Deterministic Temperature Shaping using Plasmonic Nanoparticle Assemblies
SUPPORTING INFORMATION

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1 Effect of nanoparticle coupling

The procedure we report is based on the assumption that the heat delivery per pixel is proportional to the number of nanoparticles per pixel, which mounts to considering that the total absorption cross section of the pixel equals the sum of the individual absorption cross sections of the nanoparticles. This assumption is thus valid if the nanoparticles are not optically coupled, *i.e.* far enough one from each other. Figure 1 plots the absorption cross section of an ensemble of two nanoparticles as a function of the length of the gap separating them. One can see than coupling effects affect the absorption cross section only below a gap on the order of the nanoparticle radius. This is the rule of thumb that has to be kept in mind. In our experiments, the gap was 3 times the radius of the nanoparticles. We were therefore far from facing a possible optical coupling problem.

The slight decrease of the absorption cross section is due to the fact that the resonance wavelength is redshifted away from 532 nm, the illumination wavelength corresponding to the resonance of a single nanoparticle.

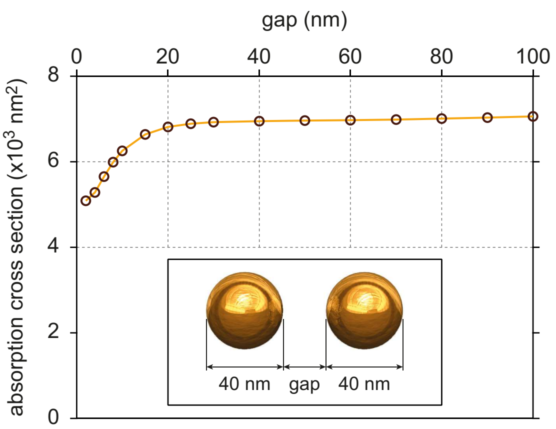

Fig. 1 Absorption cross section of an ensemble of two spherical nanoparticles as a function of the gap separating them. The nanoparticle diameter is 40 nm and calculations are performed at $\lambda = 532$ nm in a uniform dielectric medium of permittivity 1.99 (the average permittivity of glass and water). Calculations have been carried out using the Boundary Element Method[1].

[1] U. Hohenester and A. Trügler, Comput. Phys. Commun., 2012, **183**, 370

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2 Temperature profile in the z direction

Let us consider a circular heat source density $q(x,y)$ (power per unit area), of radius R and immersed in a uniform medium of thermal conductivity κ, as represented in Fig.2a. For a uniform heat source density $q(x,y) = q_0$, one can calculate a close form expression of the temperature profile along the z axis:

$$T(z) = \frac{q_0}{4\pi\kappa}\int_0^R\int_0^{2\pi}\frac{1}{\sqrt{z^2+r^2}}r\mathrm{d}r\mathrm{d}\theta \quad (1)$$

After integration over θ and using the substitution $m = r/z$, one gets

$$T(z) = \frac{q_0 h}{2\kappa}\int_0^{R/z}\frac{m}{\sqrt{1+m^2}}\mathrm{d}m \quad (2)$$

$$T(z) = \frac{q_0 h}{2\kappa}\left[\sqrt{1+m^2}\right]_0^{R/z} \quad (3)$$

$$T(z) = \frac{q_0}{2\kappa}\left(\sqrt{R^2+z^2}-z\right) \quad (4)$$

Figure 2 plots the corresponding normalized temperature profile $\alpha(z) = T(z)/T(0)$ (dash line), along with the temperature profile obtained when considering a heat source density intended to create a uniform temperature distribution throughout the heat source location (solid line). In the later case, which is obtained from numerical simulations, one can see that such a contrasted heat source density tends to slightly improve the temperature uniformity in the z direction as well.

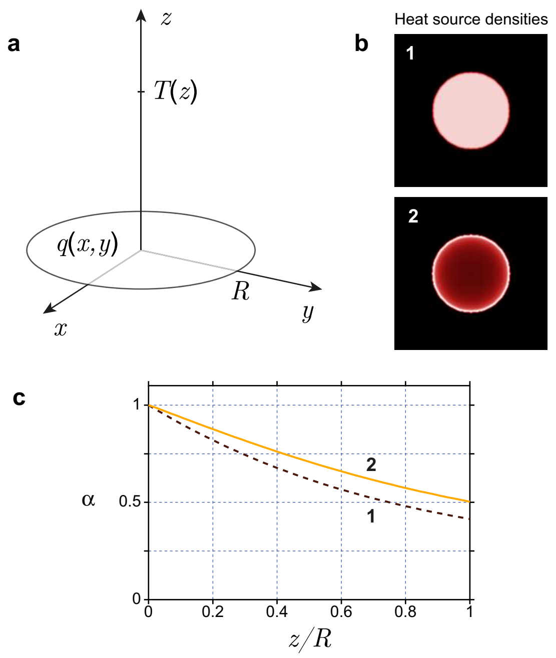
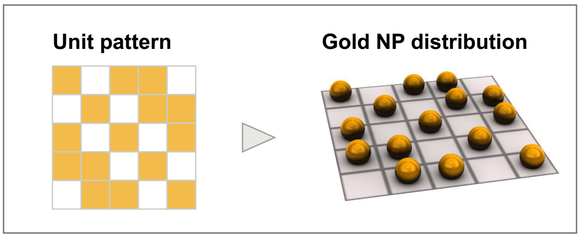


