Towards Verification of D-dot Loop Concept in Optical Regime

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A very promising concept of an 'optical wire' ('D-dot wire') that replaces the flow of the conduction current with the flow of the displacement current has been introduced a few years ago (A. Alù and N. Engheta, *All optical metamaterial circuit board at the nanoscale* Phys. Rev. Lett., vol. 103, no. 14, p. 143902, 2009; B. Edwards and N. Engheta, *Experimental Verification of Displacement-Current Conduits in Metamaterials-Inspired Optical Circuitry*, Phys. Rev. Lett., vol. 108, no. 19, p. 193902 5p, 2012). Very recently, this concept has been extended to a so-called 'D-dot loop' that is actually a capacitive dual of a classical small inductive loop antenna (elemental magnetic dipole). The 'D-dot loop' might find applications in future optical radiation and scattering systems. The basic idea has already been verified by scaled experiments in RF regime (B. Okorn, S. Hrabar, and J. Sancho-Parramon, *Verification of concepts of D-dot wire and D-dot loop in RF regime*, 2014 IEEE Int. Symp. Antennas Propag., 2014).

Here, we report a design of the proof-of-concept hardware demonstrator expected to verify the basic properties of the D-dot loop in optical regime. The structure being designed is an optical metusarface that comprises an array of circular air grooves in plasmonic layer located on a top of a thin low-dielectric-constant base. Since each circular groove operates at plasma frequency it streamlines the circular flow of the displacement current. Thus, an elemental magnetic dipole is achieved.

As a first step, full-wave simulations intended to optimize the geometry that should allow the demonstration of the circular flow of the displacement current, maintaining low loss and, at the same time, fulfilling the manufacturing constrains imposed by e-beam lithography are presented. In addition, the design of the verification experiment *per se* is rather challenging. One way might be able to apply the same method used in a previous scaled RF experiment (a direct observation of the paramagnetic effects of a D-dot loop). However, it requires either a rather complicated excitation system or the advanced ellipsometry capable of extraction of both the permittivity and permeability tensors. The alternative way would be the use of an optical waveguide loaded with D-dot loops and a simple measurement of the transmission coefficient (similar to the approach used in microwave regime (S. Hrabar, J. Bartolic, Z. Sipus, *Waveguide Miniaturization Using Uniaxial Negative Permeability Metamaterial*, IEEE Tran. Ant. Prop., vol. 53, no. 1, p. 110-119, 2005). The design, simulations and the preparation for the fabrication are in the final stage and the preliminary results will be presented at the conference.