MASTER DE PHYSIQUE ET APPLICATIONS - 2ème année
Spécialité Sciences des Matériaux et Nano-objets
International Nanomat Master Program

Internship proposal 2009-2010

Laboratory: Applied Electromagnetic Lab University "Roma Tre"

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Design of optical nanodevices and components

Scientific project:
There is a growing interest in nano-scale technology and a lot of applications in different fields (e.g. imaging, telecommunications, etc.) have been recently proposed. An interesting application has been proposed by Engheta's group, as nano-circuits working at optical frequencies. Since the conduction current does not play a significant role at these frequencies, the proposed nano-circuit elements are based on the displacement current concept. Engheta's group has shown the possibility to establish a complete analogy between the optical circuit nano-elements and their radio-frequency counterparts. The role of the conductors connecting the elements is played by optical materials with a very large real part of the permittivity (Epsilon-Very-Large materials), while the role of the insulators covering the circuit and allowing that the displacement current does not leak outside the circuit is played by optical materials with a close to zero real part of the permittivity (Epsilon-Near-Zero materials). Inductors and capacitors are given by nano-elements with a negative or a positive real part of the permittivity, respectively, and resistors are given by optical materials with high imaginary part of the permittivity. It is worth noticing that all the aforementioned materials are readily available at THz and visible frequencies. Regular materials with permittivities larger than the one in free-space are used for nano-capacitors and nano-connectors, while both nano-inductors and nano-insulators are obtained by using plasmonic materials (e.g. noble metals), which naturally exhibit at those frequencies a negative real part of the permittivity or a permittivity less than the one in free space.
In this project, we will study new approaches to synthesize basic components like nanofilters at optical frequencies, using collections of 3D nano-particles acting as lumped nano-circuit elements.
Using full-wave numerical simulations, we'll test the behavior of these nano-elements against some circuit theory fundamental laws to show how the proposed nano-elements may closely mimic their radio frequency counterparts at optical frequencies. Following the same analogy between classic circuit theory and the optical nano-circuits, we'll try to derive a complete set of design formulas for the nano-modules under investigation.

Techniques in use:
Computer literacy: CST, Mathematica, Matlab Electromagnetic wave propagation in dispersive media

Applicant skills: Able to design microwave and/or optical passive and active devices, like filters, couplers, antennas, power amplifiers etc. Knowledge of the electromagnetic properties of plasmonic materials. Able to perform both individual and team work

Granted internship: yes
C'nano IdF laboratory (France only):
Possibility for a thesis: yes , financial support possible after selection according to national rules.
Amount of the grant: approximately 13640 €/year (previdential contribution shall be deducted).