Spectral Green's Function Representation for Photo-Conductive Slot Antennas

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The basic mechanism for the THz power generation is typically achieved by resorting to optically pumped photoconductor materials (e.g., LTG-GaAs and InGaAs). In detail, when an optical source impinges on a photoconductor with appropriate carrier frequencies (e.g. 353 THz for LTG-GaAs and 193 THz for InGaAs), electrons-holes pairs are generated due to the electrons jump from the valence band to the conduction band, resulting in a change of the conductivity of the material. These charges are accelerated by an electric field induced by applying a biasing voltage between an anode and a cathode located close to the photosensitive area.

The optical pumping source typically operates in two different modes; i.e., the Continuous Wave Mode (CWM) or the Pulsed Mode (PM). The CWM consists in mixing two continuous wave lasers (photo-mixing) operating at two different frequencies. In this way an electromagnetic power density in the THz frequency range is obtained tuning the two optical frequencies. The conductivity value of the photoconductive material oscillates at the beat frequency of the two lasers. Consequently, the current induced by the bias oscillates at the same frequency, thus feeding the antenna (E. R. Brown, International Journal of High Speed Electronics and System, 13, 2, 497–545, 2003). The PM consists in using a single laser which generates an optical carrier modulated by short pulses. In this way an electromagnetic power density in the THz frequency range is obtained. The laser incident power generates free carriers in the conduction band modifying the conductivity of the material over a THz range, whose bandwidth depends on the carriers lifetime in the photoconductor. Consequently, a pulsed current is induced by the bias (P. U. Jepsen, R. H. Jacobsen, and S. R. Keiding, J. Opt. Soc. Am. B, 13, 11, 2424–2436, 1996). The performances of such devices are affected by various phenomena, i.e., the interaction between the optical source and the semiconductor, the geometrical parameters of the active gap which feeds the antenna, and the electromagnetic radiative properties of the entire structure. In order to take into account of all these aspects, equivalent circuit model have been proposed in the literature for analyzing the Photo-Conductive Antennas (PCA) by using approximations as quasi-static models and considering lumped circuit elements.

In this work a characterization of the PCA based on Spectral Green's function formalism is shown for the first time. Such approach was already successfully applied for analyzing connected arrays of slots and dipoles. The formulation proposed in this work has been developed for infinite slots printed at the interface of two different homogeneous dielectric media and it can be used for analyzing the radiating feed of lens antennas. The model can be applied both for the CWM and for the PM. We expect that the proposed solution, since based on a Green's function formulation, will provide more accurate results respect to those present in the literature. During the presentation the formulation of the model will be presented along with some numerical results showing its validity and effectiveness.