Label-free biosensors based on organic distributed feedback lasers

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Abstract

In order to have an impact on the most challenging detection applications, label-free biosensors must simultaneously provide high sensitivity, large dynamic range and resolution sufficient for detection of mass density changes less than < 1 pg/mm^2 [1]. Label-free resonant optical sensors generally detects shifts in resonant wavelength caused by the interaction between the target molecule and the evanescent portion of resonant modes and where the amount of wavelength shift is proportional to the density of immobilized biomaterial on the sensor surface. The narrow spectral linewidth achieved by using Q-factor ($>10^5$) passive optical resonators enables sensor systems to resolve smaller wavelength shifts associated with the detection analytes at low concentration, or detection of biomolecules with low molecular weight, such as drug compounds [2,3]. While detection resolution can be substantially improved through the use of high Q-factor passive resonators, the sensitivity and dynamic range of the system is generally decreased, although certain examples of passive resonators have achieved high Q-factor and high sensitivity simultaneously [4]. In addition, the implementation of high Q-factor optical resonators typically requires high precision alignment for evanescent light in/out coupling, providing potential limits to their practical application. One way to solve this problem is to use distributed feedback (DFB) lasers. These laser biosensors are simultaneously capable of a high sensitivity and a high degree resolution, since they operate with single mode, narrow linewidth emission [5-7].

This work provides a framework for designing optimized DFB laser biosensors. For that, vertically emitting second order 1D DFB lasers based on organic waveguide films as active laser media and gratings engraved by nanoimprint lithography, have been fabricated. Two types of devices have been studied: (i) with DFB gratings over SiO_2 substrates, over which active films are deposited; and (ii) with DFB gratings imprinted directly over the active films. We studied the laser wavelength shift experienced when a liquid or solid layer of material is deposited on top of the device, analyzing the influence on the sensor sensitivity of changing the thickness of the active film. In order to obtain higher sensitivities [8], devices with a top layer of a high refractive index material, such as TiO_2, have also been prepared.

Acknowledgements

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References

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Figures

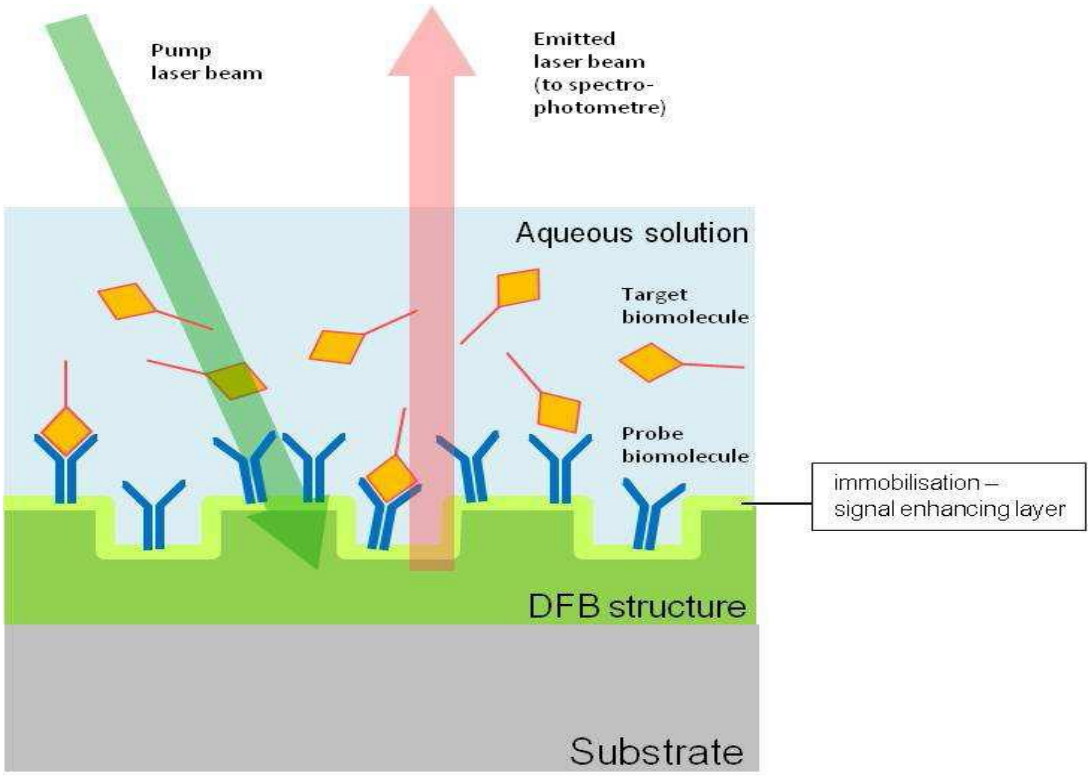

Figure 1. Schematic representation of a DFB laser device working as biosensor

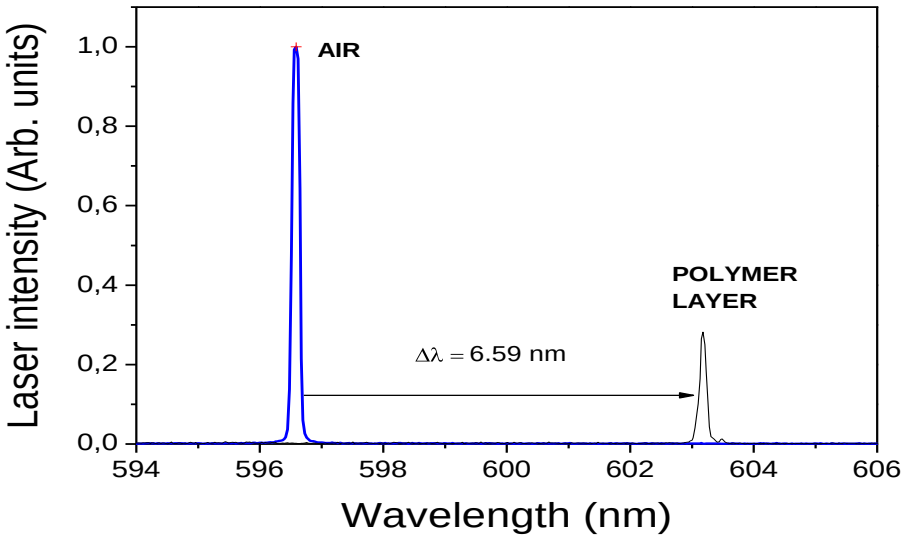

Figure 2. Laser wavelength shift experienced by a TiO_2-coated second-order 1D organic DFB laser, upon the addition of polymer layer.