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**Title:** Plasmonic nanodiscs on vanadium dioxide thin films for tunable luminescence enhancement

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SUPPORTING INFORMATION: Plasmonic nanodiscs on thin film vanadium dioxide for tunable luminescence enhancement

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From the modelling point of view the photoluminescence (PL) spectrum of the nanosystems can be described by:

$$PL(\lambda) = I_{inc}N\sigma_{Abs}(\lambda) \cdot \Omega \cdot \eta \cdot f_0(\lambda)$$

where $f_0(\lambda) = PL_{exp}(\lambda) \frac{1}{\int PL_{exp}(\lambda) d\lambda}$ is the integral-normalized experimental PL spectrum $PL_{exp}(\lambda)$ of the quantum emitter with $\int f_0(\lambda) d\lambda = 1$, $I_{inc}$ is the incident excitation intensity in W/m², $N$ is the number of emitters, in the manuscript we consider $N=1$, $\sigma_{Abs}(\lambda)$ is the absorption cross-section of the emitter at the laser excitation wavelength and $\Omega$ is a function accounting for experimental response function including the detection direction, detector area and sensitivity. This is chosen so that the total detected fluorescence radiance, often called intensity, is calculated where

$$\int f_0(\lambda) d\lambda$$

represents the total number of detected photons per second. The following parameters associated with the intrinsic optical properties of the quantum emitters can be determined experimentally:

(1) The molar extinction coefficient $\varepsilon_M(\lambda)$ from which the extinction cross section $\sigma_{ext}(\lambda) = \ln(10) \frac{\varepsilon_M}{N_A} \varepsilon_M(\lambda)$ can be calculated where $N_A$ is the Avogadro constant. $\sigma_{ext}(\lambda) = \sigma_{Abs}(\lambda) + \sigma_{Scat}(\lambda) \approx \sigma_{Abs}(\lambda)$, since the scattering cross-section $\sigma_{Scat}(\lambda)$ of the emitter is negligible compared with the absorption cross section $\sigma_{Abs}(\lambda)$, it can be neglected in the first instance.

(2) The fluorescence spectra $PL_{exp}(\lambda)$ and the intensity $I_{PL,exp} = \int PL_{exp}(\lambda) d\lambda$

(3) the fluorescence lifetime $\tau_{PL}$ and the quantum yield $\eta$ of the quantum emitters, which can both be measured in solutions of low emitter concentration.

Introducing the total decay rate constant $\gamma_T = \frac{1}{\tau_{PL}}$ and the rate constants $\gamma_R$ and $\gamma_{NR}$ for the radiative decay and non-radiative decay, respectively, we get $\frac{1}{\tau_{PL}} = \gamma_R + \gamma_{NR}$ and the quantum yield $\eta = \gamma_R \cdot \tau_{PL} = \frac{\gamma_R}{\gamma_R + \gamma_{NR}}$. The radiative rate $\gamma_R = n^2 \gamma_0 q$ is modified by the solvent refractive index $n$, while $\gamma_{NR} \approx n^4$ is not. For the calculation of the modified decay rates in the system the free space values $\gamma_0$ and $\gamma_{NR}$ are essential, so that the solvent refractive index $n$ must be considered. In order to ensure that our findings are realistic, in this manuscript we consider only commercially available quantum dots and dye molecules from the Alexa series with tabulated quantum yields $\eta$, lifetimes $\tau_{PL}$ and molar extinction coefficients $\varepsilon_M$ as well as absorption and emission spectra in diluted buffer solutions (Table S1), which are offered by Thermo Scientific [1].

| Emitter        | $\eta$ | $\tau_{PL}$ [ns] | $\varepsilon_M$ [cm^3/Molecule] | $\lambda_{Exc}$ [nm] |
|----------------|--------|------------------|---------------------------------|----------------------|
| Alexa Fluor 647| 0.33   | 1                | 270000                          | 632                  |
| Alexa Fluor 700| 0.25   | 1                | 205000                          | 670                  |
| Alexa Fluor 750| 0.12   | 1                | 290000                          | 705                  |
| Alexa Fluor 790| 0.12   | 1                | 260000                          | 730                  |
| Qdot® 800      | 0.83   | 20               | 10600000                        | 730                  |

Table S1. Intrinsic optical properties of the quantum emitters: Quantum yields $\eta$, lifetimes $\tau_{PL}$ and molar extinction coefficients $\varepsilon_M$ as well as the excitation wavelength $\lambda_{Exc}$ used within the model.

