

Supplemental information:

Adjoint-optimized nanoscale light extractor for nitrogen-vacancy centers in diamond

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S1. Near-field comparison with and without the NLE

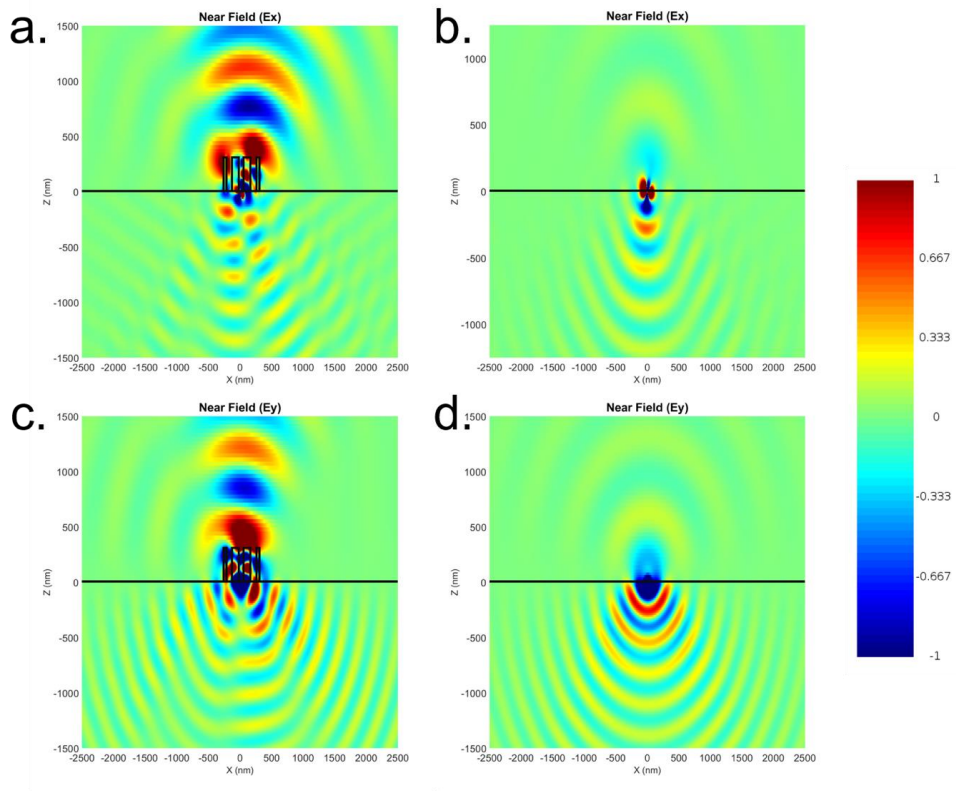


Figure S1. A snapshot of the electric fields in the vicinity of the NV center taken along a slice in the XZ plane at $y = 0$ (the center of the device and the y-coordinate of the NV), at a wavelength of 675 nm. Here we directly compare the X components of the electric field for the dipole in the XZ plane (a) with and (b) without the NLE, and the Y components of the electric field for the dipole in the XY plane (c) with and (d) without the NLE. The NLE is outlined in black for reference.

S2. FoM vs. the NLE angle with respect to the NV orientation

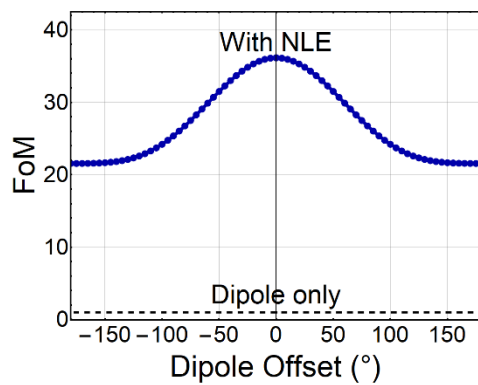


Figure S2. The full rotational robustness of the NLE demonstrated by rotating the NV emitter a full 360° around the Z axis.

