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Supplementary Material

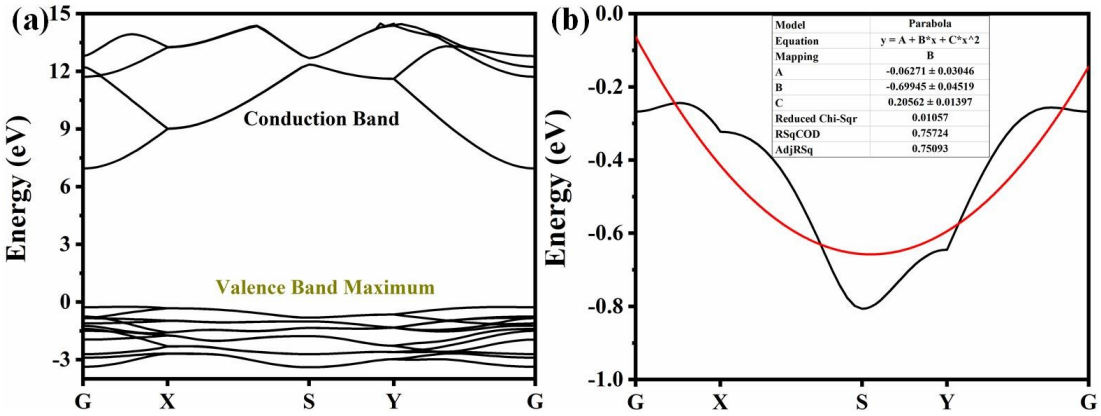

Fig. S1(a) shows the band diagram of MgF_2 in HMMs structure. (b) exhibits the energy spectrum of the valence band bottom band of MgF_2 in HMMs.

$$\omega_p = nq^2/m_e\varepsilon_0 \quad (1)$$

$$\gamma = q/\mu m_e \quad (2)$$

$$m_e = m_0/(2 + C) \quad (3)$$

Where n is carrier density got from [1], q is the electron charge ($1.602 \cdot 10^{-19}$ C), ε_0 is the permittivity of free space got from [2], γ is the damping term, μ is the electron mobility obtained from [3], and m_0 is the electron static mass. And m_e is the effective electron mass. The calculations of m_e based on the density functional theory (DFT) are performed using the Vienna ab initio simulation package (VASP). The projector augmented wave method is adopted to treat the ion−electron interaction. The exchange-correlation functional is treated by the generalized gradient approximation (GGA) parametrized by the Perdew, Burke, and Ernzerhof (PBE) exchange-correlation functional. As shown in Fig.S1 (a), the band diagram was used for energy spectrum analysis based on Fermi level transition principle. The electron was excited from the valence band maximum to the conduction band by the plasmon oscillation of the multilayer HMMs. Since the m_e of the electron was only related to the carriers on the Fermi level surface, the valence band bottom band was used to analyze and calculate the m_e of the electron, as shown in Fig. S1 (b). Using the quadratic fitting method, the m_e of the electron was calculated as $9.10956 \cdot 10^{-31}$. And it is worth noting that the errors in the time of flight of the effective material presence phase sensitive are caused by compact and passively stabilized Michelson interference. Therefore, it is necessary to introduce a correction for the phase velocity in the calculation of the wave frequency, which is referred to [4].

