Broadband NIR absorber based on square lattice arrangement in metallic and dielectric state VO_2

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The absorptions of the two absorbers are determined by the length l of the square lattice, and its height h, period Λ, and temperatures T_1, T_2. Figs. S1 (a) and (b), respectively, show the absorption spectra of the linear array absorber and cross array absorber when the length l of the VO_2 square lattice varies from 0.8 μm to 1.2 μm; the height and period of the lattice are, respectively, h = 1.4 μm and Λ = 1.4 μm. To reduce the mutual influence between high temperature and low temperature in the cross array absorber, it is important to prevent the VO_2 square lattice from touching the upper and lower glass substrates at the same time. Considering the above situation, the distance between two lattice arrays on the substrates Δh is 0.01 μm. Two substrates are respectively maintained at high temperature T_1 = 80 ℃ and low temperature T_2 = 20 ℃. With the increase in l, the absorption first increases and then decreases. This phenomenon could be attributed to the fact that the transmittance increases when l decreases and the reflectance increases when l increases.

The effect of the height h on the absorption of the two absorbers when the other parameters remain unchanged is analyzed in Figs. S1 (c) and (d). Here, h varies from 1.3 μm to 1.8 μm. For both the absorbers, when h changes from 1.5 μm to 1.8 μm, the peak absorption slightly increases in the region of 1.4-1.6 μm owing to the matching of the electronic oscillation frequency on the VO_2 surface and the incident light frequency. We can conclude that the absorption spectrum of the linear array absorber shows a little red shift as the increase of h at the wavelength range of 1.8-2.4 μm, that means through changing h can satisfy different needs for absorption rate. For the cross array absorber, the best absorption is obtained when h = 1.4 μm, which has a better impedance match with the surrounding space[1].

Figs. S1 (e) and (f), respectively, present the absorption spectra of the linear array absorber and cross array absorber when the period Λ of the VO_2 square lattice varies from 1.2 μm to 1.6 μm, while the other parameters remain unchanged. With increase in Λ, the absorption first increases and then decreases. When Λ > 1.4 μm, the distance between the square lattices is significant, there is an obvious absorption peak in the 1.6-1.8 μm band due to the coupling effect between the square lattices and the incident light weakens. In this situation, the absorber can achieve high absorption in the narrow band.

Apart from the parameters discussed above, the effect of different working temperatures of the two absorbers on the absorption spectra are also analyzed, as shown in Figs. S1 (g) and (h). From the figures, we observe that the different working temperatures have little effect on the absorption, mainly because the refractive index and the extinction coefficient of VO_2 do not change significantly when $T_1 > T_c$ and $T_2 < T_c$, even if the temperature of the same-state VO_2 is different. When the two substrates with VO_2 square lattices at both metallic and dielectric states, the two absorbers can achieve a wide adjustment region of the absorption.

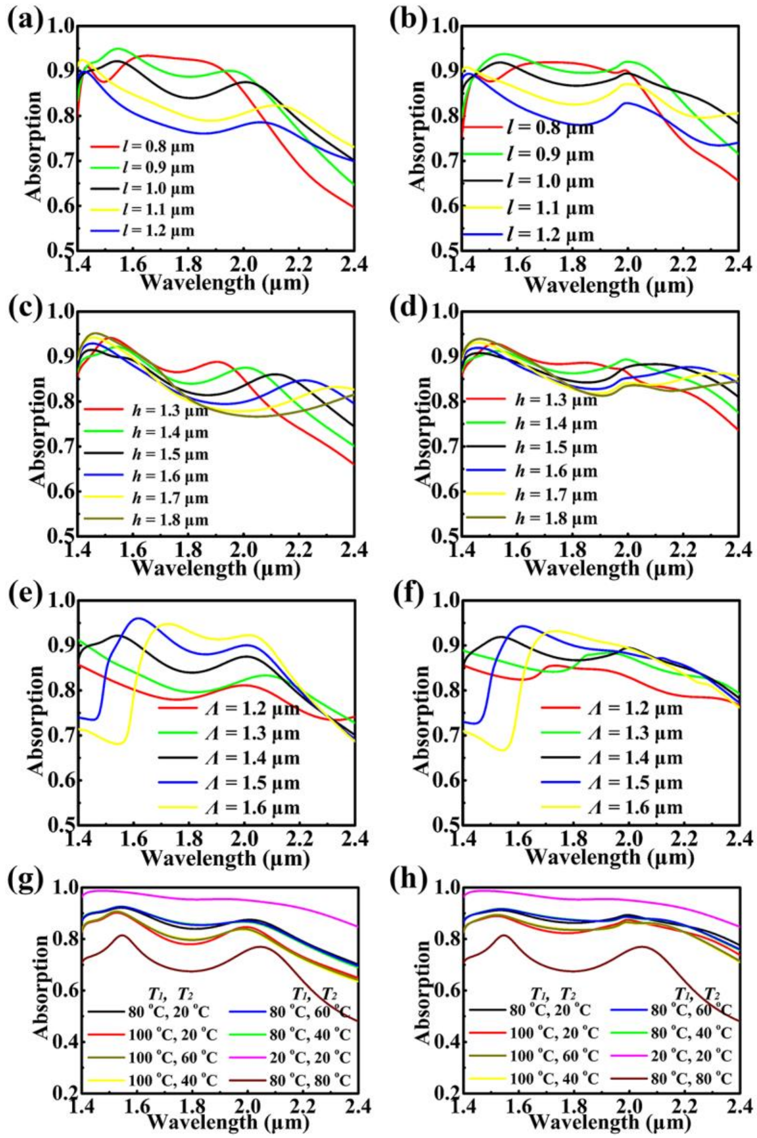

Fig. S1. Absorption spectra of the two absorbers with varying structural parameters. (a) The linear array absorber with varying length *l*. (b) The cross array absorber with varying length *l*. (c) The linear array absorber with varying height *h*. (d) The cross array absorber with varying height *h*. (e) The linear array absorber with varying period *Λ*. (f) The cross array absorber with varying period *Λ*. (g) The linear array absorber with varying temperatures T_1 and T_2. (h) The cross array absorber with varying temperatures T_1 and T_2.

References

1. Z. Liu, Y. Li, J. Zhang, Y. Huang, Z. Li, J. Pei, B. Fang, X. Wang, and H. Xiao, "Design and fabrication of a tunable infrared metamaterial absorber based on VO_2 films", J. Phys. D: Appl. Phys. **50**, 385104 (2017).