Use of Collisional Plasma as an Optimum Lossy Dielectric for Wave Absorption in Planar Layers, Analysis, and Application

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***Abstract*— Parameters of electromagnetic scattering for lossy plasma media are analytically computed for planar layered structures. The structures are backed with a perfectly electric conductor and minimal reflection is analyzed versus both incident wave angle and frequency. The physical specifications of plasma dielectric for the optimum reduction in reflection are obtained using genetic algorithm. Optimizations show a good prospect to use electromagnetic properties of cold collisional plasma as an optimum lossy dielectric. The achieved optimum plasma for the coating layer is an appropriate choice for radar cross section reduction over a wide range of incident frequencies and angles. Although the plasma layer alone can dissipate the wave satisfactorily, an applicable model within a confining layer is analyzed. The elctron density distribution is analyticaly investigated. Applications are analyzed in full wave, numeric, and analytical methods.**

***Index Terms*— Collisional plasma, electromagnetic wave scattering, genetic algorithm, lossy dielectric, radar cross section reduction.**

I. Introduction

ABSORBING electromagnetic (EM) wave contrary to its absorbing properties is important in specific applications. Studying any complex and realistic medium such as absorbing one, is to fulfill both classic and newly found desires. Therefore, inventing new materials is a way to be applicable in theory and practice simultaneously. Lossy dielectric is the most common material in the universe and of course in applied electromagnetic science. This paper mainly suggests using a proper method in different applications. The suggestion is to replace the conventional lossy dielectrics with plasma.

Plasma medium is the fourth kind of the material and refers to ionized gas. Plasmas have equal free electrons and positive ions with extra neutral particles. This media covers the earth as ionosphere layer. Interactions of EM waves with plasma medium has been published in [1]. For decades, the theory of reflected waves from the atmosphere is the basis of radio wave propagation systems in the communication field of study. Microwave frequencies transmit through plasma ionosphere for satellite communications. After reflection and transmission properties, the absorption of these kinds of materials have been investigated and experienced in [2]–[4].

Recently, good progress in this part of plasma physics and engineering has been achieved, mainly on the basis of physical aspect of the theory [5]–[12]. Using plasma in military applications such as stealth technology has been proposed in earlier studies. Plasma as a replacement for other wave absorbers has vast improvements such as great reduction of wave power, affecting large frequency band of incident wave, and so on [8].

In this paper, electromagnetic scattering theories are developed for the new infinite planar layered structures. For most wave losses in lossy regions, optimizations propose optimum features, which are satisfied by plasma medium. The innovative part of the study is exploiting plasma properties obtained from the genetic algorithm (GA) with the method of least square. The obtained reflectance coefficient for the structure is the goal function to minimize in optimizations. The inhomogeneity of plasma permittivity is considered with the method of Taylor series.

In the following, the structure is defined. EM scattering for total reflection coefficient will be formulated for two incident wave polarizations. Analysis of EM waves in cold collisional plasma is briefly explained in the next step. Optimizing the variables for the least reflection from structure and choosing the optimum plasma parameters in a frequency band are represented for the lossy layer. A theoretical application for radar cross section is demonstrated using the obtained results. An applicable model with a confining layer is sketched. Nonuniform distribution of the free electrons in plasma medium is analyzed.

II. Electromagnetic Scattering Analysis of the Structure

The purpose is to find the reflection function of the incident wave from the structure shown in Fig. 1 using full-wave method. There is a bidirectional infinity toward y- and x-axis. The planar half-space layers are set in the z-axis. The region one is a half free space, the middle one through z-axis is the lossy dielectric layer and another half-space is perfectly electric conductor (PEC). The lossy medium is the needed part to be optimized for the least reflection ability. There is not any electric field inside PEC because it reflects all of it. Implementing the conditions for loss is to lower total reflection

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