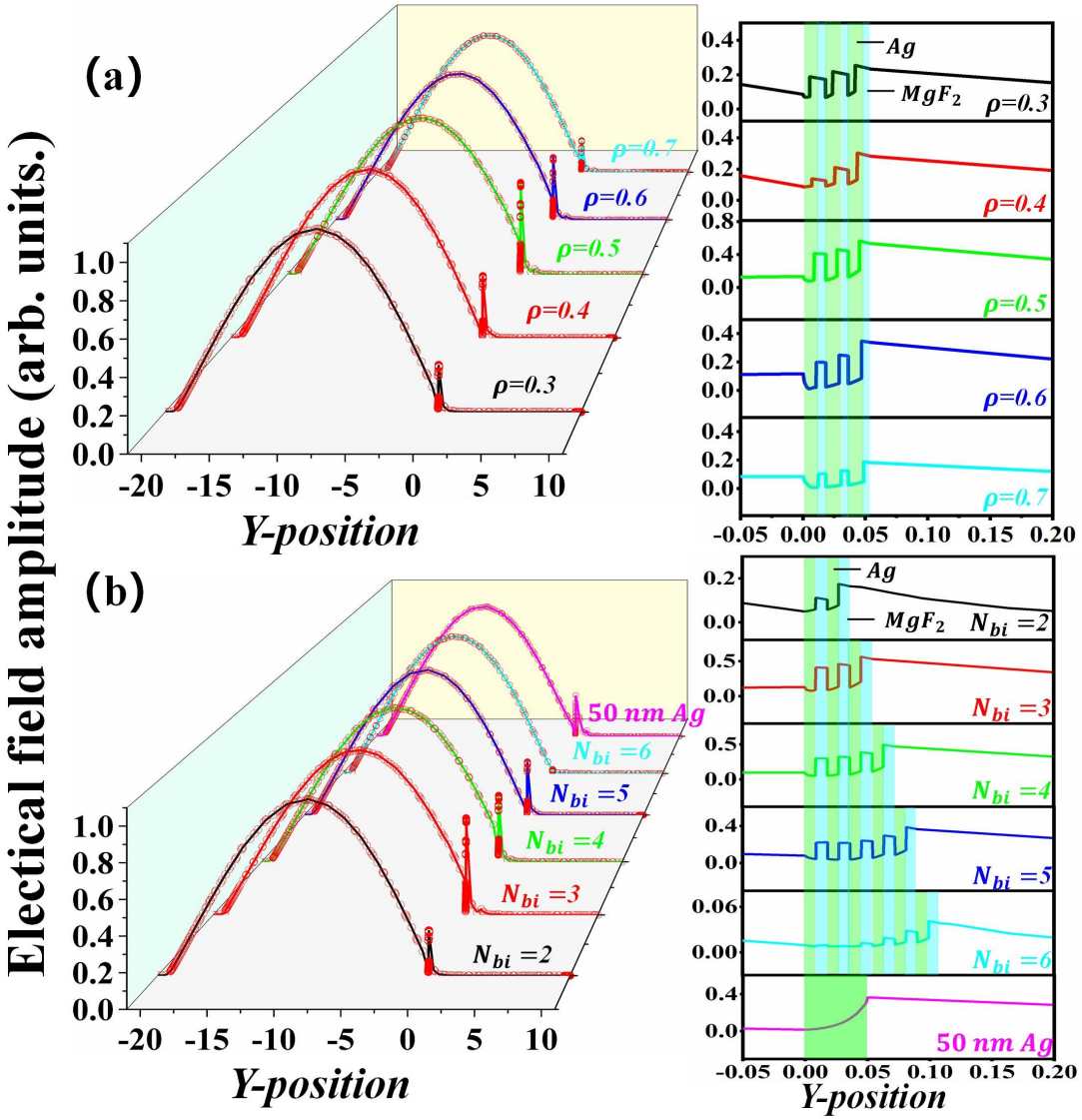

Fig. S2 (a) and (b) The electric field amplitudes along the y-axis at LP_{01} mode. The graphs on the right-hand side show the enlarged -0.05-0.2 μm region of the y-axis.

To understand how the HMMs structure performance parameters affect the electric field, we calculated the field amplitudes along the z-axis of LP_{01} mode at different ρ and N_{bi} values (see Fig. S2(a) and (b)). As the value of ρ decreases, the width of the peak in the electric field amplitude gradually increases. It is means that the multilayer structure introduces more losses, which can lead to an enhancement of the absorption spectrum broadening and thus affect the detection performance. Moreover, there is an inflection point in the intensity of the electric field amplitude (ρ = 0.5), which corresponds to the change in the absorption spectrum properties. The variation of the corresponding electric field amplitude as well as the electric field strength also verifies the suitability of ρ = 0.5. As the N_{bi} increases, the amplitude of the electric field decreases significantly (see Fig. S2(b)). At N_{bi}=6, the electric field amplitude is very small, which means that the electromagnetic losses are very large. In this case, the evanescent waves produce a huge attenuation when penetrating the HMM structure, making the plasma response very weak.

Notes and references

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[4] G. Dolling, M. Wegener, C. M. Soukoulis, and S. Linden, “Negative-index metamaterial at 780 nm wavelength,” Opt. Lett., vol. 32, pp. 53-55, 2007.