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NARROW BAND IMAGING TECHNIQUE FOR ENDOSCOPY IN THE SMALL BOWEL

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ABSTRACT

This paper presents an application of narrow band imaging (NBI) technique in endoscopic capsule (EC) for diagnosis in the small bowel. The NBI is a high-resolution imaging technique that uses 2 wavelengths: 415 nm (superficially penetrates the mucosa and enhancing the capillaries) and 540 nm (deeply penetrates and displaying sub-epithelial vessels). The design, simulation and fabrication of two thin-film optical filters resonators composed by thin-films of titanium dioxide (TiO_2) and silicon dioxide (SiO_2) are described. The thin-film optical filters were specific designed for the spectral regions of the NBI technique. The optical filters were fabricated by RF-sputtering technique and are composed by 7 thin-film layers of TiO_2 and SiO_2. The simulations present a maximum spectral transmittance for the blue LED plus optical filter of 20 % centered at 415 nm with Full-Width-Half-Maximum (FWHM) of 16 nm. The green LED plus optical filter has maximum spectral transmittance of 37 % centered at 540 nm with a FWHM of 23 nm.

Keywords: endoscopic capsule, optical filters, narrow band imaging.

INTRODUCTION

The tiny endoscopic capsule (EC) introduced in 2000 (Iddan, 2000) gave an exciting wireless prospective inside the gastrointestinal tract (GI) that were previously accessed only by surgery (small bowel). Unfortunately the EC is passive, and is impossible to control their locomotion for better illumination and higher rate of images. Furthermore some lesions are still missed because its GI diagnosis depends mainly on the EC white light. Currently the narrow band imaging (NBI) technique uses two light spectral characteristics to enhance the mucosa, including vascular structures, in greater details without dyes (Kuznetsov, 2006). The blue light (415 nm) penetrates the mucosa only superficially and is mainly absorbed by the hemoglobin, enhancing the capillaries (veins). The green light penetrates more deeply in the mucosa, displaying the sub-epithelial vessels. The two images are combined and a high contrast image of the mucosa surface is exposed.

Combining the EC and the NBI technique a more accurate diagnostic can be obtained (Fig. 1). Also, the magnetic control approach for EC locomotion (Keller, 2011) is a required feature for the NBI technique implementation. The magnetic control platform presents a solution through a magnetic link between the two magnets an external magnet (EM) and the internal magnet (IM) placed inside of the EC. This approach does not have mechanical parts and do not causes effects on the EC vision. The EC with NBI consists on the fabrication of two sputtered optical filters (SOFs) composed by 7 thin-film layers (resonators) of TiO_2 and SiO_2. The two SOFs are placed on top of commercially blue and green light-emitting diodes (LED).

The TiO_2 thin-films were deposited at room temperature by a reactive RF magnetron sputtering with $Ar+O_2$ flow ratio of 5:1 and deposition rate of 0.1 Å/s.

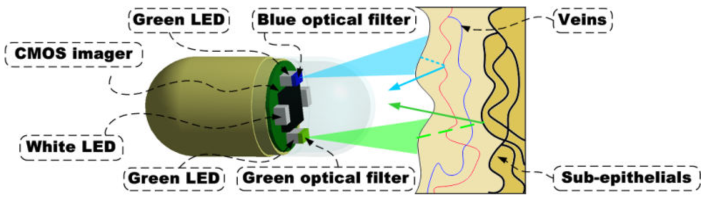

Fig. 1 - EC with the NBI technique.

The total working gas pressure was 2 x 10^{-3} mbar with the RF power of 200 W. The SiO_2 thin-films were deposited with Ar flow rate of 15 sccm at 1.2 Å/s and total working gas pressure of 8.5 x 10^{-4} mbar with RF power of 150 W. The structure of the two SOFs is shown in Fig. 2(a).

RESULTS AND CONCLUSIONS

The simulations through the *TFCalc*^{TM} 3.5 software allowed the achievement of two SOFs with specific spectral peak for the NBI technique (Fig. 1(b)). The maximum spectral transmittance for the blue LED plus SOF is 20 % centered at 415 nm with Full-Width-Half-Maximum (FWHM) of 16 nm. The green LED plus SOF has maximum spectral transmittance of 37 % centered at 540 nm with a FWHM of 23 nm. The green SOF on top the LED is shown in Fig. 2 (c).

(a)

Layer	1	2	3	4	5	6	7
Material	TiO_2	SiO_2	TiO_2	SiO_2	TiO_2	SiO_2	TiO_2
Thickness of blue filter (nm)	190	65	190	65	190	65	190
Thickness of green filter (nm)	250	105	250	105	250	105	250

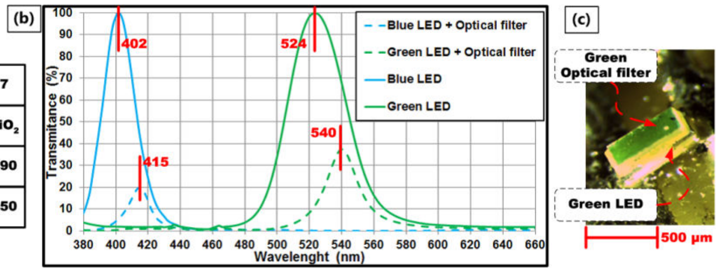

Fig. 1 - (a) Structure of the SOFs; (b) LEDs spectral emissions and SOFs simulations; (c) Fabricated green SOF

Therefore, the introduction of the NBI technique in the EC with a magnetic control approach was done by optical filters placed on commercial LEDs using RF-sputtering technology for deposition of TiO_2 and SiO_2 thin-films.

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