Title:

Design, fabrication and characterization of SiO_2/TiO_2 and MgO/TiO_2 based high selective optical filters for spectroscopic signals extraction

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The detection of cancer in the dysplastic stage is fundamental in medical diagnosis, once it gives to the patient a higher survival chance. Spectroscopic techniques, specifically diffuse reflectance and fluorescence, can considerably improve the ability to detect Gastrointestinal (GI) dysplasia, since they have exquisite sensitivity to the cancer biomarkers present on the tissues. Therefore, the development of a spectroscopic microsystem on a chip will have a high clinical value, since it could be integrated with the conventional endoscopes and colonoscopes, helping in the detection of GI dysplasia. Moreover, the microsystem could be used in the surgery room for inspecting total removing of cancer tissue.

Such microsystem must comprise: a photodetectors array and its readout electronics; a thin-film narrow bandpass optical filters matrix, deposited on top of the silicon photodetectors, for selecting the spectral bands considered relevant for spectroscopic signals extraction; miniaturized Light Emission Diodes for spectrophotometry illumination; and a wireless mode for data transmission.

The optical filtering system will allow the extraction of diffuse reflectance and fluorescence signals without the use of heavy and complex equipment, such as monochromators, featuring system miniaturization and on-chip integration. They are designed and fabricated by Ion Beam Deposition in a Nordiko 3000 tool. The fabricated filters and their base materials (SiO_2, TiO_2 and MgO) were characterized by optical transmission, ellipsometry, profilometry and SEM (as shown in Figure 1). Moreover, the filters performance and viability was evaluated, performing spectroscopic measurements with phantoms representative of GI tissues with different biochemical compositions. Figures 2 and 3 show the experimental and reconstructed spectra, based on the signals extraction using the fabricated optical filters, for diffuse reflectance and fluorescence, respectively. Thus, the fabricated optical filters are capable to correctly extract the spectroscopic signals, due to their high transmittance and low FWHM required for the relevant spectral bands.

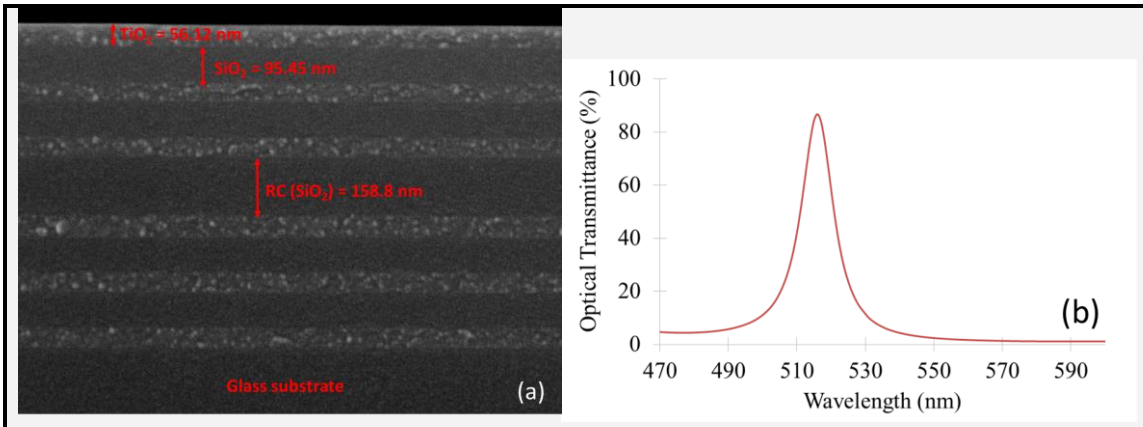

Figure 1: (a) SEM photograph showing the cross-section of the 516 nm Fabry–Perot optical filter with 11 layers (TiO_2 and SiO_2 layer thicknesses for the two parallel mirrors is equal to 56.12 and 95.45 nm, respectively, while the resonance cavity (RC) thickness is equal to 158.8 nm; magnification 200,000 times; (b) Optical Transmittance of the 516 nm Fabry–Perot optical filter, with a maximum transmittance of 86.77% and a FWHM of 12 nm.

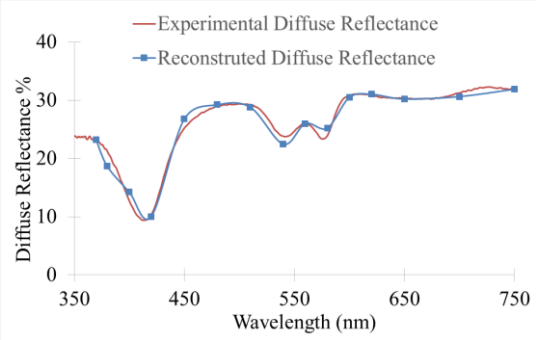

Figure 2: Diffuse Reflectance from a phantom representative of GI tissue (Haemoglobin concentration: 0.5 mg/mL; polystyrene beads concentration: 0.25%; NADH concentration: 1µg/mL; and Carbostyril 124 concentration: 1µg/mL) - experimental spectra measured with a commercial UV-Vis-NIR spectrophotometer (*Shimadzu UV 3101PC*) and reconstructed spectra obtained using the fabricated optical filters.

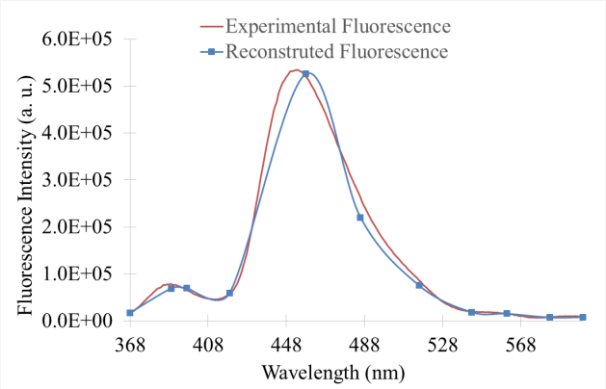

Figure 3: Fluorescence from a phantom representative of GI tissue (Haemoglobin concentration: 1 mg/mL; polystyrene beads concentration: 0.15%; NADH concentration: 1.5 µg/mL; and Carbostyril 124 concentration: 0.5 µg/mL) - experimental spectra measured with a commercial fluorometer (*SPEX® FluoroLog® 2*) and reconstructed spectra obtained using the fabricated optical filters.

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