To account for laser excitation, we introduce an excitation rate

$$\gamma_{Exc}(\lambda_{Exc}) = \sigma_{Abs}(\lambda_{Exc}) \frac{I_{inc}}{E_{photon}(\lambda_{Exc})} \cdot |\vec{\mu}_{q} \cdot E_{loc}(r,\lambda_{Exc})|^2$$
with \( E_{\text{photon}}(\lambda_{\text{exc}}) = \frac{hc}{\lambda_{\text{exc}}} \) the energy of one excitation photon, \( \vec{\mu}_Q \) is the transition dipole moment of the emitter and \( \vec{E}_{\text{loc}}(r, \lambda_{\text{exc}}) \) the local excitation field at the position of the emitter. In the first instance, we assume the emitter transition dipole \( \vec{\mu}_Q \) is perfectly aligned to the local fields, \( \vec{\mu}_Q \parallel \vec{E}_{\text{loc}}(r, \lambda_{\text{exc}}) \).

We introduce the excitation modification:

\[
 g_{\text{Exc}}(\lambda_{\text{exc}}) = \frac{|\vec{\mu}_Q \cdot \vec{E}_{\text{loc}}(r, \lambda_{\text{exc}})|^2}{|\vec{\mu}_Q \cdot \vec{E}_{\text{vac}}(r, \lambda_{\text{exc}})|^2} \quad \text{and with} \quad |\vec{\mu}_Q \cdot \vec{E}_{\text{vac}}(r, \lambda_{\text{exc}})|^2 = 1, \quad \text{we rewrite} \quad \gamma_{\text{Exc}}(\lambda_{\text{exc}}) = g_{\text{Exc}}(\lambda_{\text{exc}}) N(\lambda_{\text{exc}}),
\]

where \( N(\lambda_{\text{exc}}) = \sigma_{\text{Abs}}(\lambda_{\text{exc}}) \frac{I_{\text{inc}}}{P_{\text{photon}}(\lambda_{\text{exc}})} \) refers to the number of photons absorbed per unit time by a specific emitter in free space and \( \lambda_{\text{exc}} \) is taken at the wavelength of an appropriate laser excitation source for each emitter. The incident intensity \( I_{\text{inc}} \) is set to 1 \( \text{W cm}^{-2} \) which translates to an excitation spot of 1 \( \mu\text{m}^2 \) and a laser power of 10 nW. In experiments 50 - 100 times higher excitation intensities are usually used [2]. Rewriting \( I_{PL} = \int P(L) \, d\lambda \) yields the known formula for the fluorescence intensity \( I_{PL} = \gamma_{\text{Exc}} \eta \cdot \Omega = \gamma_{\text{Exc}} \tau_f \gamma_R \Omega \) and for the fluorescence spectrum \( P(L) = \gamma_{\text{Exc}} \cdot \tau_{PL} \cdot \gamma_R \cdot \Omega \cdot f_0(\lambda) \).

The excitation rate \( \gamma_{\text{Exc}} \), and the quantum yield, \( \eta \), of an emitter on top of a VO\(_2\) thin film can be determined via two separate numerical calculations, namely the calculation of the excitation modification \( g_{\text{Exc}}(\lambda_{\text{exc}}) \) and the calculation of \( \gamma_R \) and \( \tau_{PL} \).

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Fig. S1. (a) Real and imaginary parts of the dielectric function of a VO\(_2\) thin film in the semiconducting (SC) and in metallic (M) phases. (b) Schematic of the model used for the calculation of \( g_{\text{Exc}}(\lambda_{\text{exc}}) \). Plane wave (TFSF source) excitation was normally incident on the substate. \( g_{\text{Exc}}(\lambda_{\text{exc}}) \) is evaluated at specific positions with point field monitors. (c) We define the dipole orientations along the x direction as radial (R), along the y axis as tangential (T) and along the z axis as perpendicular (P). (d) Schematic of the positions of quantum emitters considered in (e). Alexa790 dye emitters are positioned at three different heights above the VO\(_2\) film: 5 nm (Pos. A), 20 nm (Pos. B), and 40 nm (Pos. C). (e) Changes in the interaction of Alexa790 dye emitters, located at the positions A-C, on a 15 nm VO\(_2\) thin film, upon the VO\(_2\) phase transition.

