Electronic Supplementary Material (ESI) for Nanoscale.
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Supporting information of

Flexible thermo-plasmonics: an opto-mechanical control of the heat generated at the nanoscale

Appendix 1 - Calculation of excited particles

Indicating with N the total number of Au nanoparticlaes immobilized on the sample surface with area at rest S_{rest}, their surface density is simply calculated as $\sigma_{rest} = N/S_{rest}$. Upon stretching the sample, its area undergoes a deformation and is indicated as $S_{stretch}$. Being the number N of particles constant, their surface density under strain becomes $\sigma_{stretch} = N/S_{stretch} = \sigma_{rest} * S_{rest}/S_{stretch}$. During thermoplasmonic experiments, the sample area at rest illuminated by the exciting light is initially circular with radius r and area $B_{rest} = \pi r^2$. Under stretching, this area transforms into an ellipse whose semi-axes are given by:

$$\{ x = r\left(1 + \frac{s}{2}\right) y = r\left(1 - \frac{s}{4}\right) \tag{1}$$

where, we have considered PDMS as an elastic material with a Poisson coefficient of 0.5 and s represents the percentage of applied stretching. The effective area illuminated when the sample is under stretching can be then calculated as:

$$B_{stretch} = \pi xy = \pi r\left(1 + \frac{s}{2}\right) r\left(1 - \frac{s}{4}\right) = \pi r^2 + \pi r^2\left(\frac{s}{4} - \frac{s^2}{8}\right) \tag{2}$$

As such, the area difference (before and after stretching) is simply given by:

$$\Delta B = B_{stretch} - B_{rest} = \pi r^2\left(\frac{s}{4} - \frac{s^2}{8}\right) \tag{3}$$

From Eq. 3, in case of $s = 0.2$, the excited area after stretching results 4.5% larger than the one at rest. For what concerns the number of excited particles, when the sample is at rest, the area illuminated by the exciting spot contains a number of particles $N_{rest} = \sigma_{rest} B_{rest}$. Upon stretching, some of the particles fall outside the illuminated area (along the $\vec{s}$ direction) and they are no more excited by the incoming light. At the same time, other particles enter the illuminated area (in the direction perpendicular to $\vec{s}$) which have to be considered in the excitation. In total, the number of particles excited when the sample is under stretching is given by $N_{stretch} = \sigma_{stretch} B_{rest} = N_{rest} B_{rest}/B_{stretch}$. By considering a particle density σ_{rest}=700 NPs/μm^2, estimated from the SEM micrograph of the sample (Fig. 1e, main text), and a spot radius $r = 1.2mm$, the number of particles excited when the sample is at rest and under stretching can be calculated as $3.17 * 10^9$ and $3.04 * 10^9$ respectively, with a total of $1.3 * 10^8$ less particles excited (4.1%) when the sample is stretched of 19%.

Appendix 2 - Broadening of the plasmonic response upon stretching action

Upon stretching the flexible tape, a transient formation of AuNPs chains takes place. The excitation of these chains by an E-field with suitable polarization direction can induce a strong plasmonic coupling of the nanoparticles belonging to the chains. In particular, as reported in Figs 2a-b of the main text, noticeable differences are observed between an excitation with a probe beam polarized along or perpendicular to the stretching direction $\vec{s}$. In both cases, a decrease of the amplitude of the plasmonic response and a red-shift of the spectral position of its peak are observed, with an effect that is more pronounced in case of an exciting E-field direction perpendicular to $\vec{s}$. When this happens, besides the larger amplitude decrease, a slight broadening of the curve is also observed. In order to point out this broadening, we have rescaled the curves related to rest configuration (0% stretching, black curve in Fig. 2b, main text) and maximum elongation (19% stretching, green curve in Fig. 2b, main text) of the sample. In detail, an offset has been added to all values of the green curve to make its initial value coincide with the corresponding one of the black curve (Fig. 1).

