Nanolithographically Fabricated Metallic Metamaterials showing a Strong Broadband Resonances between 1 and 3 microns

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Left-handed materials (LHM) with simultaneously negative electric permittivity ε and magnetic permeability μ have attracted a great deal of attention in recent years due to their unique electromagnetic responses which can not be expected from naturally occurring materials [1]. Since the first LHM consisting of metallic split ring resonators (SRR) and wires was reported [2], numerous investigations have been conducted both theoretically as well as experimentally to better understand such composite structures. The most interesting property of an LHM is the negative index of refraction, i.e., the incident wave will be bent to the same side of the surface normal as that of the incident wave, while for normal materials, the beam should be refracted to the opposite side of the surface normal.

We report in this talk the fabrication and the optical characterization of nanometer size metamaterial metallic split ring resonators (SRR)(figure 1). They are 2D gold shapes made by electron beam lithography and electroplating process on silicon nitrate thin membrane. The critical dimensions between 500 nm and 20 nm allow us to modulate the resonant wavelength.

They show a strong broadband absorption resonances at mid- and near-infrared frequencies (figure 2). We report also a systematic study of these resonances with different dimensions of the resonators and their spacing, combined with our theoretical simulations. We will present our experimentally measured reflection at different incidence angles, and transmission of those resonators with different feature sizes w and different lattice spacing a which control the coupling between neighboring units. We will show how the fabrication defects, as the non uniformity of the gold thickness or the quality of the electro-deposition (figure 3), can affect the performances of the resonator. In fact the conductivity of the metal nanowire can determine the resonant frequency. We found distinctively strong and broadband resonance in the spectrum of the resonators. We will discuss how our results can be used to introduce strong electric and magnetic responses and could provide a route to broadband negative refraction.

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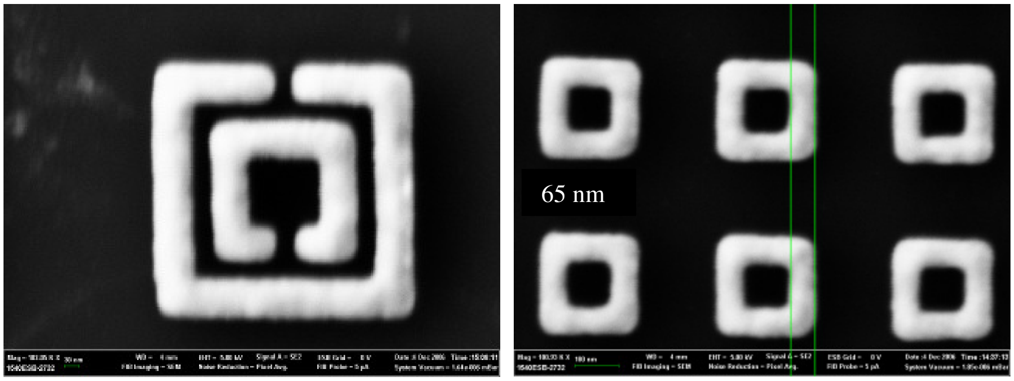

Figure 1: Two examples of metallic ring resonators made by electron beam lithography. The ring are made in gold and the substrate is a silicon nitrate membrane.

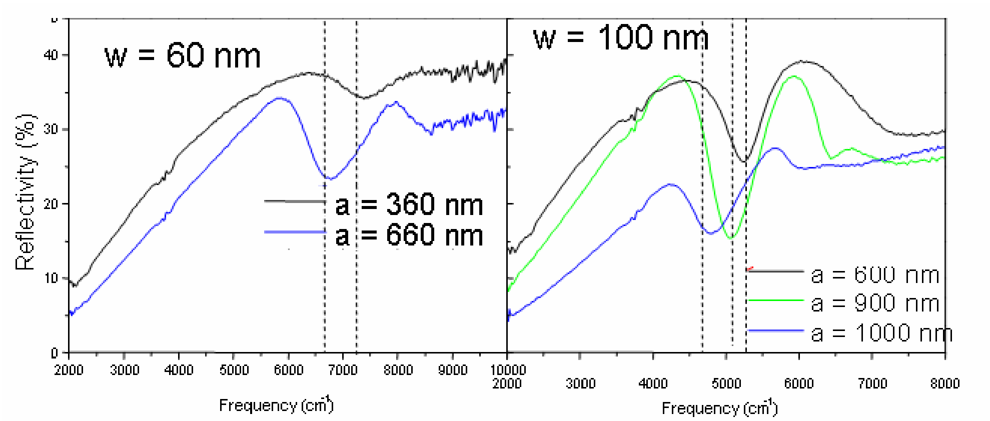

Figure 2: reflectivity resonance spectra at mid- and near-infrared frequencies. It is shown the resonances with different dimensions of the resonators *w* and their spacing *a*.

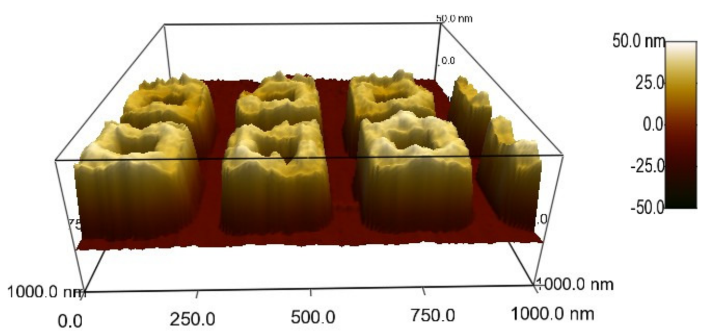

Figure 3: AFM image of the metallic split ring resonators. The roughness of the gold surface is due to the grain size of the electro deposition process.