Label free biosensors based on biogratings patterned on microfibers

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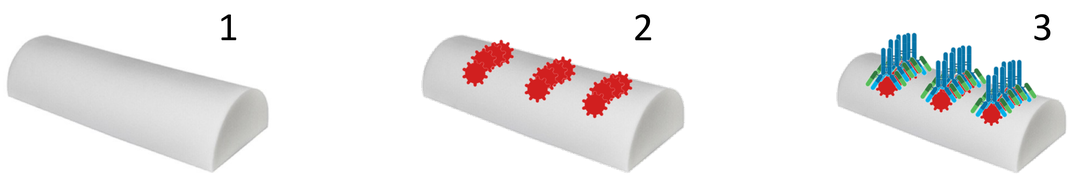
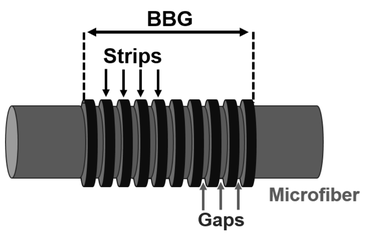
Abstract: we present the design, fabrication and proof of concept of a label free, photonic biosensor based on a bio-Bragg grating (BBG) that is imprinted on the surface of a microfiber. The biosensor was tested using a BSA-IgG model, and experimental detection and quantification limits of 0.1 μg·mL^{-1} and 0.4 μg·mL^{-1}, respectively, of unlabelled IgG in label-free conditions are obtained.

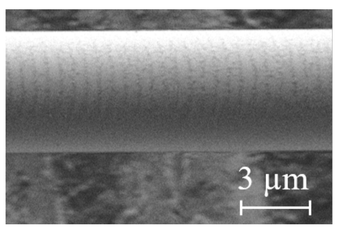
Bio-Bragg gratings (BBGs): fabrication



1 - Microfibers of 3-5 μm were fabricated by the fuse-and-pull-technique.
2 - BSA proteins are attached onto the surface by microcontact printing.
3 - IgGs present in the medium bind to the bioreceptors, conforming the BBG.



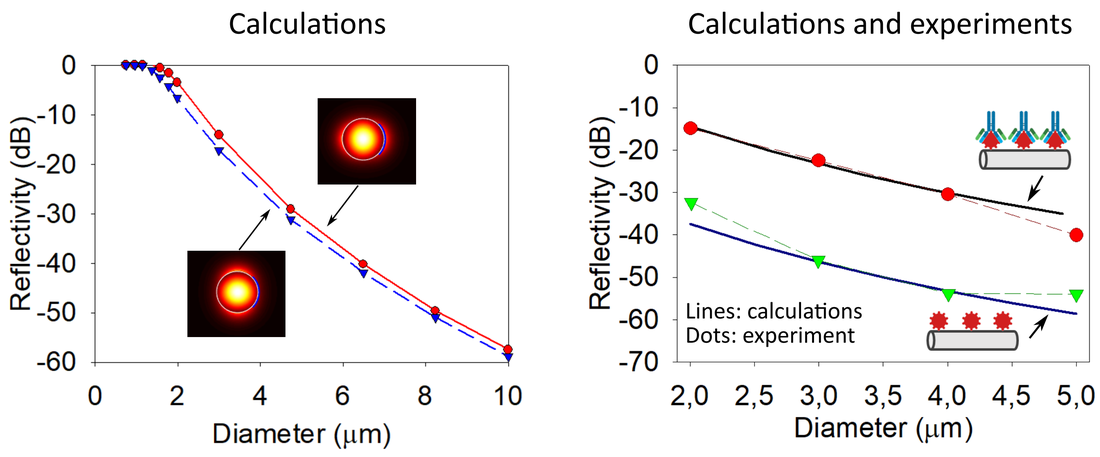
Λ: 556 ± 1 nm



FESEM image: BBG in a taper of 5 μm

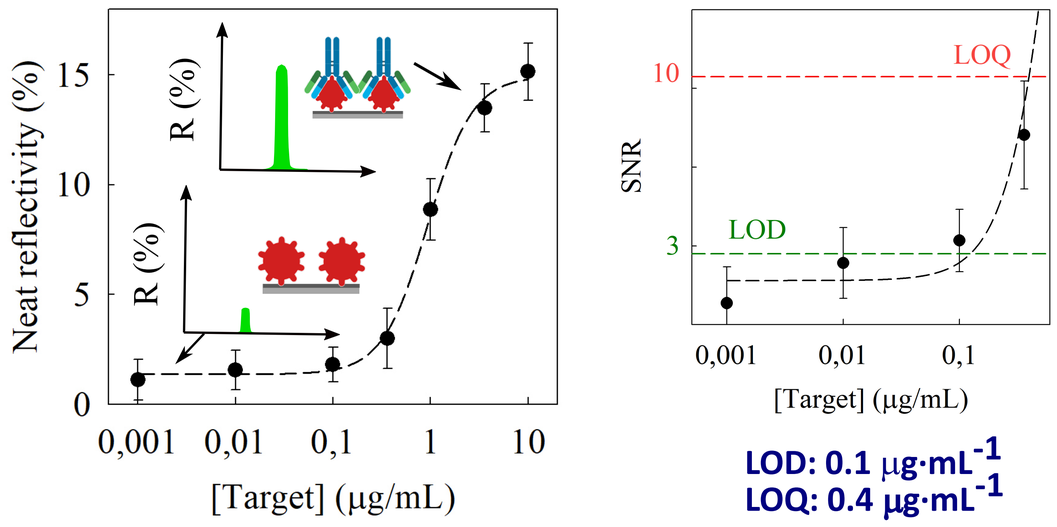
Optimization of the diameter of the microfiber

