Second-Order Terahertz Bandpass Frequency Selective Surface with Stable Angular Responses

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Abstract:
Frequency selective surfaces (FSSs) with bandpass responses have gained significant attention in recent years. Many design methods and structures are adopted to obtain bandpass responses. A frequency response with an almost flat top and a fast roll-off can be obtained by using two or more cascaded surfaces [1-2]. Conventionally, millimetre-wave and THz bandpass FSSs can be implemented by cascading resonant or non-resonant surfaces separated by dielectric layers. The thickness of the dielectric slabs is usually around a quarter wavelength to obtain a flat frequency response and fast roll-off [3]. However, the loss is usually high due to the thick dielectric material. Fig. 1(a) shows a single-layer FSS array element of a cross slot, with 45^o rotation in XY-plane. By this arrangement, the performance is insensitive to the polarization of the electrical field. Our single-layer FSS structure consists of a 3×3 cm^2 array of cross-slot elements. The schematic of a single 0.662×0.662 mm^2 element is shown in Fig. 1(a): each cross is oriented at 45^o rotation in the x–y-plane, with slot width $W = 0.15$ mm, and slot length $L = 0.662$ mm. By this arrangement, the performance is insensitive to the polarization of the electrical field. Standard photolithography and lift-off processes were used to pattern the single-layer FSS array on 0.7-mm-thick glass substrate. For the metallic layer, a bilayer of approximately 25 nm Ti coated with 100 nm of Au was deposited by e-beam evaporation. Transmission spectroscopy was carried out over a 100–400 GHz bandwidth using a pair of TOPTICA THz photomixers. Interferograms were acquired at a range of emitter frequencies by adjusting the THz beam path length between the emitting and receiving antennas and recording the amplitude of the THz field over an 80-ps delay length, with 0.83-ps step size. The transmission spectrum was obtained by comparing the interferogram amplitudes, both with and without the FSS present, at each frequency. The transmission response of the fabricated single-layer FSS array is shown in Fig. 1(b). The red line shows high-resolution scans over a narrow bandwidth, while the black line shows low-resolution scans over a wide bandwidth. The passband can be clearly observed at 166 GHz as expected. The loss is relatively high at around 5 dB. To improve the performance, a new method is proposed to design a low-loss second-order FSS bandpass filter, which exhibits very stable proposed performance for varied incident angles and polarization angles. The two layers are separated from each other by an air gap as shown in Fig. 1(c). The simulated response is shown in Fig. 1(d). It can be seen that the response has a flat passband, much better selectivity and lower loss. This design will be fabricated and tested in the near future.

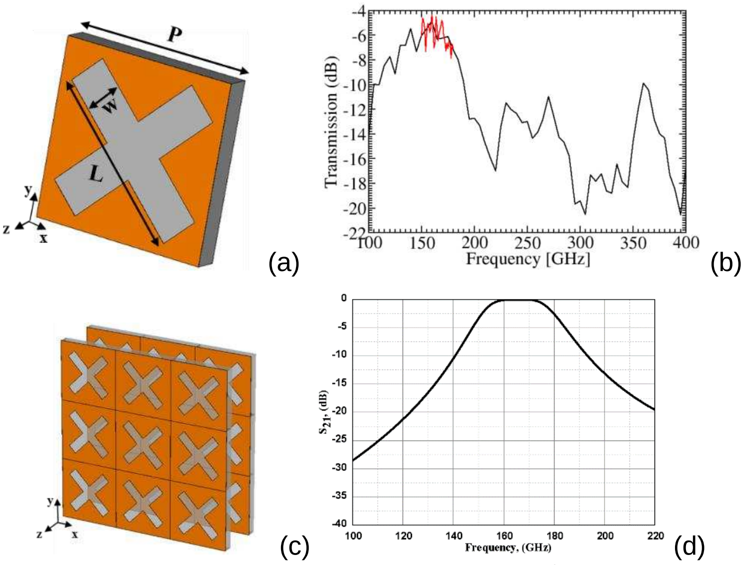

Fig. 1 (a) Schematic view of the single-layer FSS array element. (b) Transmission response of the single-layer FSS array. (c) Schematic view of the two-layer FSS array structure with an air gap. (d) Simulated transmission response of the two-layer FSS array structure.

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