Kerker effect Germanium metasurface optical absorber at 1.55 um

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1. Introduction

For silicon photonics, the infrared wavelengths around 850 nm, 1300 nm, 1550 nm are typically used. Germanium are the conventional materials of choice of NIR photodetectors due to their good absorption and transport properties.

In this work, we demonstrate a narrow-band absorber by applying the Kerker effect [1] and amorphous germanium nanoantenna arrays (a-Ge NA arrays) with lattice resonances [2,3]. The Ge metasurface can generate a high absorptance peak at 1550 nm. Comparing with Ge thin films, the Ge metasurface can get 11-fold increase in absorptance.

2. Results and discussion

The finite-difference time-domain (FDTD) method (Lumerical Inc.) has been used to calculate the absorptance spectra of Ge NA arrays. In the modeling, Ge NA arrays are on the glass substrate (n = 1.52) with x-polarization. The diameter of nanocylinder Ge NAs is 340 nm and the thickness is 300 nm.

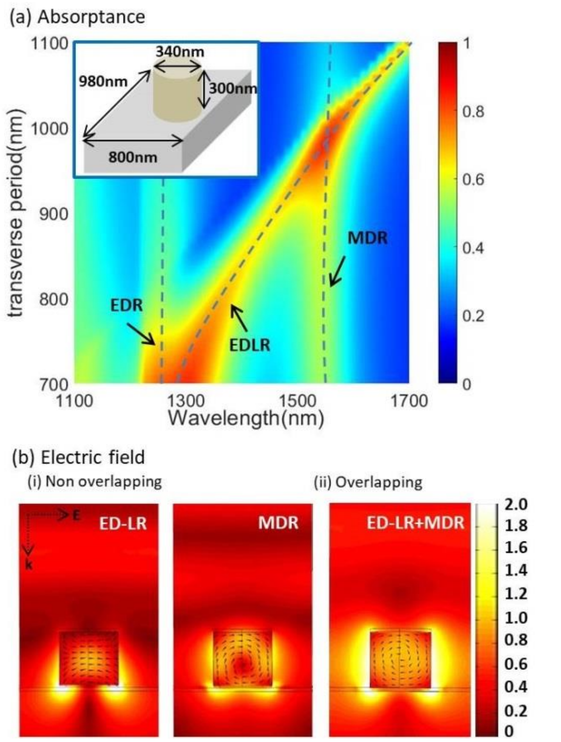

Fig.1 (a) Simulated germanium narrowband absorber absorptance spectra with different transverse periods (P_y). The longitudinal period (P_x) of Ge NA arrays is 800 nm. (b) Electric field distributions of (i) ED or MD only and (ii) Kerker conditions.

By varying transverse periods, we can modify the wavelengths of electric dipole-lattice resonance. Furthermore, when ED-LR and MD resonance are overlapped as shown in Fig. 1 at the wavelength = 1550nm, the Kerker condition is satisfied. At this condition, the backward scattering decreases. Because of the intrinsic material loss of amorphous germanium, it will cause low forward scattering at the same time and get the high absorptance.

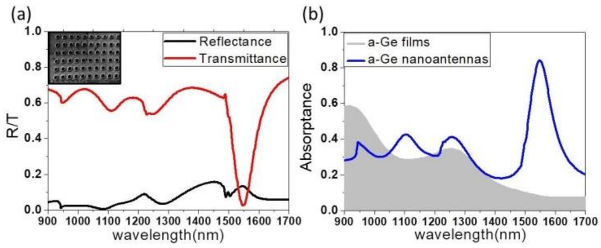

Fig.2 (a) The simulated transmittance and reflectance spectra of Ge NAs when P_y = 980nm. (b) Comparison of the absorptance spectra with Ge nanoantennas and Ge films.

As shown in Figure 2, the absorptance of Ge NAs is with 11-fold increase in comparison to unpatterned germanium films at 1550 nm. The Ge NA arrays can achieve ~ 90% in absorptance.

3. Conclusions

In summary, we manipulate the resonance wavelength of ED-LR and MDR, and the sharp absorptance peak happens when ED-LR and MDR overlaps. The narrowband absorptance peak is not due to the intrinsic loss of material, but from the coupling between ED-LR and MDR. This research can be applies to the selective narrowband absorbers/detectors in silicon photonics and optical communications.

References

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