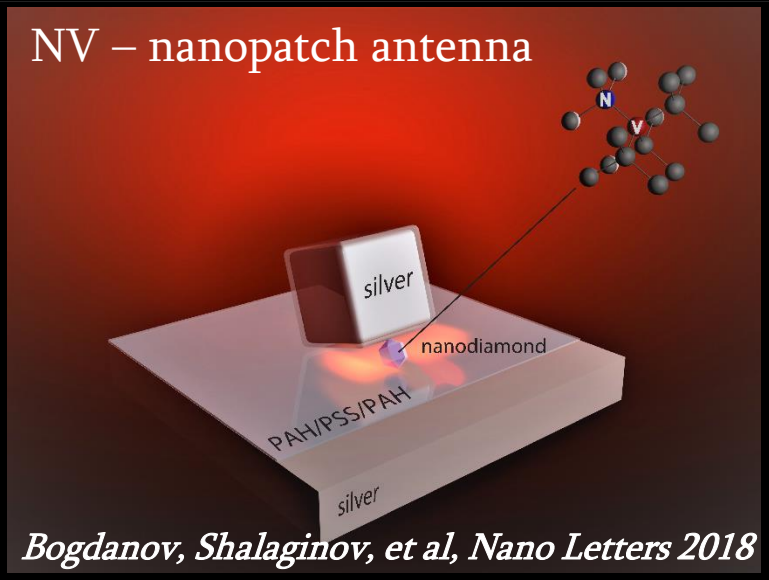
back-focal plane measurements

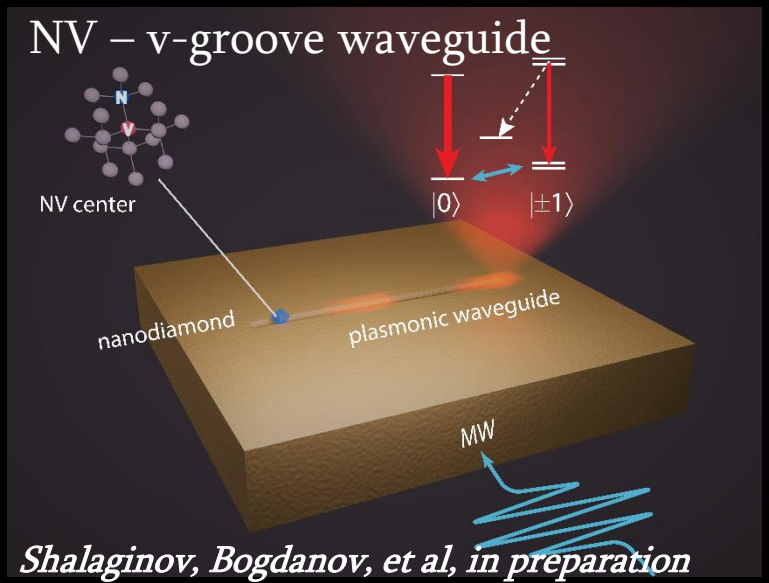


emission lifetime statistics

- Simulations provide an upperbound on emission rate enhancement and qualitative agreement with the radiation pattern.
- Possible origins of discrepancies: misaligned dipole orientation, spectral mismatch & nonunity quantum yield

Summary





- Plasmonics is an attractive platform for room-temperature quantum nanophotonics
- COMSOL simulations can be used for upper-limit estimations of rate enhancement & collection/coupling efficiencies