Here we used the FDTD solver of the commercially available Lumerical Device Suite software [3]. The simulation volume is set as a cube with 1.5 \( \mu\text{m} \) side length with perfectly matched layers (PML) used as boundary conditions.
We start our investigation with a VO2 film thickness of 15 nm on a silica substrate (n=1.5). Although, c-plane sapphire is the preferred substrate for VO2 deposition due to its lattice match with VO2, it is less ideal for fluorescence experiments, as a strong fluorescence arising from point defects is observed when the Al2O3 are excited with lasers in the visible spectral range, though this defect emission can be filtered out [4]. A VO2 thickness of 15 nm film guarantees a continuous, smooth film with a substantial phase change. The dielectric functions of VO2 in the semiconducting (SC) and in metallic (M) phase we used the dielectric functions of a VO2 film (30 nm) measured via ellipsometry, Fig. S1(a).

For the calculation of \( g_{\text{Exc}}(\lambda_{\text{Exc}}) \) a plane wave total-field scattered-field (TFSF) source was used as the excitation source of the system, Fig. S1(b). The plane wave had x-polarization in the coordinate system of our model and was normally incident on the substrate.

In our model, the dye molecules and quantum dots are treated as electric dipole emitters and are located at various positions, r. Therefore, \( g_{\text{Exc}}(\lambda_{\text{Exc}}) \) is evaluated at these positions r with the aid of point field monitors.

The modified radiative rate \( \gamma_{\text{R}}(\lambda_{\text{Exc}}) \) of an isolated electric dipole in free space is defined as \( \Gamma_0 = \frac{\gamma_0}{\hbar \omega} \), where \( P_0 \) [W] is the total power radiated by the dipole in the whole solid angle (4\( \pi \) steradians). Upon the phase transition the optical properties of the VO2 change and, consequently, the optical properties of the quantum emitter will be modified by the presence of the VO2 thin film. Numerically we can calculate the Purcell Factor \( g_{\text{P}}(\lambda_{\text{P}}) = \frac{P_{\text{EM}}}{P_0} \) by calculating the total radiated power \( P_{\text{EM}} \) [W] by an electric dipole in the presence of the VO2 thin film. Since \( P_{\text{EM}} \) [W] has to be calculated for the whole solid angle, in our model \( P_{\text{EM}} \) [W] is the transmitted power though all faces of a 3D box surrounding the emitter and the system, the substrate and the VO2 film, shown as the magenta box in Fig. S1(c). The Purcell factor \( g_{\text{P}}(\lambda_{\text{P}}) = \frac{P_{\text{EM}}}{P_0} = \sum_{\Box} T_{i} \) can be determined by summing the transmission \( T_{i} \) through each face of the 3D Box surrounding the emitter and the system, indicated by the blue and green arrows in Figure S1c.

The modified radiative rate \( \gamma_{\text{R}}(\lambda_{\text{Exc}}) \) of an emitter on the VO2 thin film is described by

\[
\gamma_{\text{R}}(\lambda_{\text{Exc}}) = \gamma_{\text{R}} \int_{400}^{1000} f_0(\lambda) g_{\text{P}}(\lambda_{\text{P}}) d\lambda
\]

In contrast to conventional dielectric substrates with negligible absorption, the imaginary part of the dielectric functions of the VO2 film in both phases can’t be neglected. This is due to additional nonradiative decay pathways existing for the quantum emitter in the presence of the VO2 thin film. These additional nonradiative decay paths are described by a rate \( \gamma_{\text{Loss}}(\lambda_{\text{P}}) \) accounting for all losses due to the VO2 thin film

\[
\gamma_{\text{Loss}}(\lambda_{\text{P}}) = \gamma_{\text{R}} \int_{400}^{1000} f_0(\lambda) g_{\text{Loss}}(\lambda_{\text{P}}) d\lambda \]

\( g_{\text{Loss}}(\lambda_{\text{P}}) = \frac{P_{\text{Abs}}}{P_0} = \frac{P_{\text{Dip}} - P_{\text{EM}}}{P_0} \)

can be calculated as the total absorbed power in the system. \( P_{\text{Dip}} \) is the total emitted power by the electric dipole in the presence of the VO2 thin film. As with the calculation of \( P_{\text{EM}} \), \( P_{\text{Dip}} \) is numerically calculated with the aid of 3D box surrounding the electrical dipole. Considering the intrinsic non-radiative rate of the real emitter, \( \gamma_{\text{NR}} \), which isn’t altered, the modified decay times can be calculated as follows

\[
\tau_{\text{PL}}(\lambda_{\text{P}}) = \frac{1}{\gamma_{\text{R}}(\lambda_{\text{P}}) + \gamma_{\text{Loss}}(\lambda_{\text{P}}) + \gamma_{\text{NR}}} \]

and quantum yields \( \eta_{\text{PL}}(\lambda_{\text{P}}) = \frac{P_{\text{PL}}}{P_{\text{Det}}} \) for emitters interacting with VO2 films of both phases.

