Study of sensitivity as a function of waist length in nanocoated tapered optical fibers

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Tapered single-mode optical fiber (TSMF) can be designed to be high sensitive structures with the adequate geometry of the waist zone. The spectra of light transmitted by the taper was studied as a function of coating thickness for different waist lengths, which permitted to observe that the design of TSMF based sensors can be optimized by an adequate selection of the waist length.

Layer-by-layer (LbL) electrostatic self Assembly [3], was used to coat the TSMF. Polyallylamine hydrochloride (PAH) mixed with Neutral Red (NR) was used for the positive solution and Poly acrylic acid (PAA) for the negative solution, all purchased from Sigma. LbL technique permits a nanometric control of bilayer thickness, which allowed observing the evolution of transmitted spectra as a function of the coating thickness.

The construction was monitorized with the set up of Fig. 1. Two standard single mode optical fibers were tapered by heating a section of the fiber with a little flame and pulling the fiber's ends. The waist lengths of the fibers were 10 and 20 mm respectively. The waist diameter was 30 μm for both cases. Then, the TSMF were connected to a white-light source at one side and to an optical spectrum analyzer at the opposite size in order to get a transmission configuration. The transmission spectrum was monitorized after the deposition of each bilayer.

In figure 2 a resonance centered at 20 bilayers can be observed for all cases. Moreover, the resonance depth of the 20 mm TSMF increased to that point that the power detected moved below the sensing threshold of the spectrometer. The reason is that light propagates more distance along an area with reduced diameter and so, the evanescent field can escape easier than in the case in which the stretched area is shorter. The maximum sensitivity of both TSMF was studied for different wavelengths in figure 3, where an improvement of a factor of 3 was observed.

To conclude, the device can be used as detector based on coating thickness changes. Its maximum sensitivity can be controlled by choosing and adequate waist length. By stopping the deposition at a thickness were a maximum sensitivity is obtained, optimized pH sensors [3], and biological immunosensors could be obtained.

References

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Figures

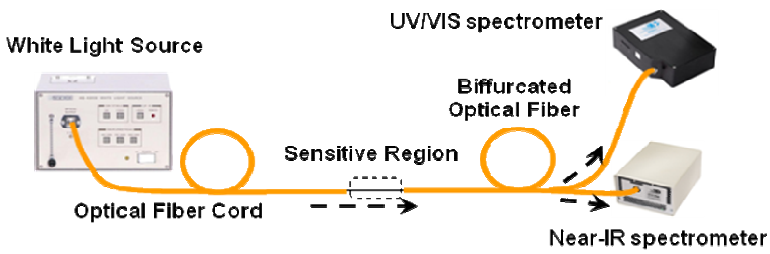

Fig. 1. Set-up of the construction.

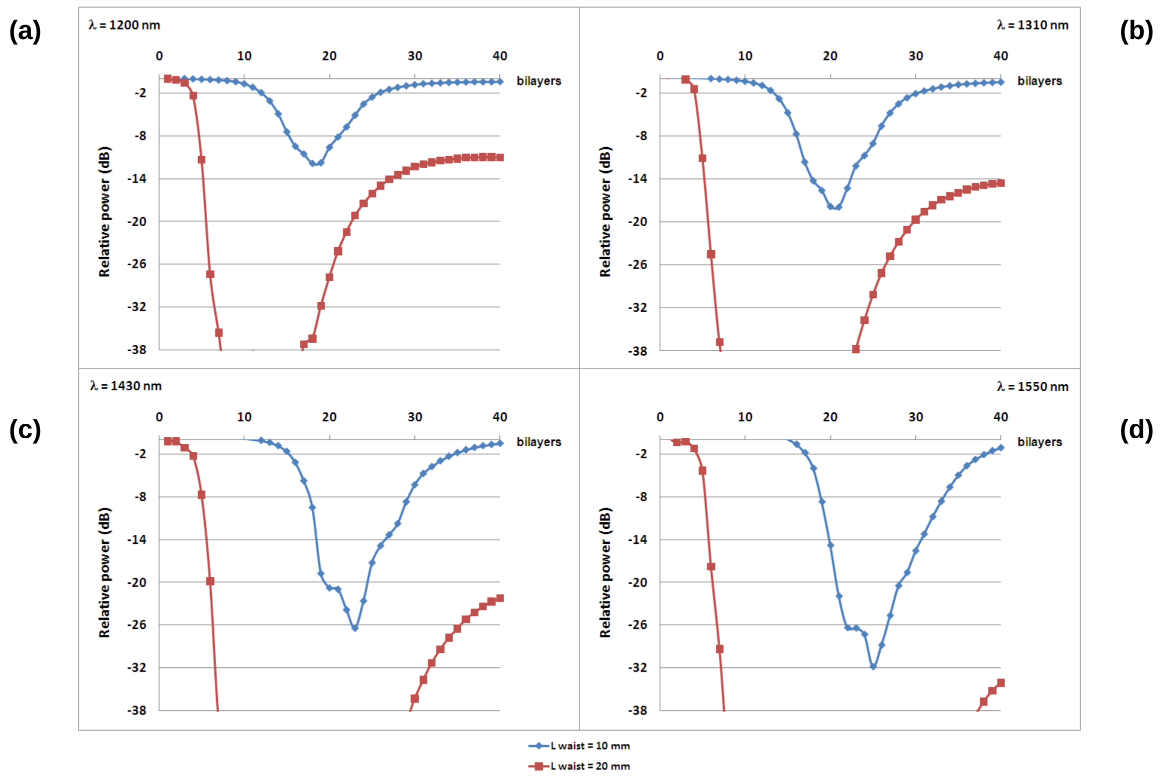

Fig. 2. Comparative of the attenuation of the analyzed tapers at (a) 1200nm, (b) 1310, (c) 1430 and (d) 1550 nm.

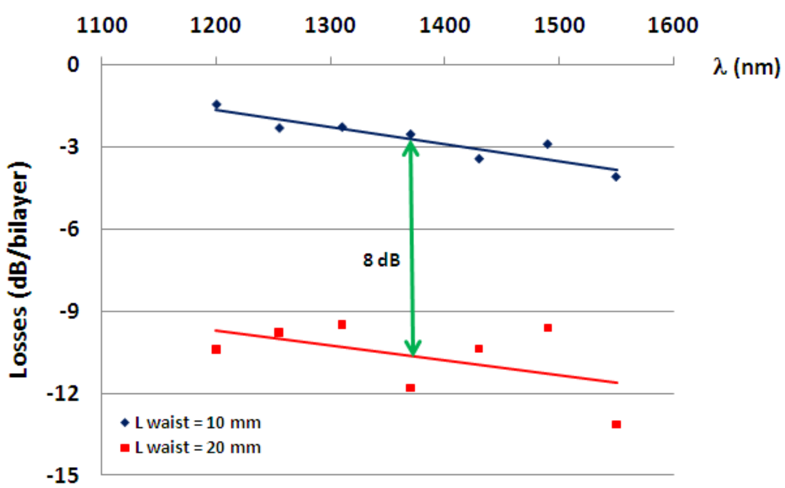

Fig. 3. Resonance sensitivity at different wavelengths.