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Electronic Supplementary Information

Suspended metasurface meets complete light absorption: a 50-nm-thick optical nanomicrophone

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CONTENT

S1: Dielectric constant of Au in the simulation

We used fully three-dimensional finite-element analysis method to calculate the proposed models. In these simulation processes, the dielectric constant of Au is given by Drude-Lorentz model as:

$$\varepsilon(\omega) = \varepsilon_\infty - \omega_p^2 / (\omega^2 + i\gamma\omega) \tag{S1}$$

where $\omega_\infty = 1.0$, $\omega_p = 1.37\times 10^{16} s^{-1}$ and $\gamma = 8.17\times 10^{13} s^{-1}$ [1].

S2: Coupled mode theory of complete light absorption

According to the coupled mode theory [2], the single mode resonator with one-side input wave can be described by the equations:

$$\dot{a} = -j\omega_0 a - a\gamma_e - a\delta + \sqrt{2\gamma_e} s_{1+} \tag{S2}$$

$$s_{1-} = -s_{1+} + \sqrt{2\gamma_e} a \tag{S3}$$

Where a, ω_0, δ and γ_e denote the mode amplitude, resonance frequency, decay rate of the amplitude caused by internal losses and the decay rate of the amplitude due to the power leaking from the resonator, respectively. s_{1+} and s_{1-} are the wave amplitude traveling towards the resonator from the upper space and traveling away from the resonator to the upper space. The reflection coefficient of the resonator in the steady state can be obtained by solving equations (S2) and (S3):

$$\Gamma = \frac{s_{1-}}{s_{1+}} = \frac{(1/\tau_e) - (1/\tau_0) - j(\omega - \omega_0)}{(1/\tau_e) + (1/\tau_0) + j(\omega - \omega_0)} \tag{S4}$$

Because the bottom Au layer prevents transmission, the absorption rate is given by:

$$A(\omega, L) = 1 - |\Gamma|^2 = 1 - \left|\frac{s_{1-}(\omega, L)}{s_{1+}}\right|^2 = \frac{4\delta\gamma_e(\omega, L)}{(\gamma_e(\omega, L) + \delta)^2 + (\omega - \omega_0)^2} \tag{S5}$$

It is worth noting that from the above formula, only $\delta=\gamma_e$ can get the maximum absorption rate (A=1), so the membrane reflectivity that determines the value of γ_e cannot be too low or too high, which is why the absorption rate at the resonance peak in Figure 4(d) decreases instead.

S3: Numerical simulation of Gaussian wave incidence on the suspended metasurface

A Gaussian beam is a beam of radiation whose transverse intensity distributions are well approximated by Gaussian functions, and can be considered as a sum of plane wave incidence at various angles.

Due to computation capacity limitation, numerical simulation is based on the structure shown in Fig. 2(a) but with a finite size. The simulation is based on finite-difference time-domain method. The thickness of the metasurface is 50-nm thick and the lattice constant is 1535 nm. Fig. S1 shows the reflectance of the a Gaussian beam incidence with different waist size 2 μm, 4 μm and 8 μm. The linewidth of the reflection dip is broadened by decreasing the Gaussian beam waist size. This is because that there is a dispersion of the reflection with different plane wave incident angles [3]. The simulation results indicate the reflection is very sensitive to the Gaussian beam waist.

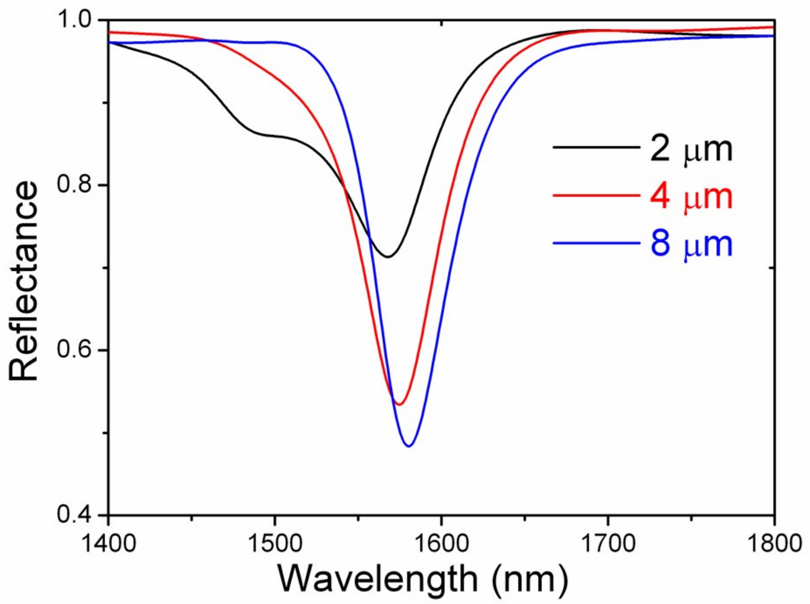

Figure S1. Reflection of a Gaussian beam incidence with different waist size 2 μm, 4 μm and 8 μm on a finite metasurface/gold-mirror cavity.

References

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3. Z. L. Tan, K. Liu, W. Xu and Z. H. Zhu, "Suspended mirrors," IEEE Photonics J. **10**, 4600506 (2018).