As mentioned previously, \( \Omega \) is a function accounting for the experimental response function, detection direction, detector area and sensitivity, and is chosen such that the total detected fluorescence radiance

\[
I_{\text{PL}} = \int P(\lambda) d\lambda = \gamma_{\text{Exc}} \tau_{\text{PL}} \eta \Omega
\]

Also called intensity, represents the total number of detected photons per second.

We define \( \gamma_{\text{Det}} = \frac{P_{\text{Det}}}{P_0} \gamma_{\text{R}} \) as detection rate \( g_{\text{Det}} \), which can be determined by calculating the power transmitted through a planar monitor in our model, mimicking the experimental transmission along the detection path.

With the detection rate \( g_{\text{Det}} \), the second important part of the luminescence modification, the emission modification \( g_{\text{em}}(\lambda) = \tau_{\text{PL}} g_{\text{Det}}(\lambda) \) can be determined. The PL spectra simplifies to \( PL(\lambda) = \)
\[ \gamma_{EE}(Fiilm) g_{em}(\lambda) f_0(\lambda) \text{ and the total number of detected photons } I_{PL} = \gamma_{EE(Film)} \int g_{em}(\lambda) f_0(\lambda) d\lambda = \gamma_{EE(Film)} T_{PL} \int g_{Det}(\lambda) f_0(\lambda) d\lambda \]
can be calculated as well. Further we define the ratio of detected photons to absorbed photons as the detectable quantum yield \( \phi_{Det} = \frac{I_{PL}}{\gamma_{EE}} \). The numerical aperture (NA) of the modelled system is 0.707.

The calculated luminescence enhancement is sensitive to NA as an increased NA increases the power transmitted along the detection path.

The PL emission also depends on the dipole orientation. We define the dipole orientation parallel to x direction as radial (R), parallel to the y axis as tangential (T) and parallel to the z axis as perpendicular (P), shown in Fig. S1(c).

Since there are no reports on PL modification in the near-infrared spectral range upon the phase transition of VO₂, we will briefly discuss the interaction of the Alexa790 Dye with a 15 nm VO₂ film, before we turn our attention to hybrid systems. The quantum emitters are positioned at three different heights above the VO₂ film (Fig. S1(d)). In Figure S1f the changes in \( I_{PL}, \gamma_{Exc}, \gamma_R, \gamma_Loss, \eta_{PL}, \phi_{Det} \) upon the phase transition of VO₂ calculated for Alexa790 Dyes located at the positions A-C above a 15 nm thin VO₂ film are displayed as the ratio between the individual quantity in the metallic (M) and semiconducting phase (SC). The results for R and T dipole orientation are equal, since in the case of the VO₂ film the R and T dipole orientation are equivalent. We see that the number of detected photons \( I_{PL} \) increases upon phase transition only if the emitter is located 40 nm above the VO₂ film, while \( \gamma_{Exc} \) increases (up to 15%) with increasing height. For R or T oriented dipoles, \( \gamma_R \) decreases upon the phase transition, and the change in \( \gamma_R \) does not depend on the height. For P oriented dipoles, \( \gamma_P \) increases slightly upon the phase transition. The losses, \( \gamma_{Loss} \), are substantially higher upon the phase transition. The change in \( \gamma_{Loss} \) is highest when the Alexa790 Dye emitter is located 5 nm above the film. An eight-fold increase in \( \gamma_{Loss} \) is seen in the metallic phase when compared to the semiconducting phase. While the \( \eta_{PL(Film)} \) decreases upon the phase transition, it can be noted that \( \phi_{Det} \) increases for the R oriented emitter in position C.

The same procedure can be applied also for modelling the PL from hybrid systems comprising of the plasmonic Ag nanodisc and the VO₂ films (Fig. S2a-b). A 730 nm excitation wavelength is selected due to the relatively strong absorption of the Alexa790 and in experiments this wavelength can be blocked with a bandpass filter without blocking the PL.

