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ARTICLE

Supporting information

Miniaturization of a micro-optics array for highly sensitivity and multiplexed detection on injection moulded lab-on-a-chip

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[S1]: Distribution of the light of the fluorophores on the interface of two different refractive indices environments

J. Enderlein *et. al.*, derived equations for the emission of fluorescent light from fluorescent molecule on a surface, with the assumption that the fluorescent molecule emits into lower refractive index environment n_1 by two terms of reflection and scattering, whereas, the light emitted into higher refractive environment n_2 by only the refraction term. The total emission light into n_1 and n_2 are described as the term S_1 and S_2 as the following equations[1]:

$$S_1 = C_1 n_1 \left| \frac{k_1^3}{2\pi\varepsilon_1} \right|^2 \iint \left\{ \begin{array}{l} \left| \left[\hat{\kappa}'_{p1} + R_p \exp(2i\omega_1 z_o)\hat{\kappa}_s \right] \cdot p \right|^2 \\ + \left| \left[1 + R_s \exp(2i\omega_1 z_o) \right] \cdot (\hat{\kappa}_s \cdot p) \right|^2 \end{array} \right\} d\Omega^2 \qquad (1)$$

$$S_2 = C_2 n_2 \left| \frac{k_1^2 k_2 \omega_2}{2\pi\varepsilon_1\omega_1} \right| \iint \begin{array}{l} \left\{ T_p \hat{\kappa}_{p1} \cdot p \middle| 2 + \middle| T_s \hat{\kappa}_s \cdot p \right| \right\} \\ \times \exp\left[-2\,\mathrm{Im}(\omega_1) z_o \right] d\Omega^2 \end{array} \qquad (2)$$

Here $C_{1,2} = \frac{\pi c}{2k_{1,2}^2}$, $k_{1,2} = \sqrt{\varepsilon_{1,2}}\,\frac{\omega}{c}$, $R_p = \frac{\omega_1\varepsilon_2 - \omega_2\varepsilon_1}{\omega_1\varepsilon_2 + \omega_2\varepsilon_1}$, $R_s = \frac{\omega_1 - \omega_2}{\omega_1 + \omega_2}$, $T_p = \frac{2n_1n_2\omega_1}{\omega_1\varepsilon_2 + \omega_2\varepsilon_1}$, $T_s = \frac{2\omega_1}{\omega_1 + \omega_2}$.

S_1 and S_2 can be calculated based on Equation 1 and 2 with the known parameters: c is the speed of the light (3×10^8 m/s); $\varepsilon_{1,2}$, and $n_{1,2}$, are the dielectric constant and refractive indices of the mediums; $\omega_{1,2}$ are the angular frequencies of the light in the investigated mediums.

Based on these two equations, the proportion of the light in different interfaces could be calculated.

[S2] Analysis of the roughness of the sidewall of SAF structures

Method for characterization of the roughness of the sidewall surface of SAF structures are illustrated in the Fig. 1 below:

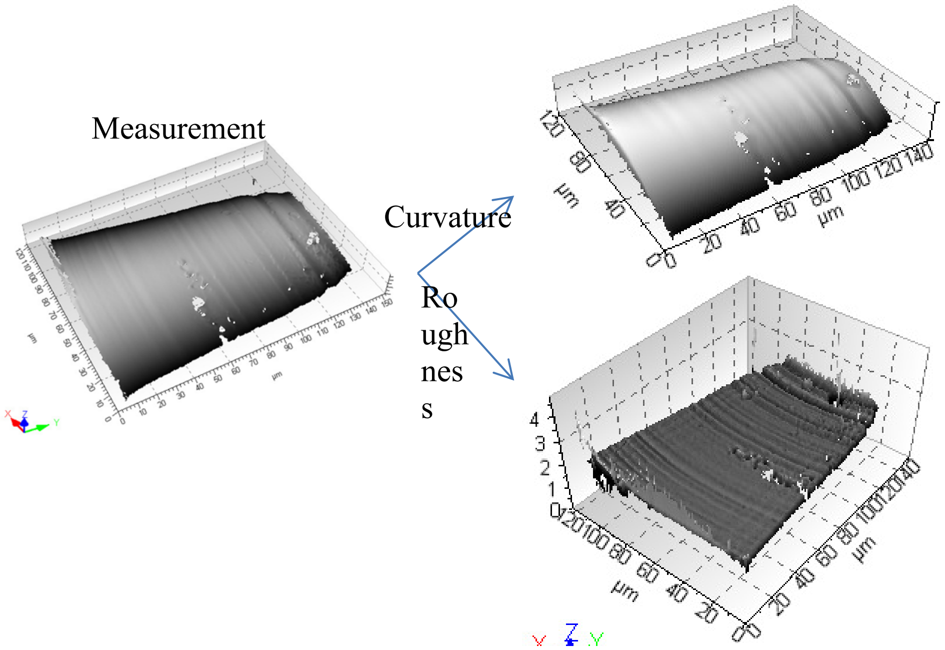

Fig. 1 Sidewall image of a SAF structure is analysed into the curvature describing its desirable shape and the roughness.

[S3] Theoretically, the total integrated scattering (TIS) of a substrate is an exponential function of its roughness expressed by Eq. 3[2]:

$$\mathrm{TIS}(R,\lambda) = R_{\mathrm{o}}\left[1 - e^{-\left(\frac{4\pi R\cos\theta}{\lambda}\right)^{2}}\right] \qquad (3)$$

Here R is root means square roughness of the surface, R_{o} is the theoretical reflectance of the surface assigned to be 1, θ and λ are the angle and wavelength of incidence light. As plot in Fig. 2, the TIS is reversely proportional to the utilized wavelength, thus using fluorophores with high emission wavelengths will reduce the TIS from the structure.

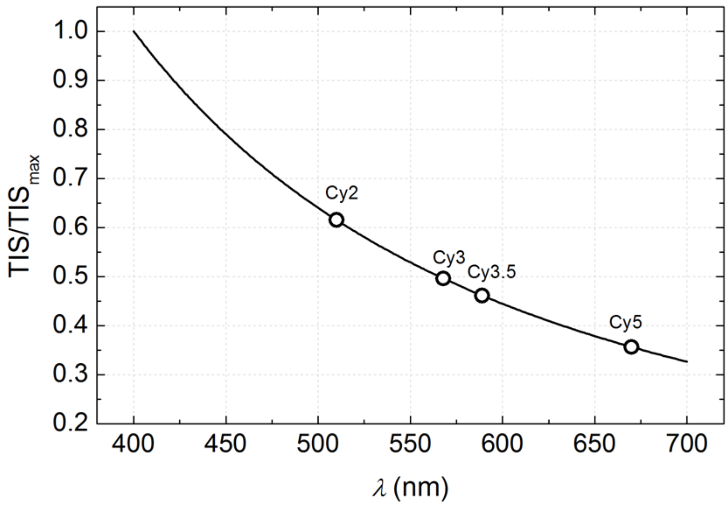

Fig. 2 Total integrated scattering from a structure with the roughness R = 68 nm *vs*. wavelength of the utilized light source in the visible range. The circles depict the total integrated scattering of common used fluorescent cyanine dyes.

1 J. Enderlein, T. Ruckstuhl and S. Seeger, *Appl. Opt.*, 1999, **38**, 724–732.

2 H. E. Bennett, *J. Opt. Soc. Am.*, 1963, **53**, 1389.