Ultra-Fast Spectral Optical Analysis of Nanophotonic Structures

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An ultra-fast spectral interrogation platform for nanophotonic structures is presented in this work. This platform allows the simultaneous interrogation of all the photonic structures in a photonic chip using a tunable laser and an IR camera as main elements, which will be controlled by a LabVIEW application.

Light from the tunable laser, with a continuous sweeping speed of 10 nm/s, is vertically injected with an aspheric collimator to the input grating couplers in the chip. After the light goes through the photonic chip, output light from all the output gratings couplers is simultaneously measured using an IR camera working at a frame rate of up to 2000 fps. This parameter allows the spectral interrogation of a region of 100 nm in 10 seconds with a very high resolution (up to 5 pm). The left figure shows the interrogation platform.

This ultra-fast interrogation has been pursued in order to carry out a continuous interrogation of nanophotonic sensing structures, where we need to acquire the response of all the sensing structures within a chip in a time as short as possible. These structures are designed to have certain characteristic spectral features (e.g., resonances in ring resonators or guided band edge in photonic bandgap structures (PBG)) which will be shifted when a change of the refractive index is produced on their upper cladding. Typically, these spectral features have bandwidths ranging from few hundreds of pm (e.g., resonances) to few nm (e.g., a PBG edge), so our interrogation platform will allow us to monitor those features with a temporal resolution of only 1-2 seconds (approximately).

With these temporal and spectral resolutions, we have been able to characterize the sensing performance of photonic sensors based on ring resonators and on PBG structures, reaching detection limit values in the range of 10^{-6} RIU (right figure) for the simultaneous interrogation of several sensing structures in the chip. We expect to reduce this detection limit value to the range of 10^{-7} RIU by implementing several improvements targeting a reduction of the platform noise (e.g., referencing, averaging, temperature control, etc.).

A LabVIEW software application is used in order to control the different instruments of the platform. A Graphical User Interface (GUI) (right figure) allows the user to control different aspects related with the experiments and monitor the results.

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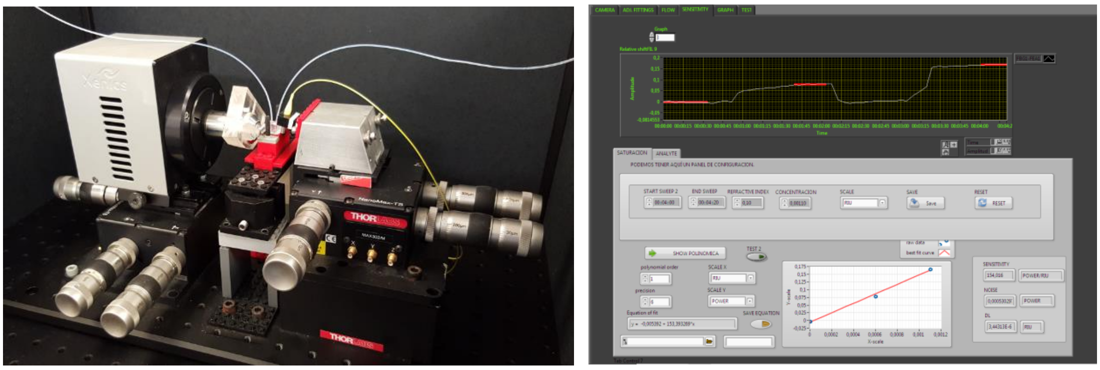

(Left) Picture of the interrogation platform where the light is coupled from the right side using a collimator and an IR camera is used in the left side to collect the output light. White tubes are the input and output channels of the microfluidic cell placed over the chip. (Right) Sensing performance of the system for a refractive index sensing experiment when the spectral response at the edge of a PBG is fitted using a combination of 2 Gaussian functions.