currents in SUR completely disappear, quenching its fundamental resonance, thus leading to the disappearance of the PIT peak. When we vary the horizontal displacement parameter *h*, neither the effective vertical distance nor the dimension of capacitance plates is significantly altered, so the pronounced PIT spectra do not display any significant changes.

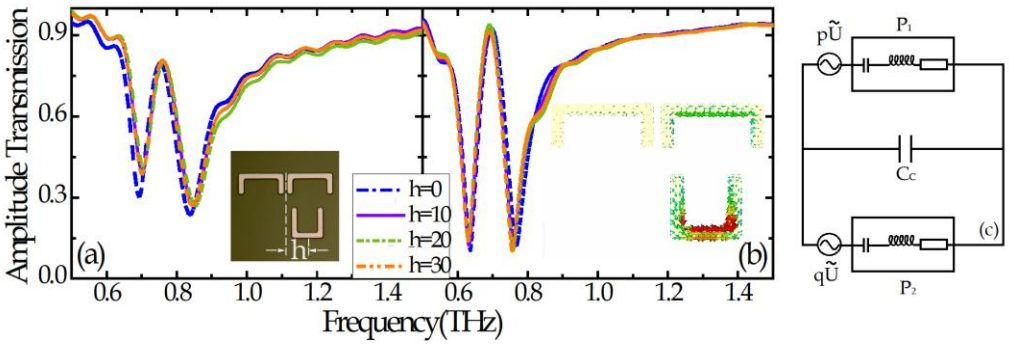

Fig. 5. (a) Measured and (b) simulated transmission spectra for different horizontal movement *h*. The inset of (b) is the surface current oscillation of the asymmetric TUR induced by horizontal displacement. (c) The equivalent RLC circuits.

3. Conclusion

In conclusion, we experimentally and numerically demonstrate that the TUR metamaterial consisting of the SUR and DUR constituent resonators exhibits a tunable PIT spectral response at terahertz frequencies. The effects of vertical and horizontal separations between the resonators on the PIT behaviors are systematically studied, indicating that the PIT spectral response can be engineered by varying the relative vertical distance between the subradiant and superradiant resonators. A counterintuitive phenomenon is observed, i.e. when the subradiant and superradiant resonators were brought closer to each other in the vertical direction, the transparency peak begins to gradually disappear beyond a critical distance of separation. This effect is mainly due to complete suppression of resonance in the subradiant resonators and enhanced radiative nature of the superradiant resonators as they are coupled at a close vertical distance. In the case of horizontal displacement, however, the transparency peak remains uninterrupted as the field distributions are not affected. The vertical coupling effect can tune the PIT behavior and thus could lead to promising applications in slow light devices in the terahertz regime.

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