MONOLITHICALLY INTEGRATED DYE-DOPED PDMS OPTICAL FILTERS FOR DISPOSABLE ON-CHIP FLUORESCENCE DETECTION

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Abstract

We report on the fabrication of novel dye-doped PDMS microfluidic layers which concurrently serve as optical long-pass filters for on-chip fluorescence detection. In contrast to using discrete optical filters, doping of the microfluidic substrate presents a low-cost alternative affording high efficiency collection of the fluorescence signal.

Keywords: Fluorescence detection, integration, PDMS doping, optical filters

1. Introduction

On-chip fluorescence detection in a co-linear or "head-on" geometry often suffers from saturation of the detector with excitation light, masking any weak fluorescence signals. Typically long-pass filters are employed which selectively block out the lower wavelength excitation light while transmitting high wavelength fluorescence from the analyte (Figure1).

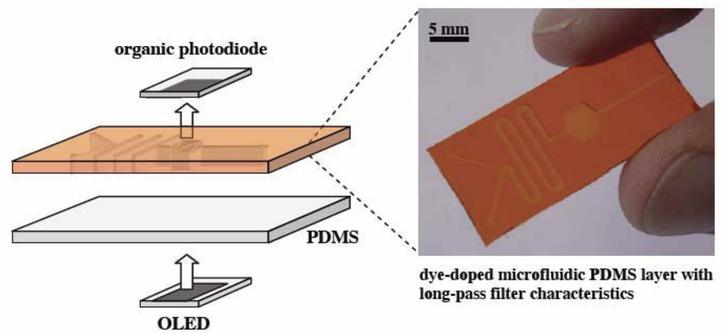

Figure 1 Schematic of monolithic optical long-pass filter use. In a co-linear detection geometry the excitation source and detector are positioned below and above the assembled microchip.

While the use of integrated interference and CdS filters has been reported [1], such filters are expensive and unsuitable for conformable elastomeric materials such as PDMS, a preferred substrate for low-cost disposable applications. We have overcome

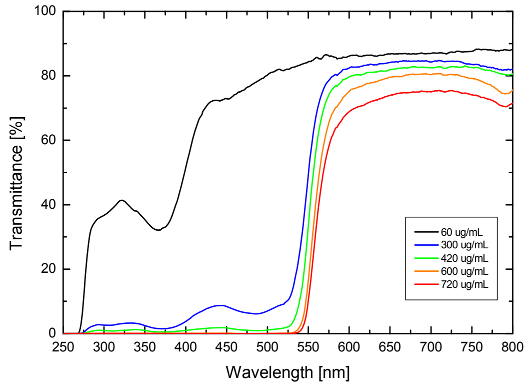

Figure 2 Transmission characteristics for Sudan II doped PDMS microfluidic layers.

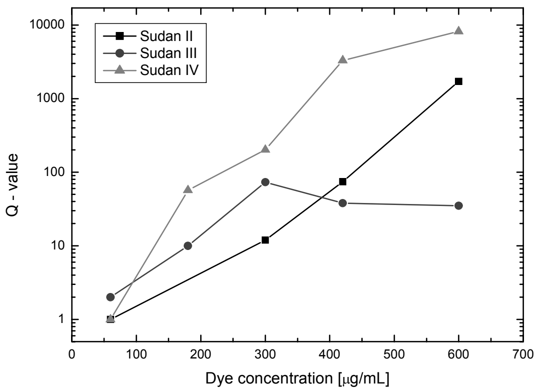

Figure 3 Attenuation factors Q for PDMS microfluidic layers doped with Sudan dyes.

this bottleneck by pre-polymerisation doping of PDMS with lysochrome dyes dissolved in small volumes of toluene [2].

2. Experimental

To fabricate the dye-doped PDMS microfluidic layers up to 30 mg of apolar Sudan II, III and IV dyes were dissolved in 1 mL toluene and then added to premixed PDMS monomer and hardener. After careful mixing the PDMS was poured over an SU-8 master comprising the micro-channel patterning and then cured at room temperature. The maximum dye load that could be incorporated without noticeable dye aggregation was 1.2 mg/mL with the toluene content kept below 10v/v-%.

3. Results and discussion

Out of the three tested dyes, Sudan II doping yielded best results with a sharp roll-on between low wavelength blocking and high wavelength transmission (Figure 2). The cut-on point was 550 nm with a transitional region of ~50 nm. For 1-mm-thin PDMS layers doped with 1.2 mg/mL Sudan II, transmission values <0.01% at 500 nm and >80% at 570 nm were obtained, corresponding to an attenuation factor of ~10,000 or a potential sensitivity gain of 4 orders of magnitude (Figure 3). The performance of the long-pass filter in a co-linear detection geometry is illustrated in Figure 4. While 500 nm light is efficiently blocked, 600 nm light is transmitted at levels similar to undoped PDMS. The upper plot shows that for 500 nm excitation there is no detectable signal over the entire range, demonstrating both effective blocking and low auto-fluorescence. More rigorous tests with laser excitation and an integration sphere revealed auto-fluoresence levels below that of commercially available Schott-glass filters [2].

Furthermore the dye doped PDMS filters proved stable when exposed to polar solvents such as water and ethanol, indicating minimal dye leaching, while exposure to

UV and Ar Ion laser light resulted in only negligible changes, indicating good photostability. Favourable PDMS bulk properties such as elasticity, wettability and bonding characteristics were also retained.

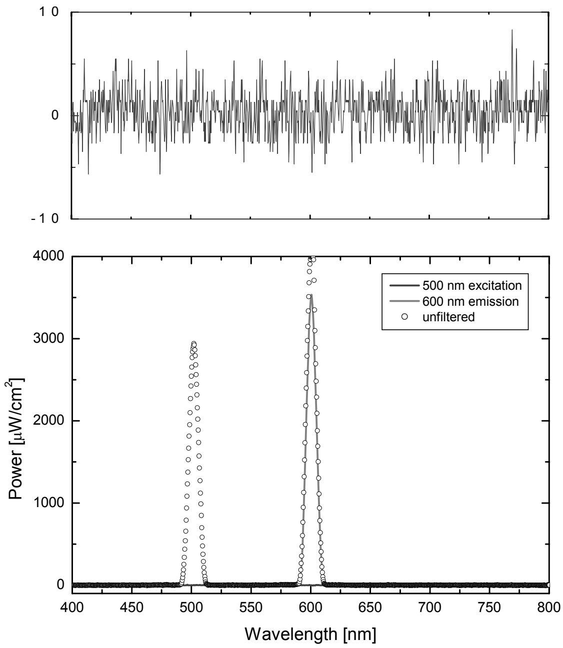

Figure 4 Co-linear detection with 1-mm-thin OD 4 Sudan II filter. The lower plot indicates that the 500 nm light is strongly attenuated while the 600 nm transmission is comparable to undoped PDMS. Top plot shows low light levels for 500 nm excitation.

4. Conclusions

In summary we have demonstrated excellent long-pass filter performance for the dye doped PDMS layers. Work is ongoing to extend the range of available long-pass filters into the blue and green spectrum to match commonly used light sources and fluorophores. In our efforts to develop disposable fluorescence detection systems for point-of-care diagnostics, we are also trying to fabricate short-pass filters to sharpen the output of integrated OLED light sources [3].

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5. References

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