Fig. 2 (a) System under study that consists of a circular heat source density q of radius R, located in the xy plane. (b) Maps of the two investigated heat source densities: a uniform heat source density q_0 (1) and a heat source density intended to create a uniform temperature profile in the xy plane (2). (c) Normalized temperature profiles α as a function of the normalized coordinate z/R related to the heat source densities 1 (dash line) and 2 (solid line).

3 Unit patterns of nanoparticle positions

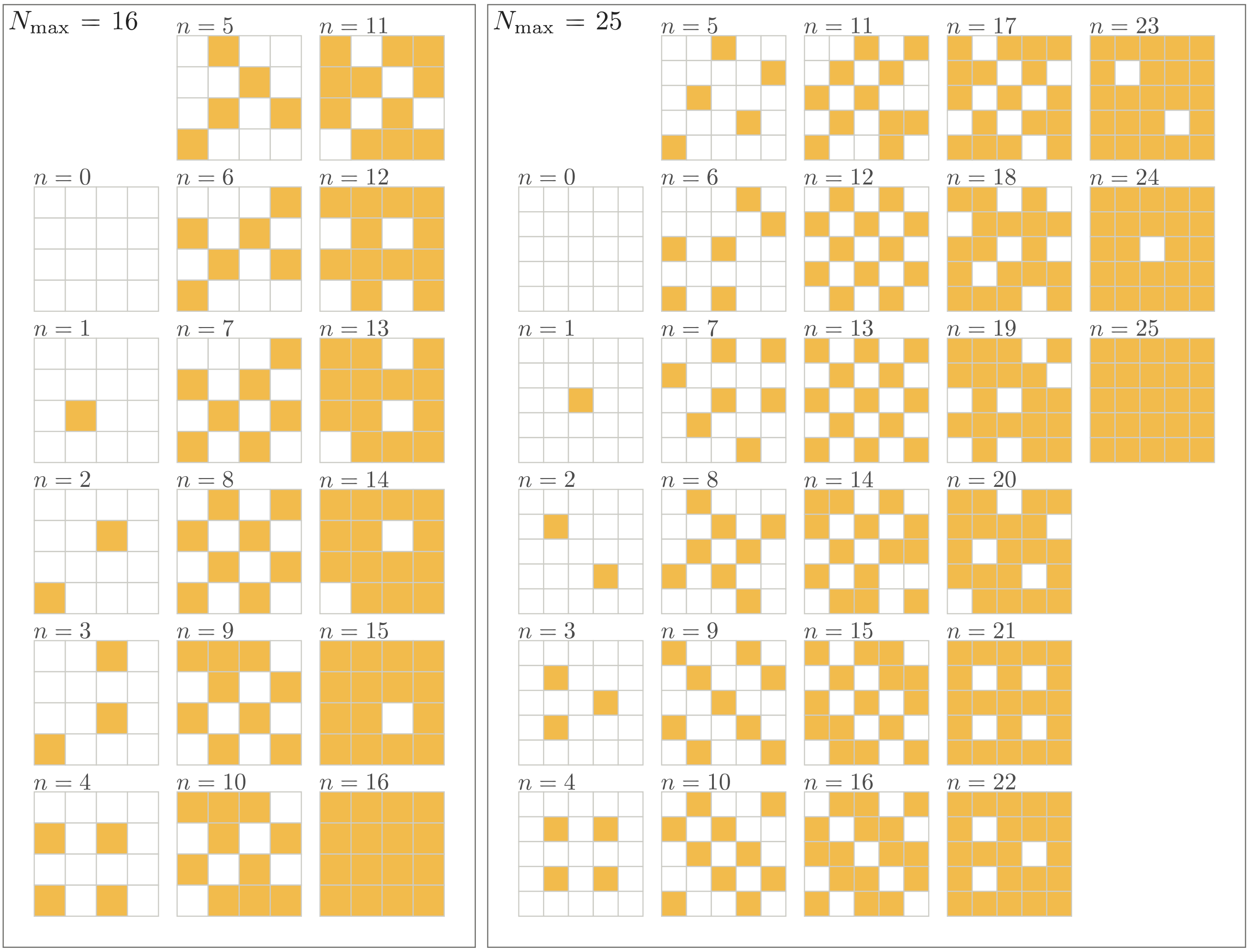
Each pixel value of the calculated heat source density is reproduced experimentally using a proportional number n of nanoparticles (NPs). For instance, a pixel value of 15 over a scale of $N_{\mathrm{max}} = 25$ values can be reproduced with 15 NPs, as schematized below:



Here is a proposition for a set of unit patterns. The cases of $N_{\mathrm{max}} = 16$ and $N_{\mathrm{max}} = 25$ are addressed. Colored squares indicate where the NP are supposed to be located. These sets of patterns are just propositions. Others pattern sets could be designed. But in these sets of patterns, care was taken to ensure an spatially regular and even distribution of NPs, even where reproduced periodically.

