Planar Integrated Sensors on Waveguides for sensing applications

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We investigate the use of a metallic nano-cavity on dielectric waveguides for sensing applications. Nowadays the fabrication of metallic structures featured by challenging dimensions is feasible thanks to the most recent technologies such as E-Beam Lithography (EBL) and lift-off [1]. We propose here to study the simulation, fabrication and characterization of such structures at the telecom wavelength (λ=1.55 µm).

Purpose

It has been recently shown that optical nanostructures could be used in sensor applications [2,3]. Optical properties such as field enhancement and localization make planar integrated devices attractive candidates for the detection of a variety of analytes in tiny volumes of space.

Small modifications in the environment (refractive index) or in the geometry of such devices lead to large variations of the spectral response. Moreover, planar integrated systems are versatile.

The structure, called slot waveguide cavity (SWC), is presented in Figure 1. It consists of a periodic array of slots in a 20 nm thick Au strip deposited on a bilayer dielectric waveguide (Si/SiO_2). Light propagates in the Silicon waveguide and is coupled to the metallic nano-cavity thanks to the evanescent waves. Three dimensional Finite Difference Time Domain (FDTD) simulations allow us to calculate an expected theoretical sensitivity of the device of $\Delta\lambda/\Delta n$=800 nm/RIU (Refractive Index Unit).

Methods

The nanostructuration of the cavity is achieved by employing EBL, gold evaporation and lift-off with ZEP520A, a special e-beam resist. Afterward the waveguide pattern is drawn by photolithography and transferred to the bilayer by means of reactive ion etching (RIE).

The transmission spectra of SWC are measured using a white-light source combined to an optical spectrum analyzer. The illumination of the sample and the collection of the light coming from the waveguide are made by cleaved fibers.

Results

As shown in Fig.1, the fabrication process flow allows to obtain the slot cavity (30 nm-wide slots in 20 nm-thick Au layer) on top of the planar waveguide (15 µm-wide Si/SiO_2 waveguide). The use of ZEP520A as e-beam resist for the lift-off process is successful and effective to realize the device. Preliminary experimental results have shown that the coupling of light in the cavity is possible and the first measurements will be presented.

Conclusions

The integration of metallic nanostructures on dielectric waveguides is demonstrated.

We are striving for the realization of a highly sensitive integrated sensor based on the evanescent-field coupling in metallic cavities.

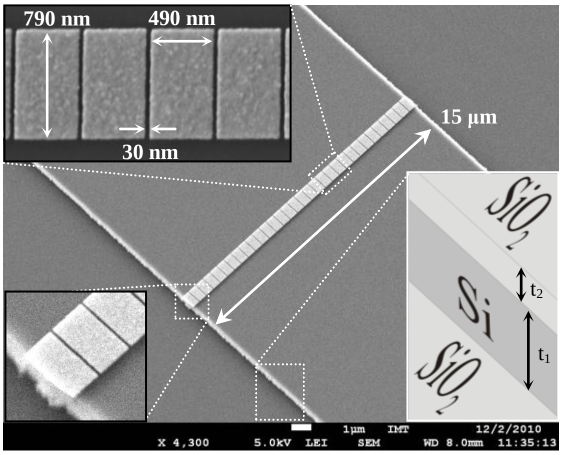

Fig. 1: SEM images of SWC: gold metal array on a dielectric waveguide bilayer (t_1=220 nm; t_2=100 nm).

[1] A. Perentes, *et al.*, *Nanotechnology, IOP Publishing Ltd*, **16**, S273-S277 (2005).
[2] J. Homola *et al.*, *Sensors and Actuators B*, **54**, 3-15 (1999).
[3] G. Gauglitz, *Anal. Bioanal. Chem.* 398:2363–2372 (2010).