In Fig. S2(c) the changes in \( \gamma_R \) and \( \gamma_{Loss} \) of the Alexa790 emitters at the positions A-C as defined in Fig. S2(b), are shown after the introduction of a Ag nanodisc as the ratio of the individual quantity of the hybrid system and the same quantity for only the VO₂ film system in both phases, namely \( \gamma_R[NP] / \gamma_R[Film] \). To investigate the possibility of PL enhancement, emitters are placed 5 nm away from the surface of a 40 nm high Ag nanodisc with a 120 nm diameter, since at distances smaller than 5 nm PL quenching, via energy transfer, will dominate.

In Fig. S2(c), its observed that the \( \gamma_R[NP] \) is up to 20 times higher than \( \gamma_R[Film] \). To investigate the possibility of PL enhancement, emitters are placed 5 nm away from the surface of a 40 nm high Ag nanodisc with a 120 nm diameter, since at distances smaller than 5 nm PL quenching, via energy transfer, will dominate.

The PL from the hybrid system is substantially enhanced (Table S2). It is worth mentioning, that although the number of detected photons stemming from the emitters located at position A in the hybrid system is 2 orders of magnitude higher than \( I_{PL}(Film) \), the highest \( I_{PL}(NP) \) occurs at a different location. To elucidate the optimal emitter
position for enhanced PL, we focus our attention on PL modification for specific positions of Alexa790 emitters around the nanodisc.

|                | Irl(NP)/Irl(Film) |
|----------------|-------------------|
|                | Semiconducting (SC) | Metallic (M) |
|                | R  | T  | P  | R  | T  | P  |
| C              | 8.15 | 0.97 | 5.48 | 18.32 | 0.90 | 12.81 |
| B              | 14.43 | 1.94 | 1.74 | 32.16 | 1.60 | 2.08 |
| A              | 132.08 | 6.57 | 8.76 | 345.53 | 3.50 | 13.99 |

Table S2 PL enhancement in the hybrid system for Alexa790 emitters at locations A-C and 5 nm away from the surface of a 40 nm high Ag nanodisc with a 120 nm diameter.

Fig. S3 (a) Schematic of the 15 different positions used for the calculation of $g_{exc}(\lambda)$ and $g_{exc}(\lambda_{exc})$, shown in Fig. 1b but repeated here for convenience. (b-d) Detected photons from Alexa790 emitters in the hybrid system comprising of Ag nanodiscs (Height = 40 nm, Diameter = 120 nm, 140 nm, 160 nm) on a VO2 film (Thickness = 15 nm) in the semiconducting phase (SC) and in the metallic phase (M). In each case $g_{exc}(\lambda_{exc})$ is calculated for $\lambda_{exc} = 730 nm$. (b) Detected photons from Alexa790 emitters with radial (R) dipole orientation. (c) Detected photons from Alexa790 emitters with tangential (T) dipole orientation. (d) Detected photons from Alexa790 emitters with perpendicular (P) dipole orientation.

To model a thin coating of dye molecules on the Ag nanodisc, similar to the one which forms when diluted dye molecules solutions are either drop casted or spin coated on top of such systems, we calculate $g_{em}(\lambda)$ and $g_{exc}(\lambda_{exc})$ at 15 different positions (Fig. S3(a)). 6 positions are on top of the nanodisc, so that the emitters are located 5 nm and 7.5 nm above the nanoparticle and are distributed along the nanodisc, i.e. at the centre of the nanodisc, at the distance from the centre corresponding to half radius of the nanodisc, and at the upper edge of the nanodisc. The remaining 9 positions mimic a homogeneous distribution of emitters at the sides of the nanodisc. For simplicity we divide our system in 3 (z direction) by 3 (in x direction) side positions. In the radial (x) direction the positions are separated by 2.5 nm and the first position corresponds to 5 nm away from the surface of the nanostucture (previously denoted as position A). In the z direction the emitters are distributed at three different distances from the VO2 thin film, i.e. 5 nm from the VO2 film surface, a height corresponding to the half-height (20 nm) and a height corresponding to the height of the nanodisc (40 nm). Using these emitter positions we consider the optimal emitter position and dipole orientation for enhanced PL. The emission properties are calculated for Ag nanodiscs of 40 nm height and increasing diameter, from 120 nm to 160 nm on top of a 15 nm thin VO2 film. $g_{exc}(\lambda_{exc})$ is calculated for $\lambda_{exc} = 730 nm$. In Fig. S3(b) the Alexa790 emitters are radially (R) oriented. For the 120 nm Ag disc in the metallic VO2 phase we observe the highest number of detected photons (134.64 Ph/s), mostly emitted from the upper edges of the nanodisc. There are several regions, on top of the discs and 5 nm above the film, where the number of photons is low (blue circles), regardless of the disc diameter or the VO2 phase. For the radial dipole orientation, the number of detected photons decreases with increasing disc diameter. The regions with high photon numbers are not altered when the disc diameter increases. This is the
opposite for the case when Alexa790 emitters are tangentially (T) oriented (Fig. S3(c)). Although the number of photons is substantially smaller, as expected for a dipole with tangential orientation interacting with a plasmonic disc, an increase in disc diameter leads to slightly higher photon numbers and an alteration of the positions with high detectable emission. For the perpendicular dipole observation, we observe that the highest number of photons stems from the upper edge of the Ag discs, and that there is an increased number of regions with low photon numbers.

