EM Analysis of Metamaterial based Radar Absorbing Structure (RAS) with Dual-resonant Characteristics

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Author Draft

Abstract The radar absorbing materials (RAM) and structures (RAS) are widely used in aerospace sectors to reduce the RCS of the aircraft, electromagnetic shielding of high reflection surfaces and metal surfaces etc. The stealth technique is the most typical application of electromagnetic (EM) wave absorption technology. Using this technique, the aircraft and warships can evade detection by reducing their radar cross-section (RCS). Initially, the EM radar absorbers were designed using Salisbury screen (Fnate and McCormack, IEEE APS, 1968; Chambers, Electronics Lett., 1994). This type of absorbers involves the use of resistive sheet and a metallic ground plane to cancel out the reflections from the screen, which may be a disadvantage in stealth technology. The radar absorbing structures are also realized with FSS technology, which provides thin design but shows satisfactory EM performance only at low incidence angle (Singh *et al*., PIER B, 2012). Recently, introduction of metamaterial technology leads the design of high performance radar absorbers in the frequency range from microwave to terahertz regimes. The permittivity and permeability of metamaterial structure can be controlled by varying the dimensions of its electric and magnetic components. By tuning the resonances of electric and magnetic components, a metamaterial can be impedance-matched to free-space to achieve 100% absorption without using metal plate backing. For instance, in the designing of a metamaterial based absorber, multiple split-ring resonator (SRR) bases with resonant-magnetic inclusion were employed to eliminate the use of metallic backing plates in absorbers (Alice *et al*., J. Appl. Phys., 2010).

In the present paper, a metamaterial based radar absorbing structure has been proposed for dual-resonant characteristics in millimeter wave frequency regime. The proposed structure consists of cascaded MNG (mu-negative) and DPS (double positive) layers. The EM performance analysis of this structure is carried out based on *transmission line transfer matrix* (TLTM) method for both TE and TM polarizations. The proposed metamaterial-RAS exhibits dual-resonant absorption at frequencies 120 GHz and 180 GHz with more than 95% power absorption at normal incidence. Likewise the power reflection is low (at less than 25 dB). Further, tuning of dual-resonant characteristics is obtained by varying the separation between the rings of the SRR. The reflection and absorption characteristics are also studied at high incident angles in view of aerospace applications.

To summarize, a dual-resonant metamaterial based RAS has been designed with excellent power absorption without metal plate backing. The proposed metamaterial-RAS can be used for stealth applications in millimeter wave frequency region.

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