Utilizing Efficient Light - Heat Conversion in Aluminum Perfect Absorbers for Spectrally Selective Infrared Detectors

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1. Introduction

Plasmonic perfect absorbers (PAs), which can exhibit near-unity absorptivity at desired wavelengths, have been widely studied over the past decade with respect to their remarkable optical properties and wide applications. In particular, the PAs operating in the middle-wavelength infrared (MWIR) region have been extensively proposed in photonics and optoelectronics such as wavelength-selective thermal emitters [1,2], molecular sensor [3] and selective infrared detector [4]. In this report, by taking advantage of the spectrally-selective and efficient light-heat conversion in the aluminum perfect absorber (AlPA) as a spectrally selective absorbing electrode, combined with a highly *c*-axis oriented ZnO film crystal, we demonstrate a compact design for wavelength-selective pyroelectric infrared detectors [5].

2. Results and discussion

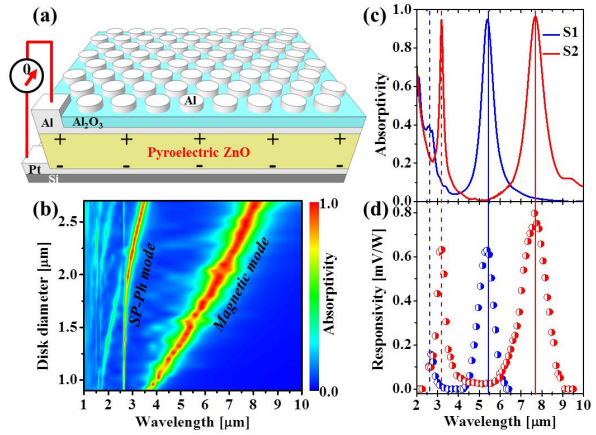

Figure 1. (a) Schematic illustration of AlPA-PIR. (b) Simulated absorptivity of the AlPA-PIR in color map plotted against disk diameter and wavelength. (c) Absorptivity spectra and (d) Responsivity curves of the two fabricated AlPA-PIAs.

The geometrical design of the aluminum perfect absorber based pyroelectric detectors (PA-PIRs) were determined by the numerical electromagnetic simulation and then fabricated by colloidal-mask lithography combined with reactive-ion etching process [1]. Figure 1a illustrates a schematic design of the proposed AlPA-PIR, which consists of an AlPA sitting on top of an epitaxial pyroelectric ZnO film grown on Pt bottom electrode. Figure 1b reveals the resonance tunability of AlPA in MWIR region by tuning Al disk resonator while fixing the periodicity and Al_2O_3 insulating layer at 3 μm and 0.15 μm, respectively. As seen in Fig. 1b, the AlPA exhibits two resonant peaks, wherein the short-wavelength resonance is attributed to the hybrid plasmon-photonic mode (SP-Ph mode) and the long-wavelength resonance is attributed to the fundamental magnetic mode. Figure 1c and figure 1d respectively reveal absorptivity spectra and responsivity curves of the two fabricated AlPA-PIRs. By controlling the intensity of the short-wavelength resonance, a single-band (S1) or a dual-band (S2) AlPA-PIR can be achieved. The responsivity curves of the two fabricated devices are in perfect agreement to their absorptivity spectra, which reveals that the pyroelectric ZnO film is effectively heated when the infrared light was resonantly absorbed by the AlPAs.

3. Conclusions

We have demonstrated a compact design for wavelength-selective MWIR pyroelectric detector utilizing efficient selective light absorption and light-heat conversion in plasmonic perfect absorber, as a spectrally selective absorbed electrode. The device can be fabricated by a facile fabrication process of colloidal-mask lithography combined with reactive-ion etching. The fabricated AlPA-PIRs showed excellent selectivity and controllability, which can be applied for thermo sensors or infrared imaging cameras.

References

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