Combining Plasmonics and Nanofluidics for Single Molecule Detection

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Plasmonic nanoantenna integrated with nanofluidics promises the development a novel class of biosensors for label-free detection of single molecules. The principle is simple: a nanochannel with the exact dimensions of a bowtie antenna gap delivers the target element to the plasmonic hot spot, where the emitted optical signal can be enhanced for real-time single molecule detection (*Figure 1a*). We report here the fabrication of such biosensors and explore different geometries and configurations of plasmonic antenna that are used to enhance the Raman signal of analyte flowing through the nanochannels.

A wafer-scale parallel method is used to fabricate the optofluidic devices with integrated plasmonic antenna for high throughput and reproducible devices. A master silicon stamp is fabricated, where the nanochannels and antenna shapes are defined by electron beam lithography (EBL) and reactive ion etching (RIE), and the microchannels are defined using photolithography (PL) and RIE. These structures are replicated in a UV-curable hybrid polymer, Ormostamp, from micro resist technology, by UV-nanoimprint lithography (UV-NIL) to make a negative replica stamp. The final structures are defined in a similar UV-curable hybrid polymer, Ormocomp, using the previously made negative replica stamp and UV-NIL to fabricate a polymer fluidic device [1].

The integrated gold plasmonic antennas are defined in the fluidic device using shadow metal evaporation and a lift-off process. A tilted shadow evaporation step is used to evaporate a sacrificial 12 nm layer of chromium over all areas of the polymer imprint, except for the defined triangular areas of the antenna, followed by a non-tilted evaporation of 20 nm of gold. The chromium lift-off process allows for only the triangular areas of the antenna to remain metalized.

We have fabricated antenna with a variety of geometries and configurations. *Figure 1b* shows gold bowtie-shaped nanoantenna (top), and "inverted" bowtie shaped (bottom), aligned to the nanochannel. Inverted bowtie nanoantenna have a higher signal enhancement, but less spatial confinement. The different configurations open up the possibility of tailoring the optical properties of the device: the resonance wavelength and range can be tuned for different applications. *Figure 2* shows dark field scattering measurements for one set of double bowtie antenna, with a very broad resonance range in the 600-800 nm range. Raman scattering measurements will be shown at the conference.

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[1] I Fernandez-Cuesta et. al. *J. Vac. Sci. Technol.* B **29**, 06F801 (2011)

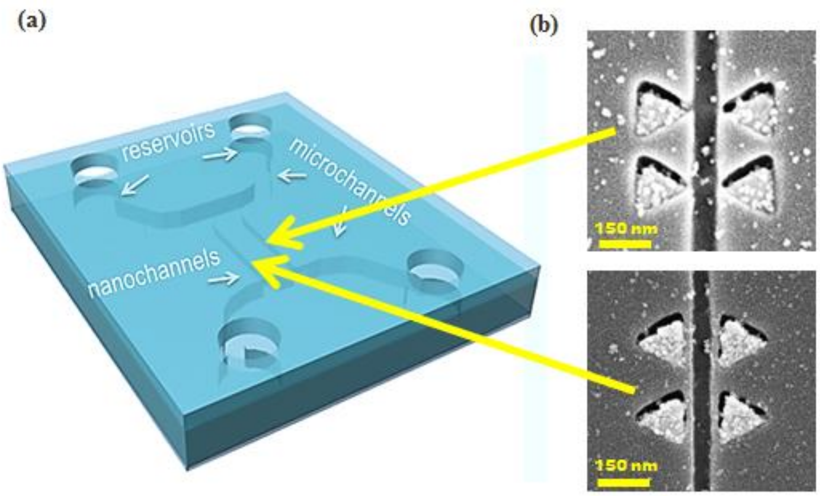

Figure 1*: (a) Scheme of optofluidic device.*4 reservoirs used to introduce liquid sample into the device, and 2 microchannels used to facilitate flow to the nanochannels with the integrated plasmonic antenna. *(b) Double antenna in a bowtie (top) and inverted configuration (bottom).*

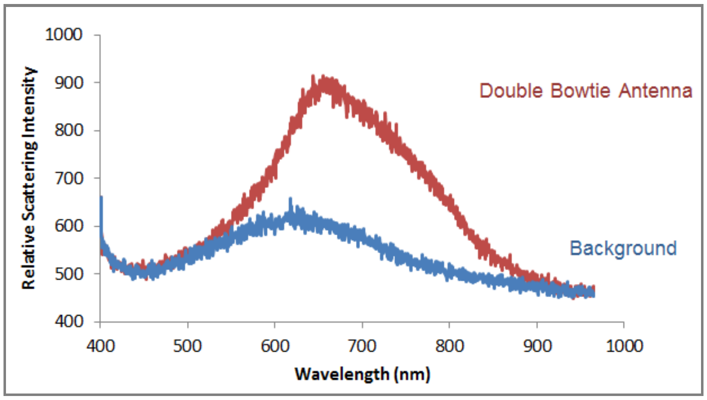

Figure 2*: Dark field scattering for one set of double bowtie antenna.* Optimal optical operating range for antenna shown to be in the interval of 600-800nm.