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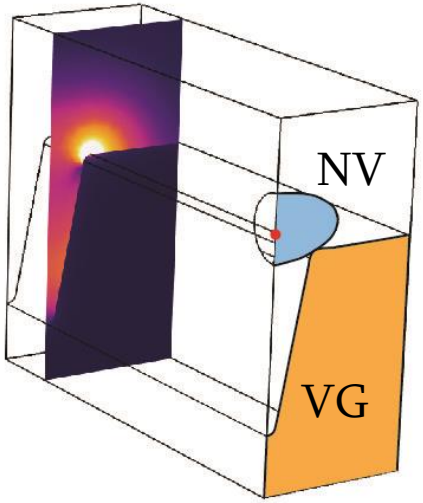
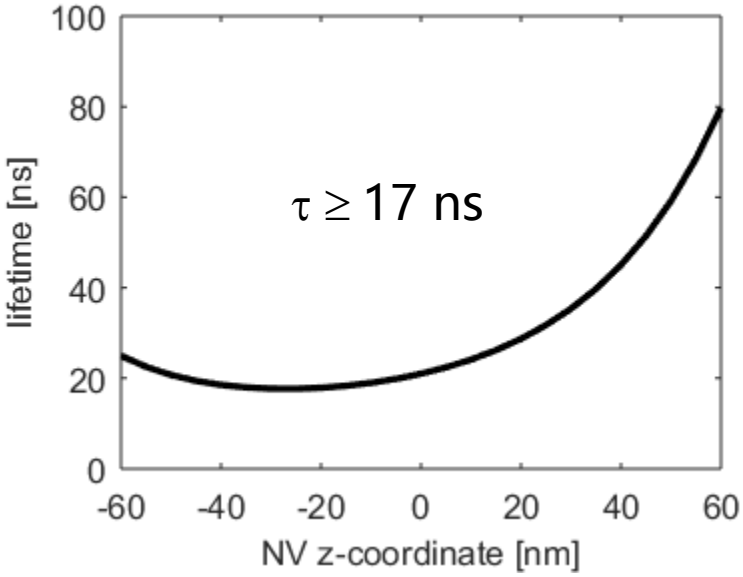
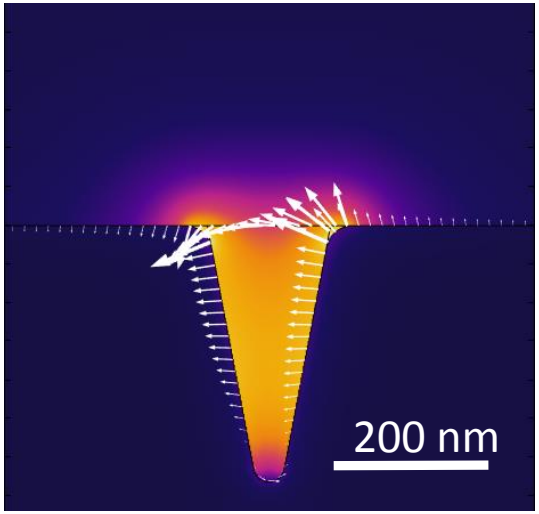
Simulations: low Purcell factor and high coupling efficiency

