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Fabrication activity for nanophotonics

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Abstract-We present the fabrication and characterization of new structures and materials to be used in nanophotonics. The first structure presented is a fractal metallic metasurface designed to be used as a high-sensitivity sensor for 810nm wavelength. A second structure is a high index contrast grating designed for phase and amplitude control of the transmitted beam. By controlling the Au percentage in a Si matrix, one may be able to obtain high refractive index with very limited loss.

In the nanophotonics, the development of new structures and materials is of utmost importance due to the strong influence of this field on various other areas ranging from optical communications to medicine. This talk will present three such structures that will have a large impact in the nanophotonics community.

Circular fractal metasurface are a new type of structures that provide high sensitivity for measuring the refractive index variation of the surrounding media [1]. The first theoretical results show a sensitivity of 780nm/RIU for structures resonating at 810nm (see fig. 1(a)). Parametric space was deliberately chosen in regards to the fabrication possibilities. The sharp and isolated dip in the reflectance spectra as well as its invariance to the incident angle (fig. 1(b)) gives the possibility of being used as refraction index sensor. The details of the fabrication procedure as well as the optical characterization results will be presented during the conference.

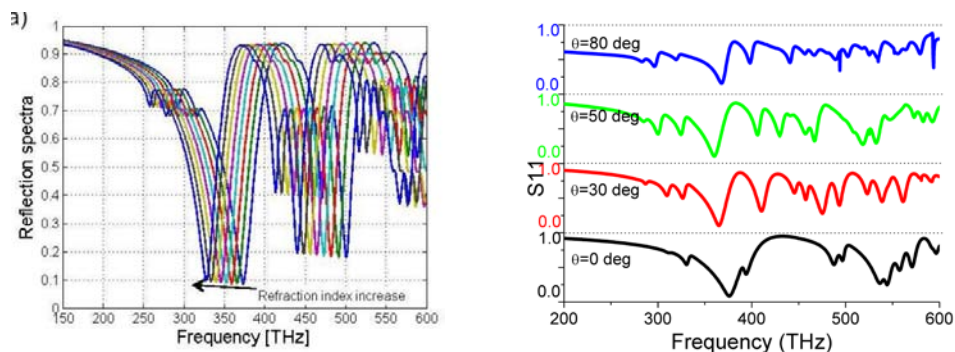


Figure 1. Circular fractal structure: (a) reflection spectra when varying the surrounding refractive index from 1.00 to 1.14, for TE polarisation; (b) angle of incidence dependency of the reflected spectra for TM polarization

The **high-index contrast gratings (HCG)** can be seen as a new development of the conventional subwavelength gratings used generally in optics [2]. An advantage with respect to other structures consists in having the possibility of controlling both the phase and the amplitude of the reflected and transmitted beam (fig 2(a)). By choosing the correct parameters, one can design a grating having e.g. the desired phase distribution while the transmittivity is below 0.5%; thus it can be used as the top mirror in a VCSEL. The advantages of such systems are multifold: on one hand, the complexity of the fabrication process is reduced by eliminating the necessity of multi-level DBR mirrors. From another point of view, by engineering the HCG structure the phase

response can be controlled eliminating the need of additional lens systems. Measurement results of steered beam (fig 2(b)) show good matching with the theoretically predicted ones [3]. The fabrication cycle and the measuring procedure will be presented.

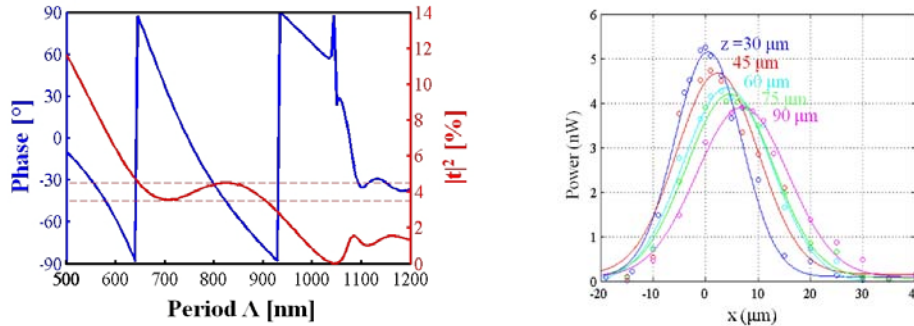


Figure 2. (a) Variation of transmitted characteristics when varying the grating period at 1550nm incidence wavelength; (b) Measured deflection of the transmitted beam.

Although using Si as a high-index contrast material for the HCG proved to be useful, **new materials** having higher than Si refractive index can improve e.g., the accurate control over the phase characteristics. According to theoretical models [4], a Si/Au mix where the atomic percentage of Au is below 10% show increased refractive index (up to 4) with negligible increase in the absorption characteristics (fig. 3(a)). First attempts in developing such materials have been done. The X-Ray Photoemission Spectroscopy measurements reveal very precise and stable atomic elements concentration on the whole depth of the sample (fig. 3(b)). Developments of the materials and their characteristics will be presented.

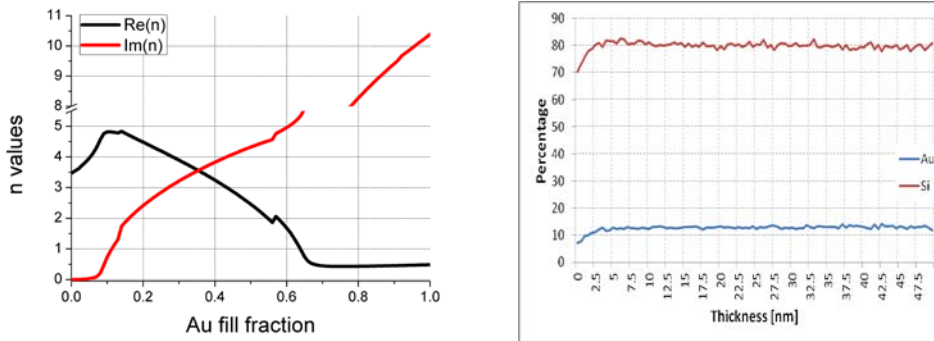


Figure 3. Si/Au material: (a) variation of real and imaginary part of the refractive index with the increase of Au content; (b) Measured XPS spectra of the deposited material showing stable content of Au in the bulk of the material.

REFERENCES

1. Malureanu, R., et al. “New fractal structures for frequencies close to the visible range,” in *Metamaterials 2011 Proceedings*, Barcelona, Spain, October 2011, 474-476.
2. Chung, I.-S., et al., “Broadband MEMS-tunable high-index-contrast subwavelength grating long-wavelength VCSEL”, *IEEE J. Quant. Electron.*, Vol. 46, No. 9, 1245-1253, 2010.
3. Carletti, L., et al., “High-index-contrast grating reflector with beam steering ability for the transmitted beam”, *Opt. Exp.*, Vol. 19, No. 23, 23567-23572, 2011.
4. Nielsen, R.B., et al., “Toward superlensing with metal–dielectric composites and multilayers,” *Appl. Phys. B.*, Vol. 100, 93-100, 2010.