S3. Far-field $|E|^2$ plots for select wavelengths across 635 – 800 nm

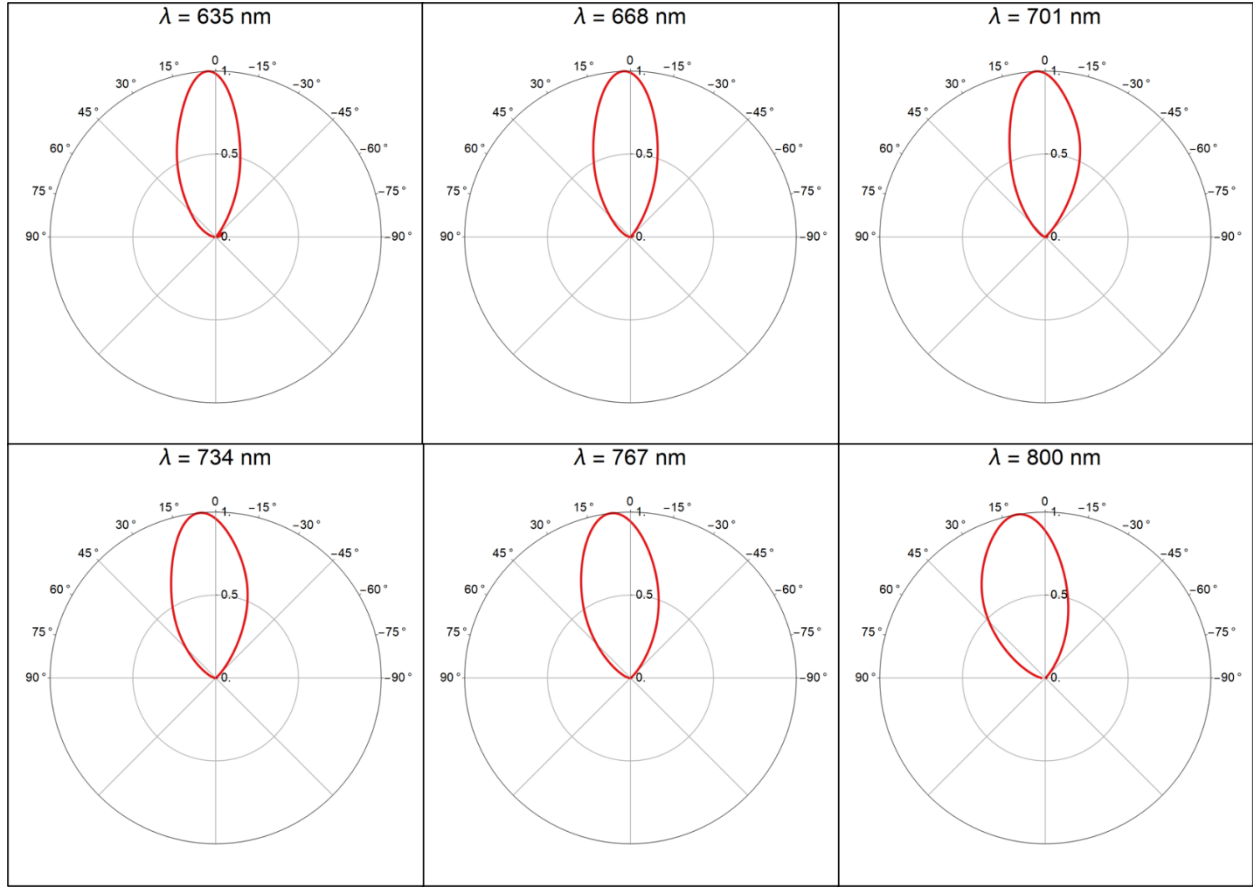


Figure S3. To make sure the beaming capabilities of our device are maintained over the full 635 – 800 nm spectrum we simulated and calculated the far-field $|E|^2$ intensities for multiple other wavelengths besides the one presented in Figure 3(d). Here we plot slices of the field profiles at an azimuthal angle of 0° and along a polar angle of $\pm 90^\circ$ for wavelengths 635, 668, 701, 734, 767, and 800 nm. The far-fields are normalized to the peak intensity over the full hemispherical projection ($-90^\circ \leq \theta \leq 90^\circ$ and $0 \leq \phi \leq 360^\circ$) so the peaks in some plots occur at another azimuthal angle. The peak intensity always stays within $\pm 15^\circ$ of the normal with only minor variations between the different wavelengths.

S4. Collection efficiency, reflection, and absorption

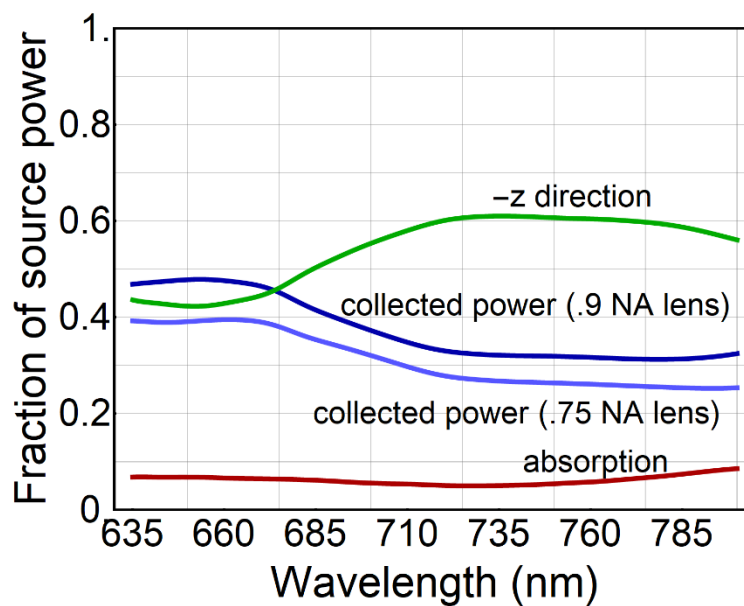


Figure S4. Breakdown of light emitted by the NV center in the presence of the NLE. The collection efficiency is defined as the fraction of emitted power can be collected by a lens with a specific NA. The power recorded in the -z direction is defined as the power flow downwards through a plane placed 100 nm below the NV center and diamond interface. The absorption is calculated as $1 - (\text{power going towards } +z) - (\text{power going towards } -z)$. The power flow is normalized to the full, Purcell-enhanced output power of the dipole source and averaged between the two dipole orientations.