Multilayer Green's Function Based Model for Carbon Nanotube Composites

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Electromagnetic scattering from CNTs (carbon nanotubes) has been extensively investigated in the past two decades. Many possible CNT configurations have been analyzed computationally, starting from single isolated CNT to array of CNTs, but mostly in free space environment. Most of these studies, consider CNTs as perfectly straight conducting wires aligned with a uniform spatial distribution. In practical scenarios, CNTs are grown either on top of a substrate or embedded within a substrate. Recently these practical CNT scenarios, have received rising interest. Three factors have a significant effect on the overall electromagnetic response of composites, namely the shape of the CNTs, their spatial distribution, and the embedding medium. Moreover, most composites possess multiscale features because the dimensions of the embedding media are several thousand times larger than that of CNTs and their separations. Commercial full-wave software packages can explicitly model such topologies, but due to the multiscale nature of the problem, an extremely large number of discretization elements is necessary which in turn demands prohibitive computational times. Moreover, when we incorporate practical distributions with hundreds of CNTs, these techniques further increase the computational burden particularly when it is necessary to analyze and optimize several structures.

In the present study, our goal is to model and efficiently compute the electromagnetic response of arbitrarily oriented CNTs, with realistic shapes, distributed randomly within a lossy dielectric slab backed by two other lossy half spaces. The dielectric slab will have a finite thickness but it will be semi-infinite in the other two directions emulating a laminate where the lateral dimensions are significantly larger than the thickness. To accomplish this goal, we have employed the multilayer Green's function approach with the rigorous Sommerfeld integral approach. This method eradicates the need of explicit discretization of the slab's interfaces. The multilayer Green's function can fully account for the layered structure, treating it as a single entity. To reduce computational time the CNTs were modeled as thin wires and method of Moment (MoM) for arbitrary thin wire (ATW) formulation was employed. The problem was solved for both cases where excitation is being applied in the embedding layer or from either of half-spaces above or below the dielectric slab. A comparative study has been carried out to check the efficiency of proposed method in comparison to the available commercial full-wave software packages. The various results are planned for presentation at the time of the conference