RCS Reduction Characteristics of Thin Wave Absorbers Composed of Flat and Curved Metasurfaces

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Abstract **– Thin wave absorbers composed of a periodic structure of metal patches have been investigated in order to reduce the radar cross section (RCS). To achieve stable operation for absorbing frequency at oblique incident angles, a high value of permittivity of the substrate or a very thin substrate are required. This paper presents the RCS reduction characteristics of a metasurface absorber with 0.1-mm thickness at oblique incident angles. The calculated result indicates that the RCS reduction of the flat-wave absorber near 10 GHz is 16 dB at normal incidence, and experimental results show a 10-dB reduction. The RCS of the curved wave absorber is attenuated by 11 dB. The transverse magnetic (TM) incident wave pattern shows steady RCS reduction characteristics at oblique incident angles. In contrast, the transverse electric (TE) incident wave pattern shows that the attenuated frequency becomes low and RCS reduction decreases as the incident angle increases.**

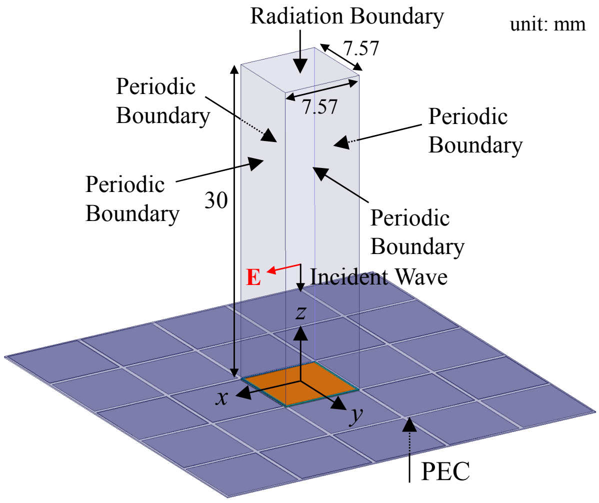
Index Terms — metasurface; curved; RCS reduction; thin wave absorber

1. Introduction

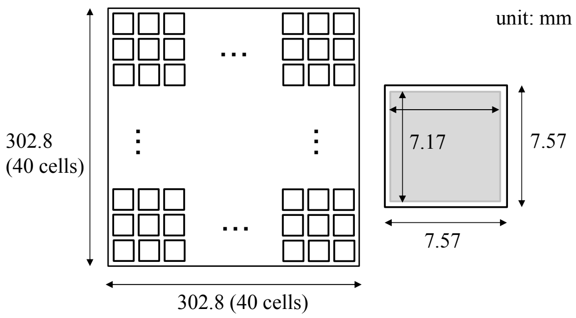
Thin wave absorbers composed of a periodic structure of metal patches have been investigated in order to reduce the radar cross section (RCS)[1]. To realize a high-impedance metasurface, typical patch structures with and without vias have been employed as the unit cell configuration [2]. To achieve stable operation for absorbing frequency at oblique incident angles, a high value of permittivity of the substrate [3] or a very thin substrate [4] are required. This paper presents the RCS reduction characteristics of a metasurface absorber with 0.1-mm thickness at oblique incident angles. The experimental results of the fabricated flat and curved metasurfaces are also shown at normal incidence.

2. Radar Absorbent Material Configuration

Figure 1 shows the configuration of a thin-wave absorber. A periodic boundary of size 7.57 mm square is set in order to shorten the calculation time as shown in Fig. 1(a) and (b). At the bottom of this model is a perfect electric conductor (PEC), and at the top is a radiation boundary. The distance between the PEC and radiation boundary is 30 mm. Figure 1(c) shows the transverse electric (TE) incident wave model. The electric field is vertical against the scanning surface (zx plane). Figure 1(d) indicates the transverse magnetic (TM) incident wave model. The electric field is parallel to the scanning plane (zx plane). A copper plate of thickness 0.018 mm and size 7.17 mm square is loaded on a dielectric substrate of thickness is 0.1 mm with ε_r = 4.1 and tanδ = 0.02 (CS-3355). The air gap between adjacent patches is 0.2 mm, and the curvature radius measuring tool is 400 mm. Ansoft HFSS ver.13 simulation with the finite-element method is used for calculation.



