matter interaction with the excitation of localized plasmon resonances and hence, enhanced absorption.

Figure 4(c) shows the electric field distributions of the third reflection dip at the wavelength of 1.84 µm in the *x-z* cut plane. Interestingly, a weak field enhancement was observed at the metal-dielectric interface within the cavity formed in the top portion of the nickel film as depicted in Fig. 4(c). However, the fields are not totally confined within the cavity rather decouple from the cavity at the end, which indicates the nature of a propagating mode. Indeed, Fig. 3(b) shows that there exists a transmission band (although weak in magnitude, the finite transmission indicates a pass band, i.e. propagating modes) which starts at the vicinity of the third reflection dip at the wavelength of 1.84 µm. This suggests that the reflection dip (enhanced absorption) for the propagating mode at the wavelength of 1.84 µm is caused by the enhanced light-matter interaction at the photonic band edge [9–11]. For further clarification we have also thoroughly checked that this propagating nature of the mode does not exist for the first and second reflections dips at the wavelengths of 2.4 µm and 2.1 µm. This certainly confirms that the enhanced absorption at the wavelength of 1.84 µm is due to the periodicity induced enhanced light-matter interaction at the vicinity of the photonic band edge within the MPC environment. Thus the inversed woodpile nickel MPC structure contains unique features of resonant absorptions driven by localized plasmon resonances and also enhanced interactions within the photonic band edge.

4. Conclusions

In summary, we have demonstrated enhanced absorptions in the optical wavelengths within 3D inversed woodpile MPCs. Our low cost fabrication method presents the novelty of combining the state-of-the-art DLW method for dielectric PC template fabrication and the electrodeposition method for metal deposition for the realization of the 3D inversed woodpile nickel MPC structures. The fabricated MPCs show the unique optical properties of enhanced optical absorptions over a broad spectral range, which is consistent with the detailed numerical simulations. The experimental and theoretical investigations reveal two distinct mechanisms for the observed absorption enhancement, the resonant optical absorption caused by localized plasmon resonances and the photonic band edge induced enhanced optical absorption. Our MPC designs could thus be useful for applications in plasmonic solar cells [15–17] and for efficient tailored thermal radiation emission [8,12,14].

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