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A broadband bidirectional visible light absorber with wide angular tolerance

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Structure design and calculations

Firstly, to obtain the optimum bidirectional light absorber (BLA) structure for wide-band efficient visible light absorption, the absorbtivity as function of wavelength with different periods were calculated. Here, the parameters of fill factor and groove depth were chosen to 0.35 and 300 nm in order to ensure a high aspect-ratio (≥1) for efficient optical transmittance at the substrate/air interface following the previous reports [1-3]and the thickness of mono-layer Au was fixed at 10 nm. According to the simulated results in Fig. S1 (a), it is easy to find that the optimum BLA should possess a period of ~180 nm, which is favorable for highly light absorption. Moreover, to reduce material consumption and further enhance absorption ability, the absorbtivity as function of wavelength with different thickness of Au were simulated based on the optimum period and displayed in Fig. S1(b). It is well known that metal plasmon skin depth is given by the equation:[4]

$$\delta = \frac{c}{\omega Im\sqrt{\varepsilon_m}}$$

Where ε_m, ω, and c are imaginary values of metal dielectric constant, angular frequency of light and speed of light. As a consequence, the plasmon skin depth of Au varies from 5 to 25 nm for wavelength range of 200-800 nm based on calculation, respectively. Thereby, the thickness of 25 nm is enough for the maximum absorption simulation. It is apparent that the absorbtivity with the thickness of 20 nm is comparable to that of 25nm thick, revealing the thickness of 20 is enough for highly light absorption .

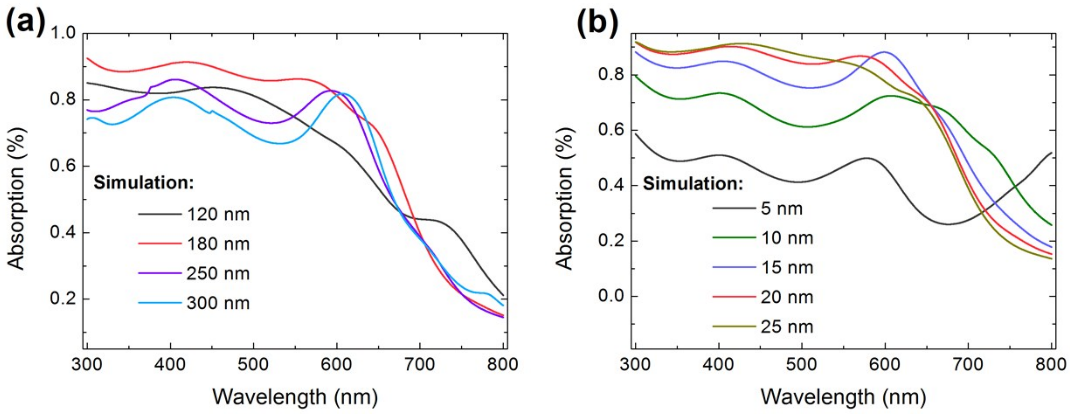

Fig. S1 Calculated absorption spectra of BLA as function of wavelength with different (a) periods (fill factor = 0.4, groove depth = 300 nm, thickness of Au = 10 nm) and (b) thickness of Au layer (period = 180 nm, fill factor = 0.4, groove depth = 300 nm).

Cladding dielectric design and calculations

To further optimum the BLA structure, the absorbtivity as function of wavelength with different dielectric layer of SiO_2, MgF_2 and Si_3N_4, which thickness were originally fixed at 5 nm, were simulated and presented in Fig. S2. It can be clearly seen that the sample with Si_3N_4 layer exhibiting excellent absorbtivity, implying a preferred material. As a result, we calculated absorption with different thickness of Si_3N_4 and fixed the thickness of 18 nm as the optimized value.

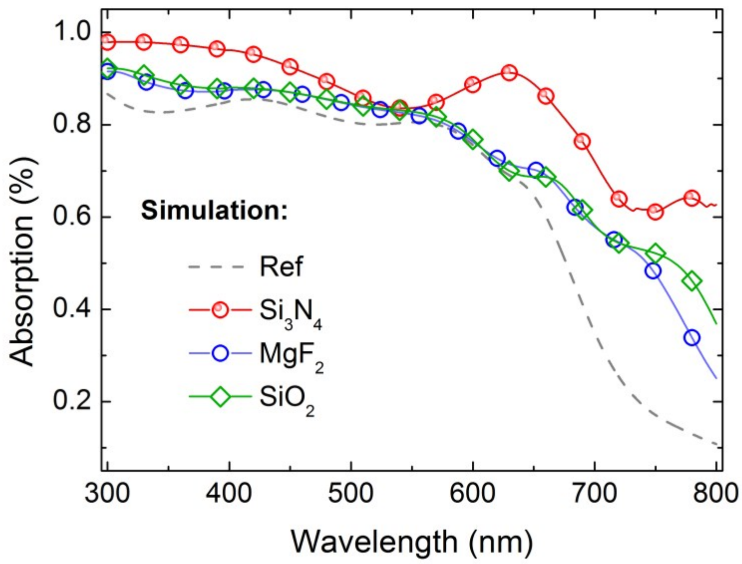

Fig. S2 Simulated absorption spectra of BLA as function of wavelength with and without different cladding dielectric layer.

