Narrow bandwidth thermal emission with Tamm plasmon polaritons

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1. Introduction

Selective thermal emitters have gathered great attention recently, which can radiate only in narrow band and reduce the radiation losses in other wavelengths [1]. In order to fabricate large area selective thermal emitters, a planar multilayer structure that can excite surface state resonances can be the best candidate [2]. Among surface waves, Tamm plasmon polaritons (TPPs) can be excited through normal incidence both in TE- and TM- polarized light, which is advantageous in sample design [3-4].

In the current work, we demonstrate TPP based selective thermal emitters in mid-IR region where the DBR is on the emission side (hereafter, DBR-side TPP structure). First, the difference between the DBR-side TPP structure and metal-side TPP structure (the metal thin film is on the emission side) are discussed. Then, by taking the optical constants and the impedance matching conditions into account, the optimized conditions are calculated for different metal layers. Finally, the tunability of the DBR-side TPP structures and emission properties using different metals are demonstrated in experiment. The threshold temperatures of the DBR-side TPP structures using different metals are also discussed.

2. TPP based selective thermal emitters

In Fig. 1, the metal-side TPP structure and DBR-side TPP structure are compared. The DBR-side TPP structure gives narrower bandwidth and higher absorptance. The reason for the better performance for the DBR-side structure is due to the better light coupling at the metal/DBR interface.

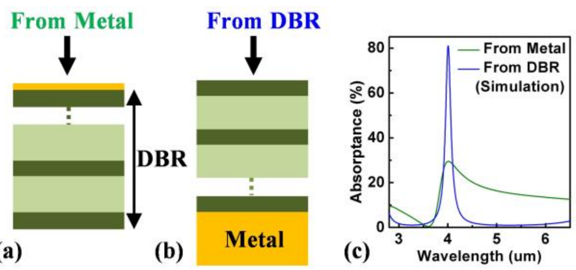

Fig. 1. TPP structure with Si/SiO_2 DBR and an Al film. Schematic diagrams for light incident (a) from the metal side and (b) from the DBR side. (c) Simulated absorptance for the TPP structures aimed at 4 μm.

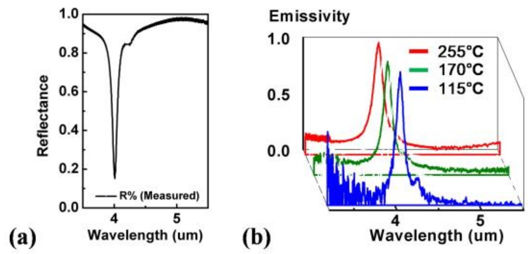

Fig. 2. (a) Measured reflectance spectrum. (b) Measured emissivity spectra at different temperatures by joule heating.

Figure 2 shows the measured reflectance and emissivity spectra of the DBR-side TPP structure using Al as a metal layer. The proposed structure can achieve twice higher Q-factor for the measured emissivity compared to most of the plasmonic thermal emitters reported so far.

3. Conclusions

In conclusion, the DBR-side TPP structures are demonstrated to have ultra-sharp selective thermal emissions in mid-IR region. The DBR-side TPP structure is less prone to the intrinsic property of the metal, hence able to support a stronger and narrower TPP resonance. Lithography-free, low cost, and refractory features of the DBR-side TPP structures pave the way for applications such as gas sensing, IR source, and thermophotovoltaics.

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