5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Radar cross-section reduction of a metallic target using plasma-based microwave absorber.

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Abstract

When electromagnetic waves interact with plasma, the incident electromagnetic waves lose their energy by scattering and resonance. This physical phenomenon substantially reduces the Radar Cross Section (RCS) of a Device Under Test (DUT) when covered by plasma. Various techniques like shaping, use of radar absorbing materials, frequency selective surfaces, engineered materials have been attempted to reduce and control the RCS of an object. Plasma-based RCS reduction is a technique that is associated with the reflection and absorption of incident EM waves by the plasma layer surrounding the structure whose RCS is to be reduced.[1]–[3] Plasma-based RCS reduction is particularly promising because of its wider frequency band of absorption, selective reduction in RCS because of the electron density control, and also because there is no alteration in the shape of the target.[4], [5] The RCS of an object can be calculated using the following equation: $\sigma = \frac{p_r}{p_t}\left[\frac{4\pi^3 \times R^4}{G_t \times G_r \times \lambda^2}\right]$ [6]

Plasma is a host to a variety of waves and collisions. During such collisions, at a particular plasma frequency and collisional frequency, the microwaves of frequencies 8-12 GHz are absorbed in the plasma, and the reflection from the metal plate is reduced substantially, giving a reduced RCS. A measurement setup called NRL Arch configuration is developed as recommended in IEEE standard 1128 to study the RCS of the DUT. [7]–[9]Two identical standard gain horn antennas are placed on an in-house fabricated NRL arch setup and transmit (T_x) and receive (R_X) MW signals reflected from the target via a plasma panel. MW power reflected from the target is received at the R_X antenna after passing through the plasma panel. The difference in R_X signal with and without plasma is understood as absorption. The entire experiment is carried out in an Anechoic Chamber that is designed and developed as per IEEE standards to carry out microwave measurements at frequency range 2-18 GHz with a quiet zone of 1 m^2.[10]–[12] We report the experimental study of reduction in RCS of a given metallic plate (target) using a plasma panel. The plasma panel is formed by a series of 7 cylindrical plasma tubes enclosed in a cuboidal Teflon housing that is designed and fabricated in-house. This panel is placed in front of the target/DUT, whose RCS has to be studied. X-band microwaves are radiated upon the plasma panel using a standard gain horn antenna and received using a similar antenna. The difference in the return loss of the MW power with and without plasma is understood as absorption. A minimum of 25 % and a maximum of 90 % reduction in RCS is observed in the X-band. An attempt has been made to explain the variations in the RCS reduction in the targeted frequency range.

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