Reflectivity of the BBG as a function of the microfiber diameter



The microfiber diameter was set at 3 μm, as a compromise between reflectivity, and fragility and loss. Experiment and simulation show good agreement.

Dose-response immunoassay curve



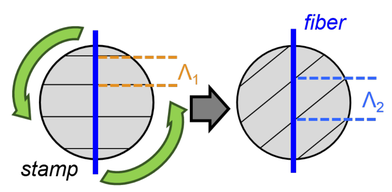
LOD: 0.1 μg·mL^{-1}
LOQ: 0.4 μg·mL^{-1}

A set of 3 μm microfibers were individually fabricated and tested to perform a BSA-IgG immunoassay in label-free conditions. Experimental data are fitted to a sigmoidal (logistic four-parameters) regression, R^2 = 0.997.

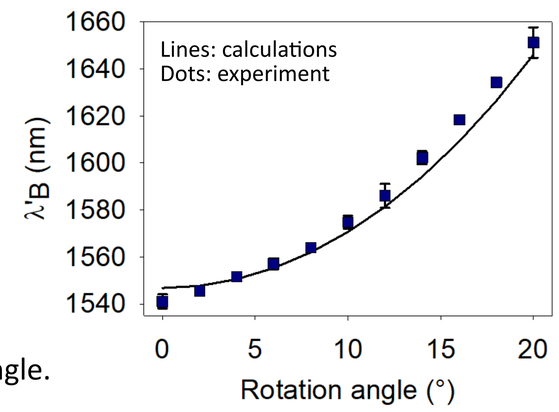
Operation principle

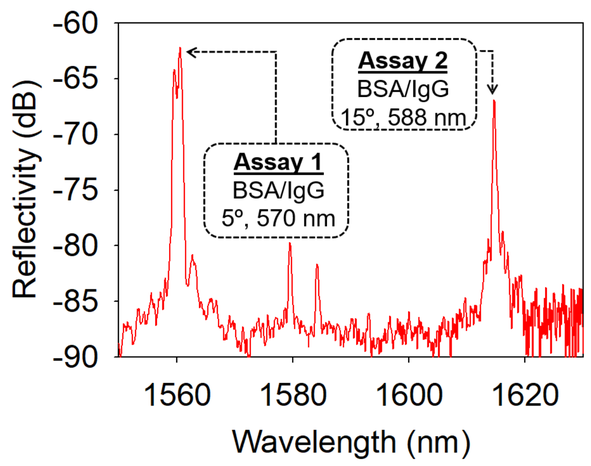
The incipient BBG formed by the BSA proteins are detected in reflection as a weak grating, at its Bragg wavelength. As the IgGs bind to the bioreceptors, the reflectivity of the BBG increases. Quantification of the concentration of IgG is possible by means of the measurement of the increasing ΔR.
A conventional FBG was introduced in the setup as a reference, to monitor possible loss introduced during the different steps of fabrication.

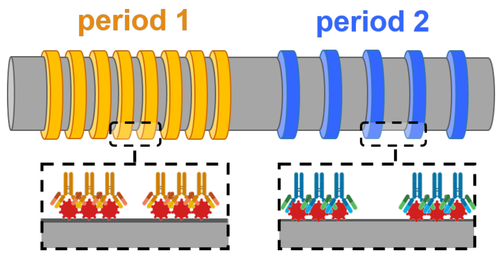
Multiplexing BBGs



The stamp used for imprinting the BSA molecules was rotated to tune the period of the BBG. Right: tuning of the Bragg wavelength as a function of the rotation angle.







Two BBGs of diferent period were fabricated on a single microfiber of 3 μm. The two BBGs appear well resolved in the spectrum.
[IgG]: 10 μg·mL^{-1}

Conclusions

We presented a photonic biosensor that combines the ability to pattern a periodic network of bioreceptors on the surface of a microfiber, with the sensing capacity of microfibers due to its significant evanescent optical field.

Different devices were individually fabricated and tested to perform a BSA-IgG dose-response immunoassay, and promising LOD and LOQ were obtained in label free conditions.

Multiplexing of different BBGs in a single device has been demonstrated.