Supplementary Information

for

Strong electric field enhancement near an amorphous silicon metasurface with non-vertical symmetry

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1. Analytical methods utilized to calculate dispersion relations and mode properties

First, we explain the theoretical analysis method. We solve the wave equation along the path of high symmetry points:

$$\nabla \times (\nabla \times E) - \varepsilon_r k_0^2 E = 0 \# (1)$$

here, ε_r is relative permittivity and k_0 is the wave number of free space. The two-dimensional discrete translational symmetry of the metasurface allows us to simplify our calculations: we replace the plane wave with a plane wave modulated by a two-dimensional periodic function. The field modulated by a two-dimensional discrete periodic structure can be expanded as a Fourier series:

$$E_z(r_\parallel) = E_{z,k_\parallel}(r_\parallel) = \sum_{G_\parallel} E_{z,k_\parallel}(G_\parallel) e^{i(k_\parallel + G_\parallel) r_\parallel} \# (2)$$

$$H_z(r_\parallel) = H_{z,k_\parallel}(r_\parallel) = \sum_{G_\parallel} H_{z,k_\parallel}(G_\parallel) e^{i(k_\parallel + G_\parallel) r_\parallel} \# (3)$$

here, E_z and H_z represent the normal electric field and magnetic field of the metasurface respectively. $r_\parallel$, $k_\parallel$, and $G_\parallel$ denote the in-plane position vector, wave vector, and reciprocal lattice vector, respectively. Substituting these into equation (1), we can derive the components of the electric and magnetic fields in the z-direction. After that, the components of the electric and magnetic fields in the other two directions can be derived based on the properties of electromagnetic waves. And we have $G_\parallel = 0$ since the hybrid MD mode of interest is below the diffraction limit frequency.

Then, we describe the simulation method. During the simulation process, we employ a finite element method, which involves subdividing the computational domain into a mesh and sequentially calculating the values at the grid points. To account for the influence of material absorption loss on the mode characteristics, we use the complex form of the relative permittivity. Therefore, the characteristic frequencies we calculate are in complex form: $\tilde{\omega} = \omega + i\gamma$, with the real part representing the characteristic frequency and the imaginary part indicating the mode loss which is related to the Q factor (Q=ω/2γ).

Ultimately, we can determine all the characteristics of the modes: electric and magnetic fields, characteristic frequencies, and Q factors. In particular, we perform a parametric scan of the wave vector to determine how the characteristic frequencies of the modes vary with the wave vector (the dispersion relation).

2. The dispersion relations and Q factor of the hybrid MD mode as the filling factor f varies

We calculate the dispersion relations and Q factors of the hybrid MD mode as f varied from 0.5 to 0.55. It is found that the ideal condition for achieving a super flat band occurred at f = 0.53.

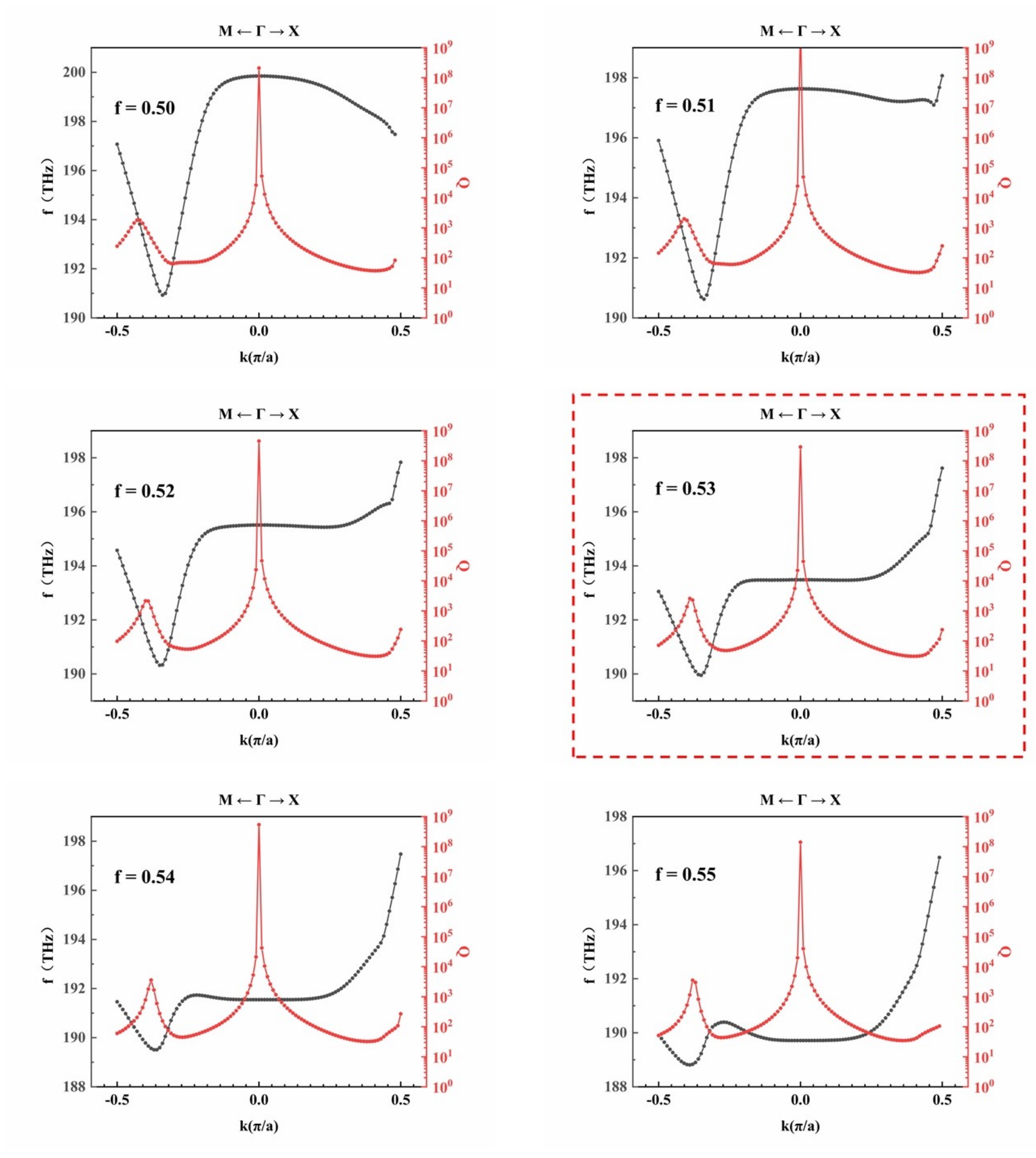

Fig. S1 The dispersion relations and Q factor of the hybrid MD mode as the filling factor f varies from 0.50 to 0.53. At f = 0.53, a super flat band is formed.