An Optofluidic Device for Surface Enhanced Raman Spectroscopy

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Abstract:

Here we demonstrate a surface enhanced Raman spectroscopy (SERS) optofluidic device using a nanochannel fabrication method developed by our group. This device consists of nanochannels and a SU-8 waveguide. As a test, we demonstrate the detection of SERS-active Rhodamine6G.

Introduction:

Since the discovery that a cluster of silver or gold nanoparticles can serve to enhance Raman emission [1], several approaches have been reported to improve both the degree and reproducibility of this enhancement. Recent examples of this include: electrokinetically active microwells [2], which electrically trap flowing nanoparticles, and nanochannel structures [3], which serve as a sieve to collect nanoparticles. Generally speaking, these methods require complex fabrication techniques and are difficult to directly integrate with on-chip embedded photonic structures.

Here, we demonstrate an optofluidic SERS chip that combines both a new method for simple nanochannel formation and a SU-8 waveguide to obtain the reproducible and enhanced Raman signals. The device consists of two parts; nanochannels as a filter to form SERS-active clusters, and the SU-8 waveguide to integrate a Raman spectroscopy on a chip. The optofluidic device has several advantages; (1) the simple formation of nanochannels using the roof collapse method [4], (2) the reproducibility of SERS-active clusters—we can easily assemble and disassemble the clusters by controlling flows in nanochannels, (3) the rapid SERS activation of target molecules—because we don’t need pre-treatments to activate the sample, we can detect Raman signals from the SERS-active sites immediately after the target molecules are introduced in nanochannels and, (4) the integration of SERS detection system with a polymer waveguide on a chip—we integrated a light source to excite SERS-active clusters and an objective lens to collect the Raman signals on a chip, using a SU-8 waveguide.

Experimental Research:

Figure 1 shows a schematic representation of an optofluidic SERS chip. One part of our device is a nanochannel filter to form SERS-active clusters. When PDMS chip patterned with micro channels bonded to a Pyrex® substrate with a SU-8 waveguide, nanochannels were formed along the junction between the PDMS chip and the SU-8 waveguide (500 nm height, 3 µm width) as shown in Figure 1. Because of flexibility of PDMS, nanochannels have collapsed triangular inlets and sharply elongated edges at the bottom of the chip. By introducing colloidal silver nanoparticles (70 nm diameter), SERS-active clusters of the silver nanoparticles (SNPs) were efficiently created at the predictable sharp edges of nanochannels.

Another part of the device is the SU-8 waveguide. When we launch a laser through an optical fiber to the waveguide on a chip, the evanescent field of the incident light will excite the SERS-active clusters and target molecules binding on the clusters as shown in Figure 2. We expect the scattered Raman signals will be collected in the SU-8 waveguide and the signals will be detected at the end of the waveguide.
Conclusion:
Based on the roof collapse method, we have successfully developed a novel sample enrichment device for label-free SERS detection. We have demonstrated here that the simple optofluidic device enables to detect Raman signals of target molecules at a predictable location.

References: