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New Circular Fractal Sensors for Near-infrared Wavelengths

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Abstract— In the last years, the use of metals in optics has been seen in a new light due to advances in theory and modelling of metal-dielectric structures. Due to their unusual behavior, the term "metamaterials" was coined to describe these class of structures.

One of the new possibilities in applying the metamaterials concepts is by using fractal structures [1, 2]. Such structures combine the advantages of the photonic crystals with the ones of frequency selective surfaces [1] thus allowing e.g., obtaining high selective reection using small components. Typically, fractal metamaterials have been reported in microwaves or THz. In this paper, we present the optical properties of the new type of red/near IR fractal resonator, designed aiming at fabrication possibilities.

Due to fabrication issues, we designed a fractal structure having circles as its base elements. By appropriate choosing of the disks' dimensions, a sharp resonance in the second and third generations of the fractals is seen at 810 nm (see Figure 1(a)). Such resonance can be used for sensing applications. The theoretical selectivity this structure reaches is of 780 nm/RIU making it one of the most sensitive structures up to now.

The fractal metamaterial shows high independency of reflection/tranmsission properties with the incidence angle (see Figure 1(b)), thus alleviating the engineering problems that might arise from its use in the real-life applications.

In this paper, we have presented a new type of fractal resonator feasible for reproducible fabrication, which shows enhanced transmission at 810 nm wavelength. When used as a sensor, the theoretical sensitivity is of 780 nm/RIU, one of the biggest ever presented in this range.

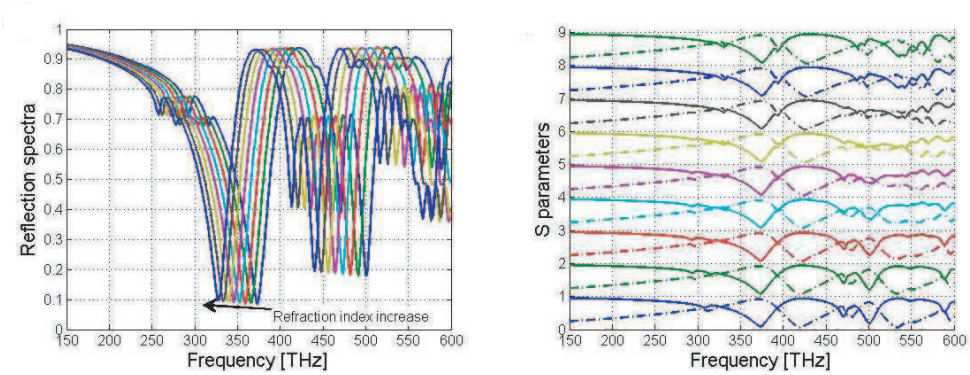

Figure 1: (a) The variation of the reflection spectra with respect to the refraction index of the surrounding media. The refraction index varies from 1 to 1.14 in steps of 0.02; (b) Transmission (dashed) and reflection (solid) spectra when varying the incidence angle from 0 to 80 degrees. The graphs were displaced for better viewing.

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