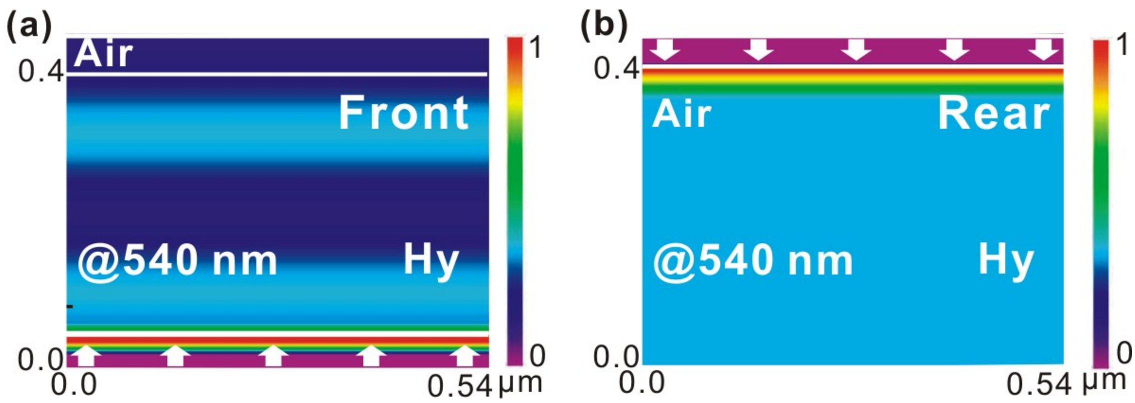

Fig. S3 Calculated normalized near-field distributions of the magnetic field intensity for a flat sample excited by a TM polarized plane wave located (a) in the air for front illumination and (b) in the PET substrate for rear illumination, respectively. The white lines denote the interface of different dielectric.

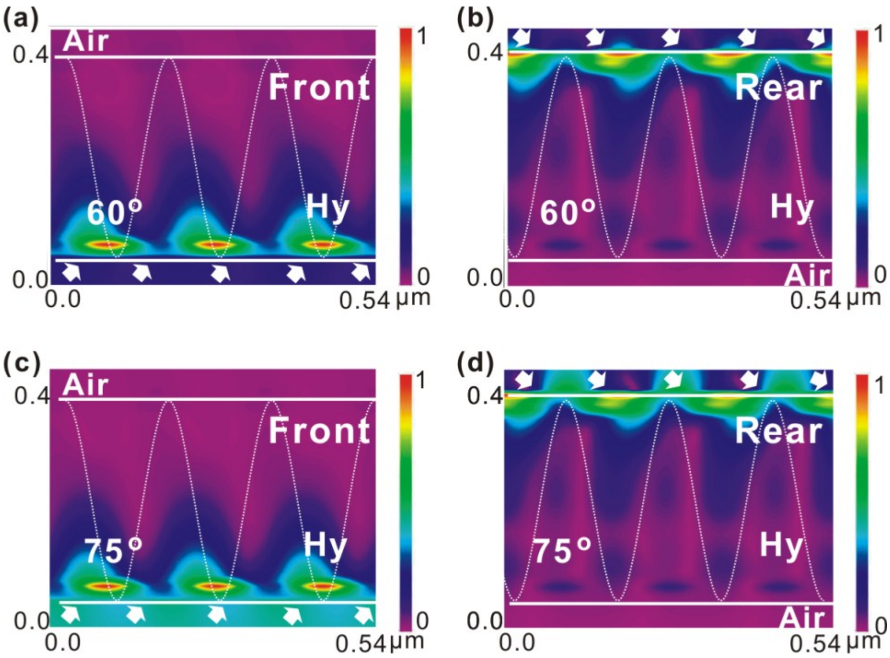

Fig. S4 Calculated normalized near-field distributions of the magnetic field intensity excited by a TM polarized plane wave for BLA at a wavelength of 620 nm with different oblique incident angles. (a) 60° (front), (b) 60° (rear), (c) 75°(front) and (d) 75°(rear).

Notes and references

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