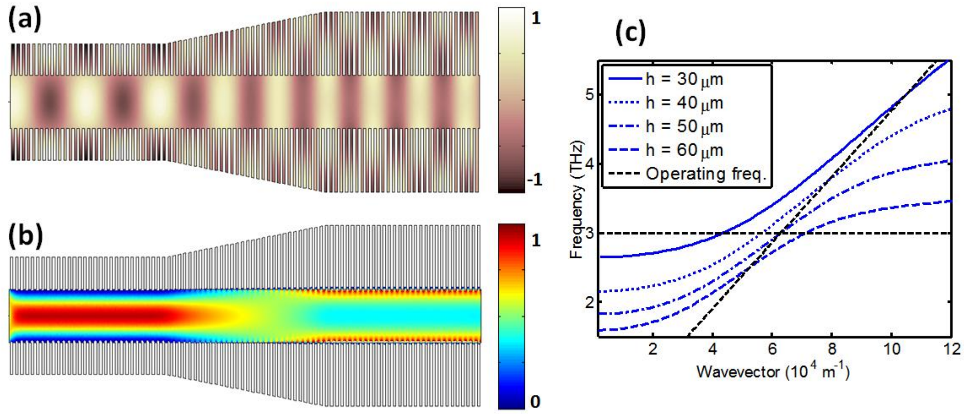

Fig. 4. (a.) Normalized magnetic fields in an SIS photonic-plasmonic mode converter calculated by the finite element method when a symmetric mode is injected from the left. (b.) The relative magnitude of the power flow in the mode converter. In the photonic mode on the left side, the majority of the power is flowing through the center of the waveguide, whereas in the plasmonic mode on the right side, the power flow is confined to the edges of the waveguide (c.) Dispersion diagram of an SIS waveguide with a = 5μm, d = 10μm, and g = 50μm for different values of h. The operating frequency of the mode converter is indicated by the horizontal dotted black line and the light line is indicated by the diagonal dashed black line.

While implementations of the SIS structures proposed here could be difficult to fabricate due to the ~$\lambda/4$ requirement for the groove height h coupled with the deep-subwavelength limit required for a and d ($a,d \ll \lambda$), other geometries are possible for which we expect similar dispersion to exist. It has been shown that nearly-planar geometries involving a metallic back-plane, a thin dielectric spacer, and metallic structures on top can support SSP modes [45, 46] and can function as artificial narrowband PMC surfaces (e.g. [29–31]). It is likely that these geometries can be used in the place of vertical grooves to create SIS waveguides which would be significantly easier to fabricate using conventional techniques.

4. Conclusion

We have analyzed the photonic and plasmonic modes of doubly-corrugated parallel plate structures which we refer to as spoof-insulator-spoof (SIS) waveguides. We analytically derived the dispersion relations of these modes in the limit of deeply-subwavelength corrugation, and found that they can be viewed as the interaction between the modes of a conventional parallel plate waveguide and hybridized localized cavity resonances of the grooves that make up the SIS structure. We found that the existence of this coupling, which is indicated by anticrossings in the dispersion curves, is dependent on symmetry-based selection rules. We anticipate that these SIS structures will be useful as waveguides in the mid-IR, THz, and RF regimes due to the extensive range of tunability in their dispersion curves provided by the many geometrical degrees of freedom of the structures, enabling applications such as low-group-velocity delay lines and photonic-plasmonic mode converters.

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