Fig. S5: (a-c) Scattering cross sections and PL spectra for Ag nanodiscs (Height = 40 nm) with increasing diameter on VO2 (Thickness = 15 nm). Nanodisc Diameters are as follows (a) 120 nm (b) 140 nm (c) 160 nm.

Fig. S6: (a-f) Maps showing Electric-Field Enhancement (|\(E^2\)|/|\(E_0^2\)|) at \(\lambda = 730\) nm around Ag nanodiscs (Height = 40 nm) with increasing diameter on VO2 (Thickness = 15 nm) in semiconducting phase (a-c) and metallic phase (d-e). Nanodisc diameters are as follows (a,e) 120 nm (b,d) 140 nm (c,f) 160 nm.

Fig. S7 (a-c) Scattering cross sections and PL spectra for Ag nanodiscs (Height = 40 nm, Diameter = 140 nm) with silica shells (n=1.5) with increasing thickness on VO2 (Thickness = 15 nm). Silica shell thicknesses are as follows (a) 5 nm (b) 10 nm (c) 15 nm.
Fig. S8 (a-c) Scattering cross sections and PL spectra for Ag nanodiscs (Diameter = 140 nm, Height = 40 nm) with 15 nm thick silica shell (n=1.5). (a) The quantum dots (QD800) are attached to the outside of the shell. (b) The quantum dots (QD800) are attached and embedded within the 15 nm silica shell. The excitation wavelength is 730 nm.

Fig. S9 (a-c) Scattering cross sections and PL spectra for Ag nanodiscs (Height = 40 nm, Diameter = 120 nm) with increasing VO$_2$ thickness. VO$_2$ thicknesses are as follows (a) 15 nm (b) 30 nm (c) 60 nm.

Fig. S10: (a-f) Maps showing the electric-field enhancement ($|E|^2/|E_0|^2$) at $\lambda = 730$ nm around Ag nanodiscs (Height = 40 nm, Diameter = 120 nm) with increasing VO$_2$ thickness in semiconducting phase (a-c) and metallic phase (d-e). VO$_2$ thicknesses are as follows (a,e) 15 nm (b,d) 30 nm (c,f) 60 nm.
Fig. S11 (a-c) Scattering cross sections and PL spectra for Ag nanodiscs (Diameter = 120 nm) with increasing height on VO$_2$ (Thickness = 15 nm). The nanodisc heights are as follows (a) 20 nm (b) 40 nm (c) 60 nm.

Fig. S12: (a-f) Maps showing the electric-field enhancement ($|E|^2/|E_0|^2$) at $\lambda = 730$ nm around Ag nanodiscs (Diameter = 120 nm) with increasing height on VO$_2$ (Thickness = 15 nm) in semiconducting phase (a-c) and metallic phase (d-e). Nanodisc heights are as follows (a,e) 20 nm (b,d) 40 nm (c,f) 60 nm.

Fig. S13 The ratio $I_{NP}/I_{FL}^{[NP]}$ at room temperature and the ratio $I_{NP}/I_{FL}^{[M]}$ for (a) Ag nanodisc (Height = 40 nm) on VO$_2$ (Thickness = 15 nm) and varying diameter (b) Ag nanodisc (Diameter = 120 nm) on a VO$_2$ (Thickness = 15 nm) and varying height (c) Ag nanodisc (Diameter = 120 nm) on a VO$_2$ (Thickness = 15 nm) and varying height.

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