Abstract

Metamaterials and Metasurfaces (2D equivalent of metamaterials) have paved the way for effective controlling the electromagnetic interaction properties of the engineered composites enabling new technologies for several applications in the field of microwave engineering. This Thesis is devoted to designing of metamaterial and metasurface based structures for stealth application. Stealth is an inevitable part of any military platform, and with rapid development in detection technologies, advanced stealth features are required. The main objective of stealth technology is reduction of the Radar Cross Section (RCS) of the object under surveillance. The RCS reduction is achieved in four ways, i.e., (i) shaping, (ii) absorption, (iii) cloaking, and (iv) phase cancellation. The Thesis address the absorption and phase cancellation approaches for the RCS reduction. In the first part of the Thesis, disordered metamaterial absorbers are proposed and analyzed experimentally for polarization-insensitive broadband RCS reduction. In the subsequent part of the Thesis, two different metasurfaces based on the phase cancellation approach are proposed for broadband RCS reduction.

Disordered metamaterials are less explored compared to their periodic counterparts, as periodicity simplifies the design and analysis process. However, disorder can be used to enhance the absorption properties of the metamaterial absorber structures. In this work, disordered metamaterial absorbers are proposed and analyzed numerically. A controllable degree of position disorder is introduced in the initial periodic setting. It is observed that in the disordered structures additional absorption peaks arise due to the coupling among neighboring resonators. Further, the filling factor (which is defined as the ratio of the total area occupied by the resonators and the area of the entire sample) is increased gradually. It is observed that more the filling factor more densely the resonators are packed, resulting in increased coupling among the neighboring resonators which leads to an inhomogeneous broadening of the absorption spectrum. It is seen that the proposed disordered absorbers are polarization-insensitive even for oblique incidences. Moreover, a different patch shape resonator is analyzed, and it is observed that the enhancement in absorption bandwidth is independent of the shape of patch resonator.

The proposed disordered metamaterial absorbers are also experimentally investigated. Two different resonator configurations, i.e., overlapping and non-overlapping, are analyzed. It is observed that the enhancement in the absorption bandwidth is due to the coupling among the neighboring resonators. It is seen that clusters are formed due to the overlapping of two or more resonators in the overlapping configuration. These clusters support additional absorption at lower frequencies. The fabricated disordered metamaterial structures are further tested for oblique incidences, and it is seen that they have a stable absorption response for both the polarization for large incidence angles. The experimental results are then compared to the numerical results and a reasonable degree of the agreement is found among them.

In the subsequent part of the work two different metasurfaces based on two different design concepts: array antenna theory and generalized Snell-Descartes's law are proposed. Firstly, a random checkerboard metasurface based on array antenna theory is introduced. It is designed in two steps. The first step is selecting the basic meta-atoms having a 180^o phase difference among themselves over an ultra-wide frequency band. The second step is randomly distributing these meta-atoms in the checkerboard pattern for completely disturbing the phase layout resulting in diffused scattering. It is shown that the proposed metasurface can achieve polarization-insensitive RCS reduction for a wide frequency band. Later, a second metasurface based on generalized Snell's law is presented. This phase gradient metasurface is capable of redirecting the backward scattered

waves in predefined directions. Eight phase gradient supercells comprised of two different meta-atoms were randomly distributed in a checkerboard configuration. Randomly arranging these supercells completely disturbs the phase coherence and results in the diffused scattered wave resulting in a wideband, polarization-insensitive RCS reducing metasurface.

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