Microfluidic-Controlled Optical Router for Lab on a Chip

Jiri Dietvorst, Jeroen Goyvaerts, Tobias Nils Ackermann, Erica Alvarez, Xavier Muñoz-Berbel, and Andreu Llobera

Supplementary Information

Mirror angle

According to Snell's law, total intern reflection is obtained at the backside of the PDMS phaseguide at around 45º, considering some variance in the PDMS refractive index of 1.41 ± 0.01:

$$\theta_{crit} = \sin^{-1}\left(\frac{n_{air}}{n_{PDMS}}\right) = 45.18º \pm 0.41º$$

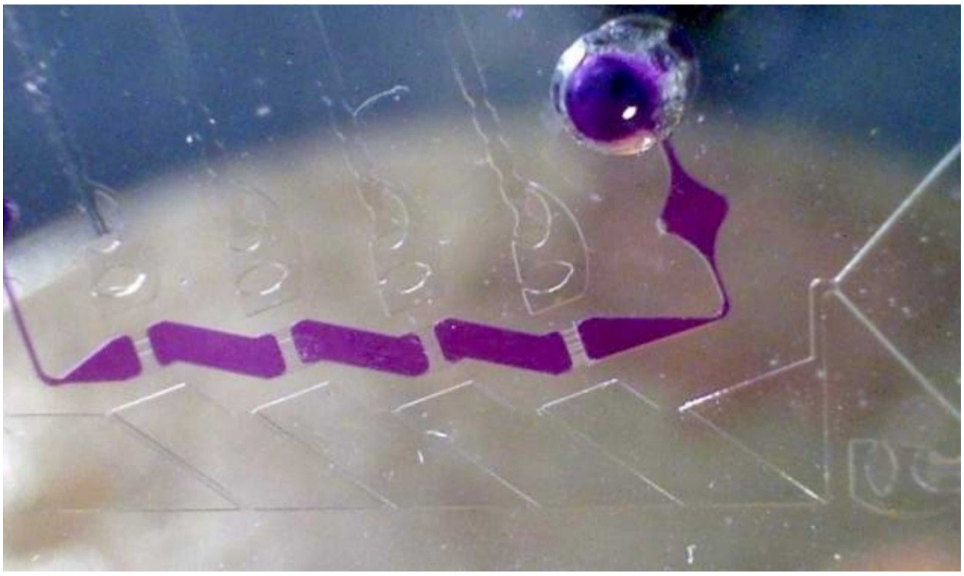
$$\theta_{crit} = \sin^{-1}\left(\frac{n_{air}}{n_{H_2O}}\right) = 48.75º$$

The most common fluid in μ-TAS systems is water, with a comparably lower refractive index of 1.33 than PDMS. Equation 2 shows that the critical angle in such a system is 48.75º.
Taking into account that the light is not perfectly collimated, some tolerance must be taken with respect to the critical angle. The optical fibers that are used have a numerical aperture (NA) 0.22. This corresponds to a 10º angular spread in PDMS medium. With the use of the lenses, the light is more or less collimated, but a +5º spread is assumed as a tolerance. Taking the lower bound critical angle between water and air, along with the tolerance, results in a 55º angle.

Increasing the mirror angle to higher values is not desired. By increasing the angle, the back-reflection inside the phaseguide also increases. Above 71º there is total internal reflection inside the phaseguide when using water as a liquid, resulting in light loss. Within the range of 55 to 70º, it is advise-able to use the lower angled mirrors to reduce beam spreading.

Ink Aperture

An ink aperture has been integrated in the device for reducing cross-talks, noise and the measurement of the backscattering of light. The aperture and its filling liquid serve a dual cause. The liquid is chosen to maximize light absorbance, whereas the design minimizes the absorbance of the focussed light. This is accomplished by using capillary connections at the height of the focussed light beam, the so called pinholes. These capillaries absorb minimal light, whilst serving as a connection between the large reservoirs, simplifying filling. The latter maximize absorption of stray light due to the increased volume and optical path. The filling of the aperture is done by filling one of both inlets with the absorbing liquid. A small vacuum is then applied to the other inlet/outlet, to pull the liquid through. Crystal violet was used as ink due to its absorption maximum at 620 nm, matching the used light source, to ensure maximum absorbance of scattered light. If other light wavelengths are operated, different inks can be used. In case of broadband or a white light source, a black ink is recommended due to absortion in the full visible spectrum.



Supplementary Figure 1: filling of the ink aperture with a crystal violet solution.