FAST CALCULATION OF ELECTROMAGNETIC SCATTERING IN ANISOTROPIC MULTILAYERS AND ITS INVERSE PROBLEM

Giacomo RODEGHIERO[1], Ping-Ping DING[1*], Yu ZHONG[2], Marc LAMBERT[1], and Dominique LESSELIER[1]

[1] Département de Recherche en Electromagnétisme - Laboratoire des Signaux et Systèmes UMR8506 CNRS-SUPELEC-U. Paris Sud, 3 rue Joliot-Curie, 91192 Gif-sur-Yvette, France
[2] A*STAR, Institution of High Performance Computing, 138632 Singapore

Abstract

How to electromagnetically test damaged anisotropic multilayers like planar composite panels applied in aeronautic and automotive industry is a difficult question to solve: one needs fast and robust inversion algorithms aimed at measuring transforming fields (in high-frequency cases, microwaves) or impedances (in low-frequency cases, eddy-currents) and transforming the results into images amenable to end-users' decision about the damages. Besides, it is also important to have the results in close-to-real-time. Yet one also needs accurate modeling of the multilayers' responses to the electromagnetic sources at preliminary forward stage.

Here, one proposes a comprehensive solution aimed at modeling the scattering by such multilayers, in harmony with [1-2]. It involves particularly the fast calculation of dyadic Green's functions for uniaxial multilayers and the response of sources distributed within, and solutions of the associated inverse problems in the hypothesis of small defects. The Green's functions have to be accurate even when the sources are far away from the origin, which yields a fast-oscillating spectrum of the dyads, as carefully considered in the present contribution. The material of defects could be isotropic, like voids or fluid-filled cavities, or even uniaxial. Here, "small defects" means with respect to the wavelengths or skin-depth of the probing waves at location of the defects depending on the conductivity of the medium.

A first-order solution of the direct problem involving possibly anisotropic defects described by the depolarization tensors will be presented and compared to a somewhat brute-force approach involving cutting the small defects into smaller pieces [3].

To some extent, the inversion proposed herein is the generalization of the work summarized in [4]. The focus is on MUltiple SIgnal Classification (MUSIC) imaging which calls for the input of dyadic Green's functions which associate sources assumed in the region of interests, excited by a finite-array input source and scattering when testing the damaged medium, and exploitation of the resulting Multi-Static Response (MSR) matrix, to the fields observed at nodes of a fine sampling mesh of a parallelepiped search domain in which one finds the defects to be located. The above is illustrated by a number of numerical examples.

References

[1] Y. Zhong, M. Lambert, D. Lesselier, and X. Chen, Electromagnetic response of anisotropic laminates to distributed sources, *IEEE Trans. Antennas Propag.* **62** (2014) 247-256.

[2] Y. Zhong, P.-P. Ding, M. Lambert, D. Lesselier, and X. Chen, Fast calculation of scattering by 3-D inhomogeneities in uniaxial/biaxial multilayers, *IEEE Trans. Antennas Propag.*, submitted, Feb. 2014.

[3] A. Sihvola, Metamaterials and depolarization factors, *PIER*, **51** (2005) 65-82.

[4] G. Rodeghiero, Y. Zhong, M. Lambert, D. Lesselier, and X. Chen, An efficient interpolation for calculation of the response of composite layered material and its implementation in MUSIC imaging, *COMPUMAG 2013 Conf.*, Budapest, June.

[*] Corresponding author. *Phone:+33169851666, E-mail address:pingping.ding@lss.supelec.fr*