(a)



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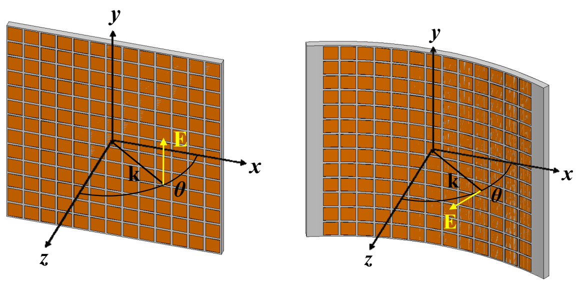
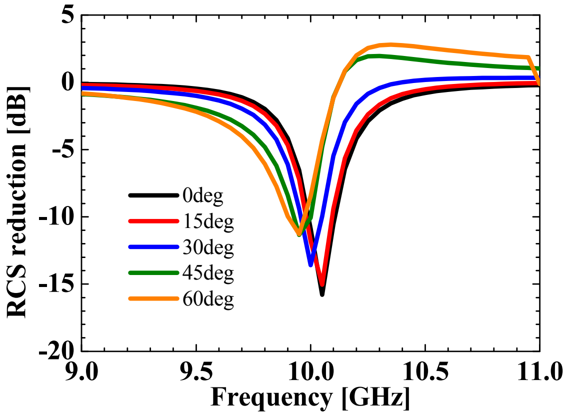
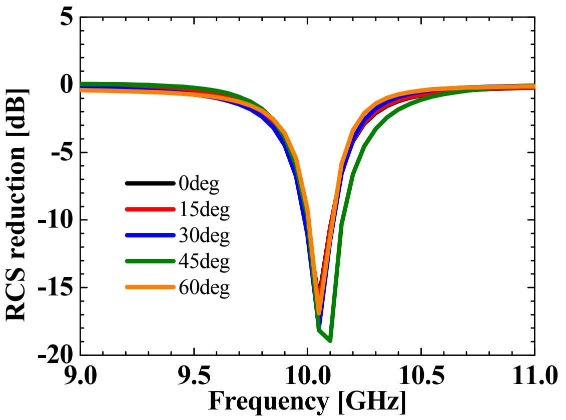


(c) (d)

Fig. 1. Configuration of the thin wave absorber: (a) General view, (b) configuration of patch and unit cell, (c) TE incident wave model (flat metasurface), and (d) TM incident wave model (curved metasurface).



(a)



(b)

Fig. 2. RCS reduction characteristics: (a) TE incident wave and (b) TM incident wave.

3. Results

Figure 2 shows the RCS reduction characteristics of wave absorbers composed of a flat metasurface. Figure 2(a) indicates the RCS reduction characteristics for the TE incident wave. The attenuated frequency becomes low and RCS reduction decreases as the incident angle increases. Figure 2(b) shows the RCS reduction characteristics for the TM incident wave. RCS reduction at each incident angle illustrates a sharp peak from 16 dB to 18 dB near 10 GHz.

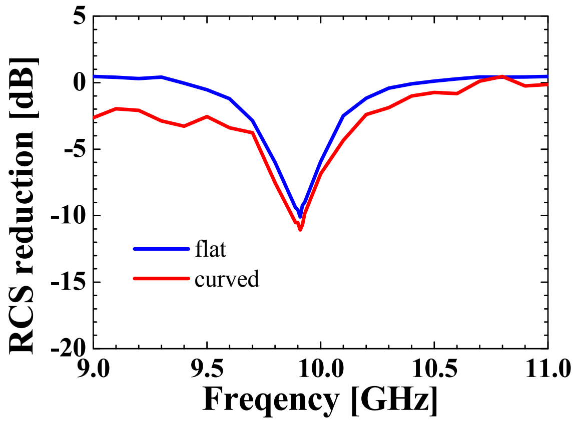


Fig. 3. RCS reduction characteristics of wave absorbers composed of flat and curved metasurfaces at 0° (experimental results).

Some broadband characteristics are shown at 45°. Both TE and TM incident wave patterns show the same monostatic RCS at normal incidence. The calculated result at normal incidence shows a 16-dB RCS reduction around 10 GHz. Figure 3 shows the RCS reduction characteristics of wave absorbers composed of flat and curved metasurfaces for a TE incident wave taken in the experiments. The RCS reduction of the flat metasurface is 10 dB near 10 GHz as well for the calculated result. Moreover, RCS reduction of the curved metasurface is 11 dB and the curved RCS characteristics are similar to those of the flat metasurface.

4. Conclusion

In this study, the RCS reduction characteristics of a metasurface absorber with 0.1-mm thickness were investigated. The calculated results of the flat wave absorber show an RCS reduction of 16 dB, and the experimental results indicate a 10-dB reduction. In addition, the curved wave absorber shows similar RCS reduction characteristics to those of the flat one. The TM incident wave pattern shows steady RCS reduction characteristics at both normal and oblique incident angles. On the other hand, the TE incident wave pattern shows that attenuated frequency becomes low and RCS reduction decreases as the incident angle increases.

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