4 SEM images

Here are the high-resolution Scanning Electron Microscope (SEM) images of the lithographic gold structures investigated experimentally.


$N_{\max} = 16$
$n = 0$
$n = 1$
$n = 2$
$n = 3$
$n = 4$
$n = 5$
$n = 6$
$n = 7$
$n = 8$
$n = 9$
$n = 10$
$n = 11$
$n = 12$
$n = 13$
$n = 14$
$n = 15$
$n = 16$
$N_{\max} = 25$
$n = 0$
$n = 1$
$n = 2$
$n = 3$
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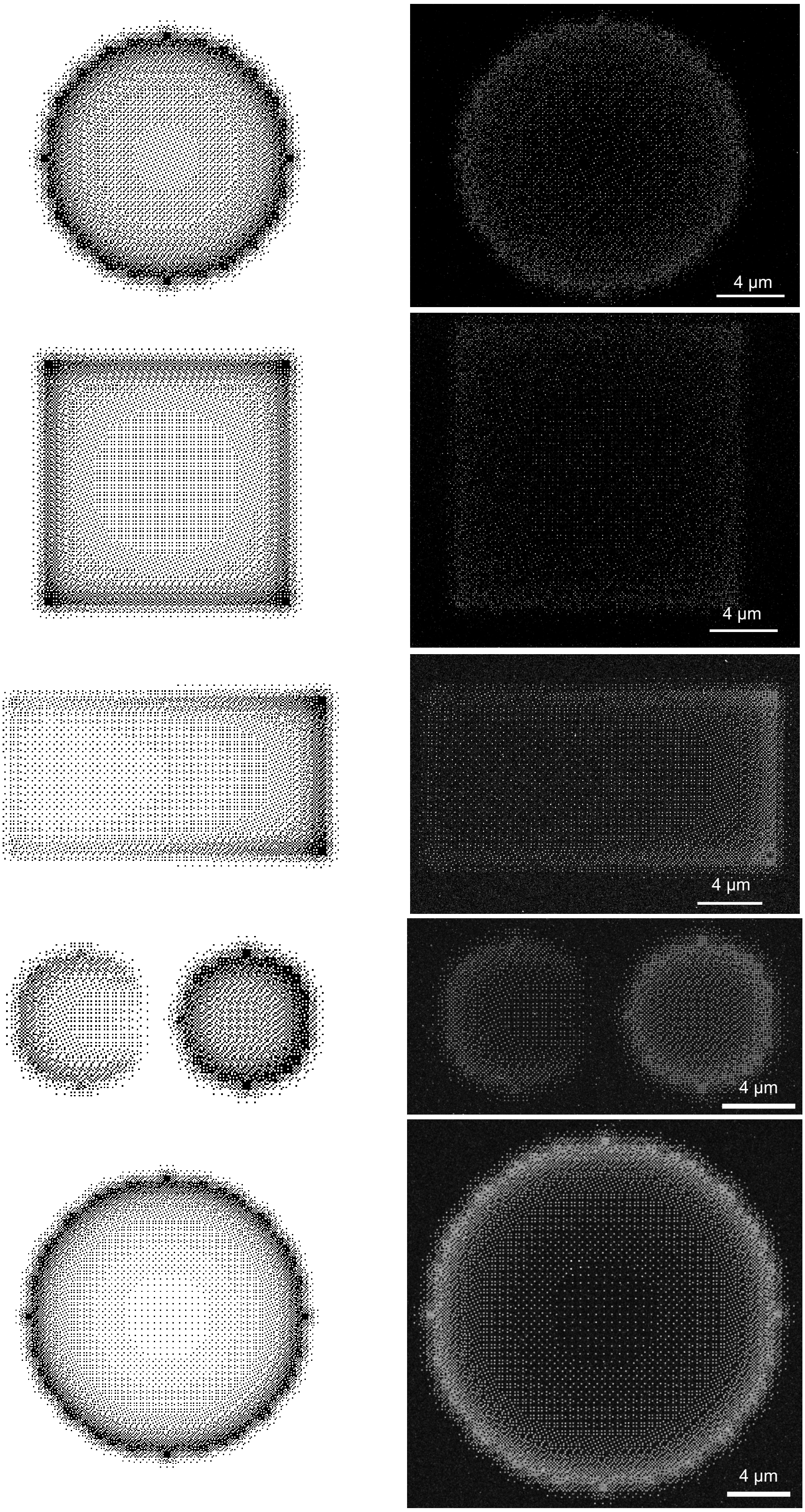

4 μm
4 μm
4 μm
4 μm
4 μm