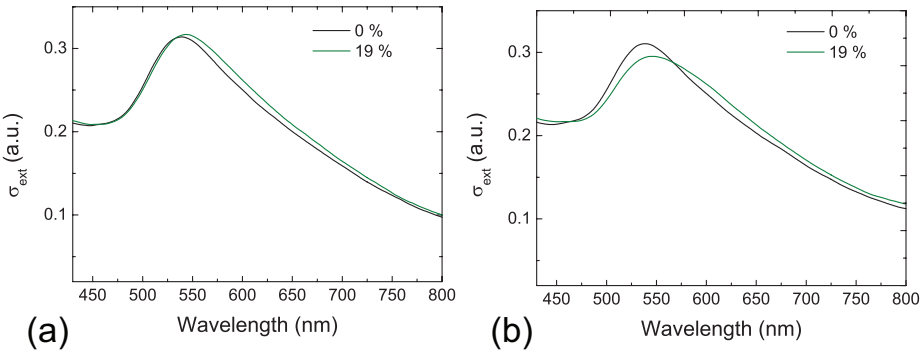

Figure 1: Rescaling of the extinction curves of the sample at rest (black) and upon stretching (green). (a) and (b) represent the sample under an excitation with E-field parallel and perpencdicular to the stretching direction respectively.

In Fig. 1b, it can be noticed that the applied strain induces the appearance of a shoulder peak centered at about 600 nm that is possibly related to the formation of particle chains.

Appendix 3 - Excitation conditions for numerical simulation

In order to adapt the numerically simulated case to the experimental excitation conditions, the starting point is the estimation of the number of particles respectively excited in the experimental and numerical cases. In the condition of sample at rest, with a laser spot radius of 1.2 mm and a particle density σ_{rest}=700 NPs/μm^2, the number of excited particles is calculated as $N_{rest} = 3.17 * 10^9$. In the numerical case, the circular white dashed

line in Fig. 2 of the main text representing the exciting spot encloses only $N_{th} = 17$ particles. The experimental laser intensity corresponding to a pump power P=250 mW (magenta curve in Fig. 2d, main text) can be calculated as $I_{exp} = P/B_{rest} = 55.3 * 10^3 mW/m^2$. In the numerical case, the corresponding intensity value can be calculated by assuming that the intensity per single particle must be the same as in the experimental one: $I_{th}/N_{th} = I_{exp}/N_{rest}$, so that $I_{th} = I_{exp}N_{th}/N_{rest} = 2.97 * 10^{-4} W/m^2$. From the intensity, the E-field value can be simply derived through the formula $I = \frac{1}{2}\varepsilon_0 cE^2$, obtaining the value $E_{th} = 0.47 V/m$.

Appendix 4 - Role of the absorption and scattering cross section

By extracting the simulated scattering and absorption cross sections from the extinction curves (reported in the main text, Fig. 3d), it is well evident how the absorption cross section value (responsible of heating) increases at the excitation wavelength of 532nm (see green arrow in Fig. 2a). At the same wavelength, the scattering cross section decreases (see green arrow in Fig. 2b).

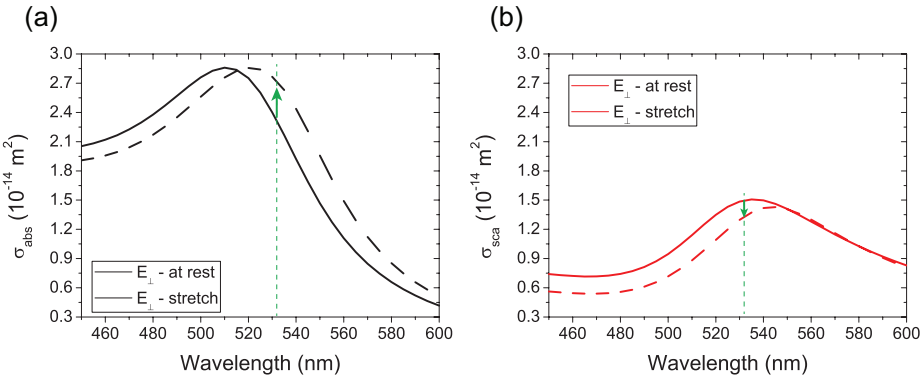

Figure 2: FEM numerical simulation of the absorption (a) and scattering (b) cross sections for $E_\perp$ polarized incident light, when the substrate is at rest (solid lines) and under stretching (dashed lines).