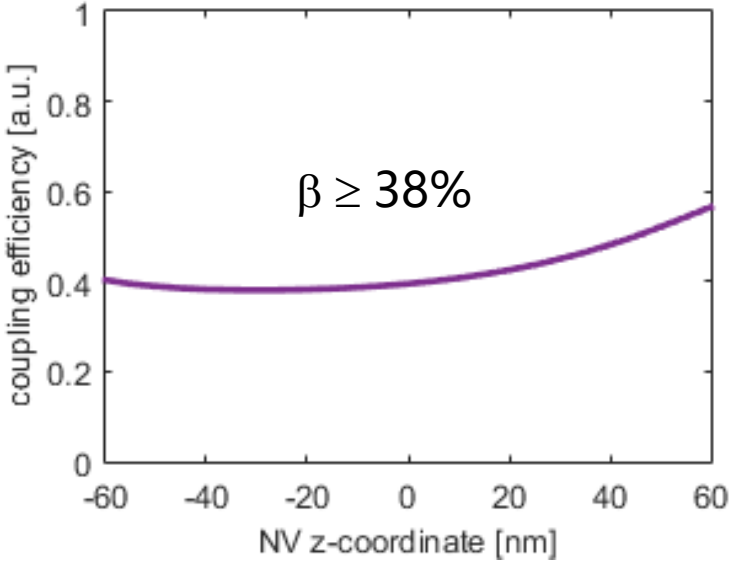


3D domain of numerical simulations

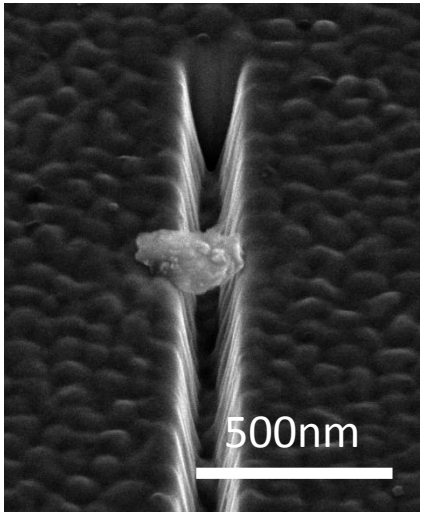




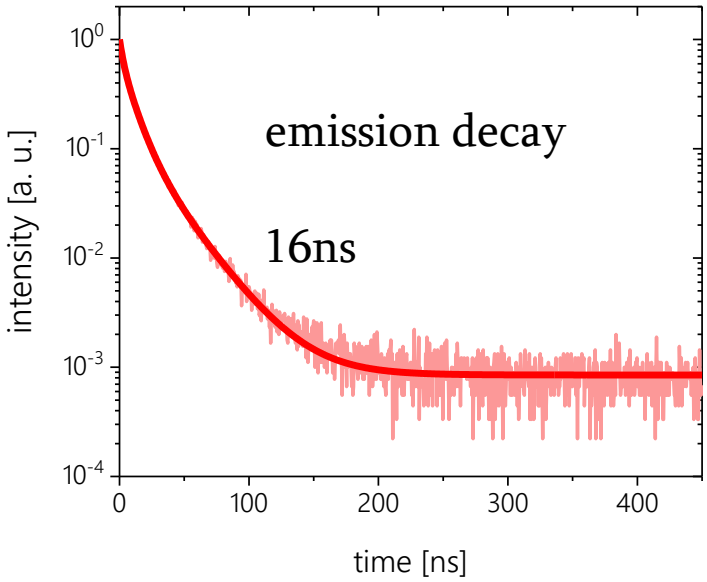
E-field of VG fundamental mode at λ 665nm

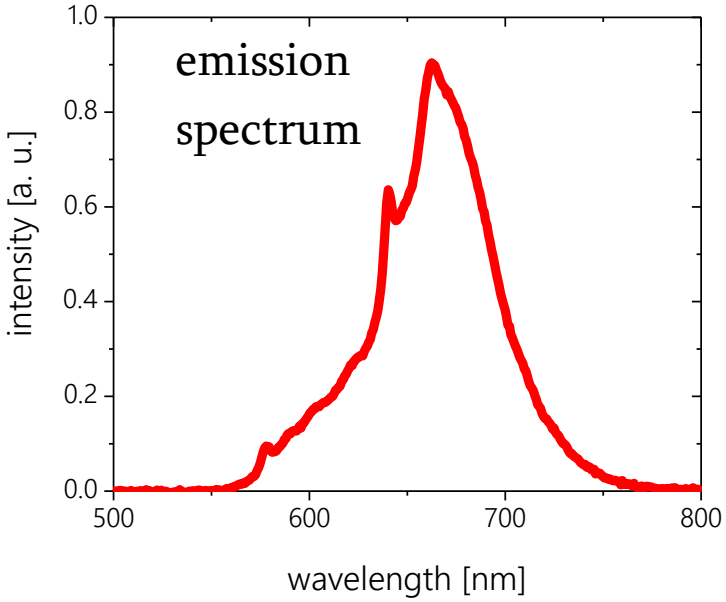


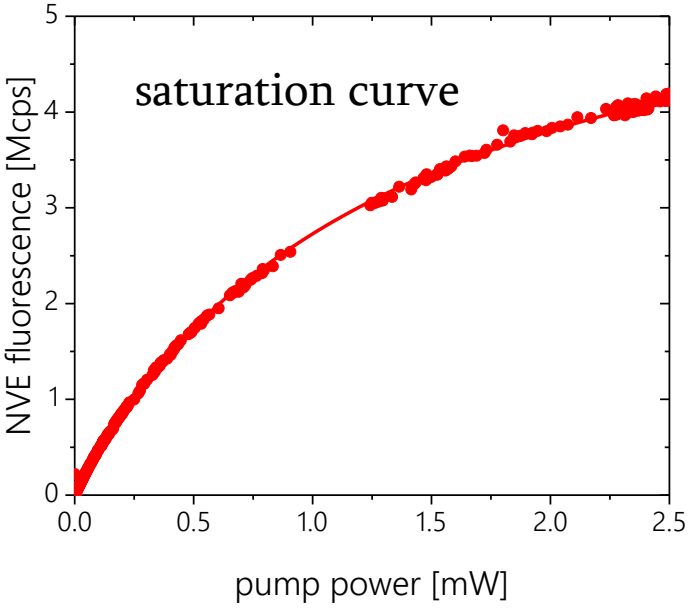
Nanodiamond in a vgroove: photophysical properties

