Single molecule detection in multifunctional nanofluidic devices

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Single molecule detection is one of the main challenges in biosensing. But it requires devices capable of controlling and manipulating minute amounts of liquid and the (bio)molecules inside. In addition, ultra-high sensitivity read-out techniques are needed, from where the information of the molecules can be withdrawn.

In our group we use all-transparent, all-plastic single-use nanofluidic devices with multidimensional components to filter, control and bring the liquid into sub-100 nm nanochannels. These complete fluidic devices are made by direct nanoimprint lithography in polymers, like Ormostamp or Ormocomp, in a two-minute process [1,2]. One of the main applications of these type of devices is for DNA optical mapping, where we can obtain the fingerprint of a single, intact DNA molecule as it flows through a focused light spot. In this particular case, the transition inlets which connect the nanochannels and the microchannels are very important. They can be used to pre-stretch the molecules, to slow them down before they enter or exit the nanochannel, and to increase the molecular flow to the point where we have spontaneous flow of DNA into 50 nm x 50 nm nanochannels, without using external forces like electrophoresis or pressure.

As additional functionalities, we can also integrate the nanochannels with plasmonic bowtie antennas [3]. In this case, the bowties can nano-focus the light spot beyond diffraction, and the nanochannel, which is 30 nm x 30 nm and runs trough the hot spot, can deliver the target elements one by one. We have shown the proof of concept for reading and counting quantum dots one by one in an ultra-high concentration, where there should be 2600 dots in a diffraction-limited spot.

In the conference we will show examples of the multifunctional devices used for DNA optical mapping, including on-chip filtering and transition inlets to control the molecular flow and speed, and of integration with plasmonic antennas, membranes, and other functional structures.

[1] Fernandez-Cuesta et al, JVST B, 06F801 (2011)
[2] Esmek et al, Nanoscale, 11 (28), 13620 (2019)
[3] Fernandez-Cuesta et al, Lab Chip, 19 (14), 2394 (2019)