Frequency tunable metallo–dielectric structure for backscattering reduction

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Electromagnetic scattering behaviour of a superstrate loaded metallo–dielectric structure based on Sierpinski carpet fractal geometry is reported. The results indicate that the frequency at which backscattering is minimum can be tuned by varying the thickness of the superstrate. A reduction in backscattered power of ~44 dB is obtained simultaneously for both TE and TM polarisations of the incident field.

Introduction: Reflector-backed metallo–dielectric structures have been studied extensively by many researchers for the elimination of backscattering and specular reflection [1, 2]. Most of these structures employ metallisation based on conventional Euclidean geometries on a low-loss dielectric substrate. These surfaces find application in RCS reduction, frequency scanning reflectors and antenna design. The idea of using fractal-based metallisations in the design of metallo–dielectric structures has been reported recently in which reduction in backscattered power of ~30 dB is obtained simultaneously for TE and TM polarisations using Sierpinski carpet fractal geometry as the metallisations on the dielectric substrate [3].

A fractal is a recursively generated structure that posses self-similarity and fractional dimension [4]. These structures are finding wide applications, especially in the design of antennas for multiband applications, due to their inherent self-similarity and space-filling properties [5]. In this Letter, the effect of loading superstrate on a metallo–dielectric structure based on Sierpinski carpet fractal geometry is envisaged. It is found that the frequency at which reduction in backscattered power is obtained depends on the superstrate thickness. This technique can be used to reduce backscattering from a fixed metallo–dielectric structure at a desired frequency by varying the dielectric thickness of the superstrate. The frequency tuning effect is achievable for both TE and TM polarisations of the incident field.

Methodology and experimental setup: The metallo–dielectric structure based on Sierpinski carpet fractal geometry is fabricated by photo-etching the metallisation on a reflector-backed low-loss dielectric substrate ($\varepsilon_r = 2.56$) of size 30 × 30 cm. The geometrical layout of a superstrate loaded metallo–dielectric structure is shown in Fig. 1. Fig. 2 shows the top view of the metallic structure based on the third iterated stage of the Sierpinski carpet fractal geometry used in the present work.

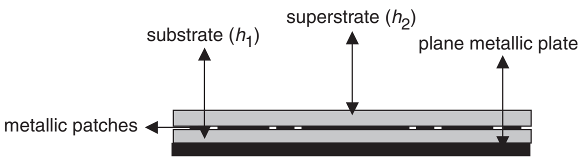

Fig. 1 *Cross-sectional view of superstrate loaded metallo–dielectric structure*

h_1 = substrate thickness, h_2 = superstrate thickness

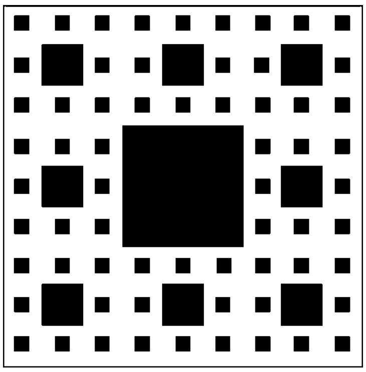

Fig. 2 *Top view of metallic structure based on third iterated stage of Sierpinski carpet fractal geometry*

The metallo–dielectric structure backed with a plane metallic plate and loaded with superstrate is placed on a turntable in an anechoic chamber. The measurements are performed over X and Ku band frequencies using an HP 8510C vector network analyser. The structure is illuminated using a wideband horn antenna. The backscattered power from the third iterated stage of the fractal geometry is measured for frequencies ranging from 8 to 17 GHz by loading superstrates of various dielectric thicknesses (h_2). The experiment is repeated for metallo–dielectric structures fabricated on different dielectric thickness of the substrate (h_1) and the backscattered power is compared with that from a plane metallic plate of the same dimensions.

Results and discussions: From the results it is observed that the superstrate loading on a fractal-based metallo–dielectric structure reduces the backscattering to a great extent. It is also observed that the frequency tuning effect is achieved by varying the dielectric thickness of the superstrate. Fig. 3 shows the variation of backscattered power with frequency in the X and Ku bands. It can be seen that a considerable reduction in backscattered power over a broad range of frequencies is achieved by loading superstrates of varying thickness on a metallo–dielectric structure. A maximum reduction of 44 dB in backscattered power is obtained at 12.025 GHz for a substrate thickness $h_1 = 3$ mm when loaded with a superstrate of thickness $h_2 = 0.6$ mm. The variation of resonance frequency with superstrate thickness loaded over a metallo–dielectric structure is shown in Fig. 4. From the experimental results, it is clear that the backscattering reduction can be obtained at any desired frequency by using a superstrate of the proper dielectric thickness.

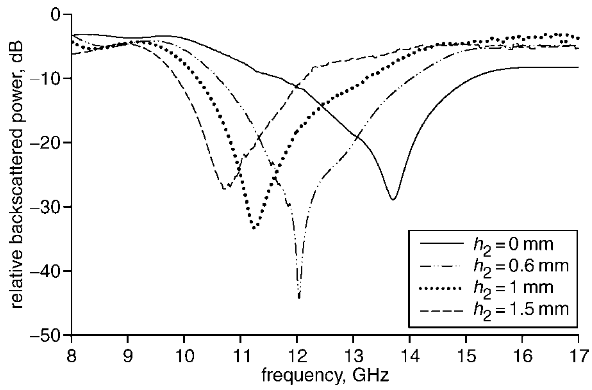

Fig. 3 *Variation of relative backscattered power with frequency* ($h_1 = 3$ mm)

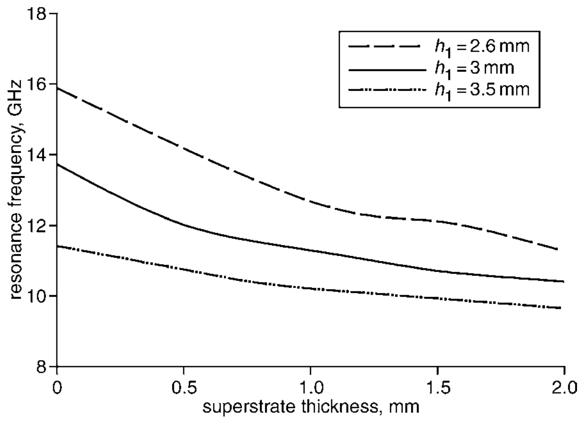

Fig. 4 *Variation of resonance frequency with superstrate thickness*

Conclusions: Superstrate loading on a metallo–dielectric structure based on fractal geometry is found to reduce backscattering to a great extent. A frequency-tuning effect is achieved for this structure by varying the dielectric thickness of the superstrate. The reduction in backscattered power is obtained for both TE and TM polarisations of the incident field, owing to the symmetry of the metallic structure geometry. The property of this structure with proper parameter selection can perform over a wide range of applications such as frequency selective surfaces, RCS reduction techniques etc.

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