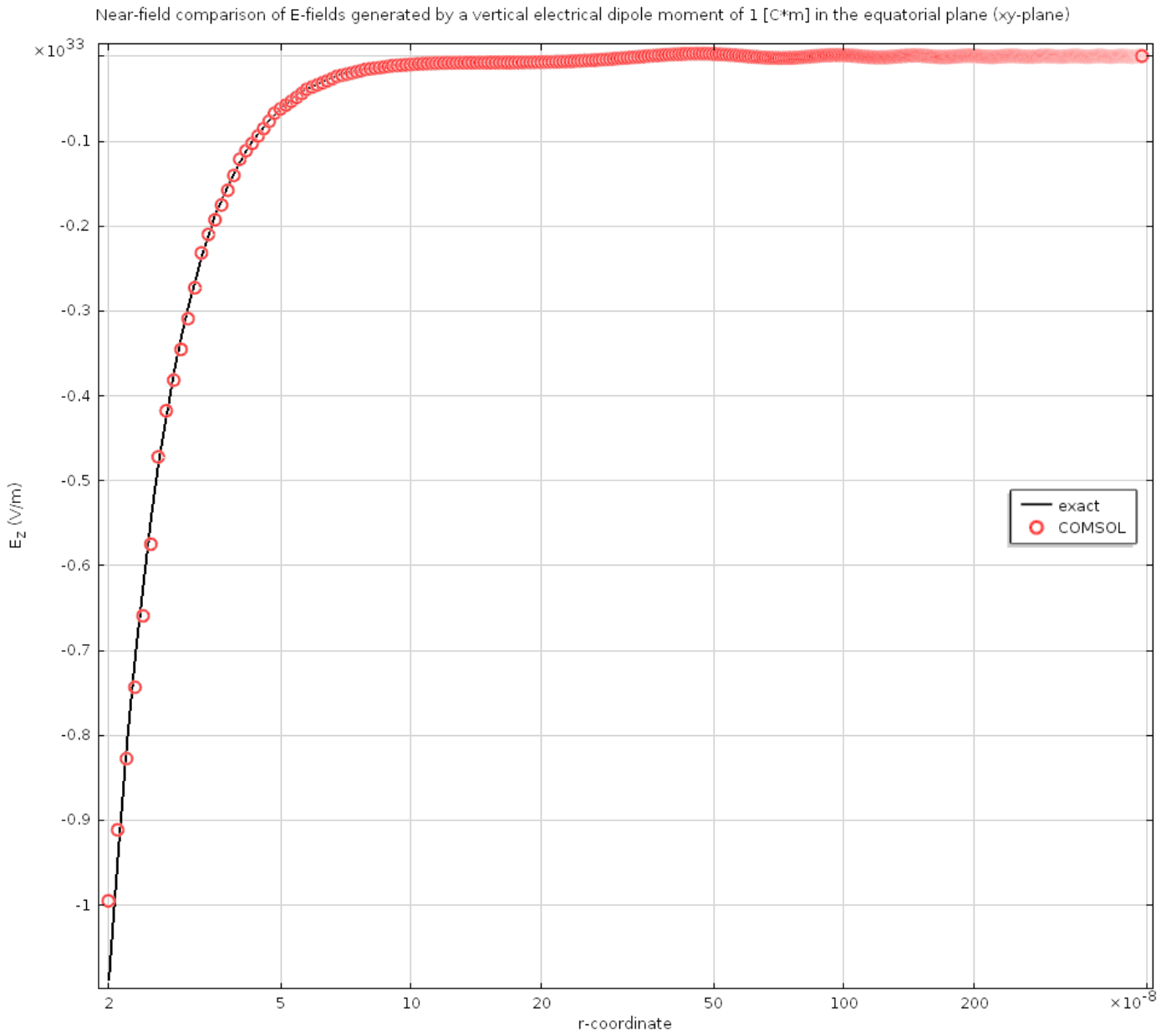


SEM scan of ND inside fabricated VG








Near-field comparison of E-fields generated by a vertical electrical dipole moment of 1 [C*m] in the equatorial plane (xy-plane)
×10^33
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
E_z (V/m)
exact
COMSOL
2
5
10
20
50
100
200
×10^-8
r-coordinate