SERS Decoding using Functionalized Micro Gold Balls Flowing in a Microfluidic Channel

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ABSTRACT
This paper reports the decoding strategy of surface-enhanced Raman scattering (SERS) signals from microspheres with Au shell structures, or gold balls, with Raman-tags in a microfluidic channel. On the surface of the gold balls, Raman tags were functionalized. We measured SERS signals from functionalized gold balls on a glass plate and in a fluidic channel at static and flowing conditions, respectively.

KEYWORDS: SERS, Microfluidic channel, Decoding

INTRODUCTION
There have been growing interests in the coded microparticle strategies for last few decades due to its promising advantages in drug screening and biomolecular detection [1]. SERS is an advanced Raman spectroscopy which has a high intensity and sensitivity for structural analysis. In recent years, SERS has been spotlighted as a detection tool for coded microparticles. Rongchao Jin *et al.* demonstrated Raman-tag labeling strategy for RNA and protein detection [2]. There are also reports on SERS detection from nano metal particles in a microfluidic channel [3, 4], which has an inherent weak point requiring a particle aggregation method like the optical tweezing [4]. Unlike nano metal particles, we used microsized gold balls for stable SERS measurement without any other additional processing. In this paper, we propose a simple strategy for SERS decoding using gold balls with different Raman-tags in a microfluidic channel.

THEORY
SERS is a powerful tool for analyzing structural properties of chemical compounds. In addition, SERS has good characteristics of narrow signal band, low destructive, nonphotobleaching, sensitive and selective detection. These properties makes SERS a promising detection tool for microfluidic suspension array, especially for detecting coded particles.

EXPERIMENTAL
Gold balls were made by coating PMMA beads with diameter of 15 μm with gold particles. On the surface of the gold balls, four different Raman tags, 1 mM 4-

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aminobenzenethiol (4-ABT), 1 mM benzenethiol (BT), and mixture of 1 mM 4-ABT and 6 mM BT(1:6 and 1:12 in molar ratio) were functionalized. SERS signal was generated by using a 50 mW He-Ne laser with 633 nm wavelength (LASOS Lasertechnik GmbH, US). Fig. 1 (a) shows the schematic diagram of the measurement set-up for the functionalized gold balls fixed on a slide glass substrate. Gold balls were spread out on the slide glass and we measured SERS signal from a single gold ball. For the test in a microfluidic channel, a glass microfluidic chip with a channel of 25 μm in depth, 100 μm in width and 1 cm in length was fabricated by standard photolithography and wet etching techniques. Hydraulic pressure was used for transporting gold balls in the microfluidic channel (Fig. 2). Consecutive measurement of SERS signal was performed at every 0.5 s.

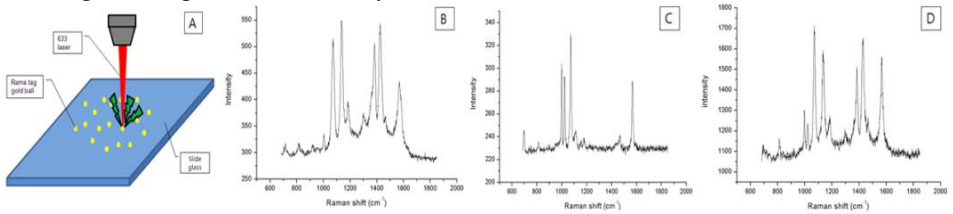

Figure 1. SERS spectra of functionalized gold balls fixed on a slide glass. (A) Schmatic diagram of the measurement set-up. (B) 4-ABT SERS spectrum. (C) BT SERS spectrum. (D) SERS spectrum of mixture of 4-ABT and BT.

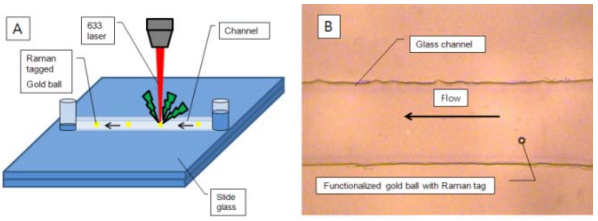

Figure 2. SERS measurement of functionalized gold balls in a microfluidic channel. Channel flow was driven by hydraulic pressure. (A) Schematic diagram of the measurement set-up. (B) Microscopic view of a flowing functionalized gold ball through the microchannel.

RESULTS AND DISCUSSION

As a static condition experiment, fig. 1(B), (C) and (D) show SERS spectra of the functionalized gold balls with different a Raman-tag on a slide glass. For the functionalized gold balls flowing in a microfluidic channel, fig. 3 – 4 shows the consecutive SERS spectra from different Raman-tags of 4-ABT, BT, and mixture of 4-ABT and BT, respectively. Especially, in fig. 4, the functionalized gold balls with mixture of 4-ABT and BT in different concentration ratio showed specific SERS peaks of both 4-ABT and BT with different relative intensity. This result confirms that by using the relative intensities of several specific SERS peaks as identification indices, one can decode functionalized gold balls in a microfluidic system. We prepared microsized gold balls with 4-ABT, BT, mixture of 4-ABT and BT as different Raman tags. With this functionalized gold balls, we successfully showed the possibility of a simple microfluidic SERS decoding strategy.

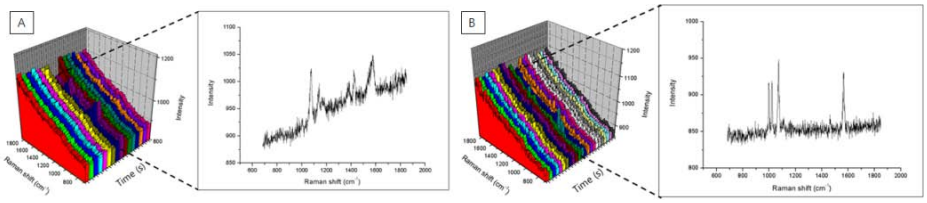

Figure 3. Consecutive SERS spectra from a microfluidic channel at every 0.5sec. (A)A flowing gold ball was detected and its Raman-tag can be identified as 4-ABT. (B)A flowing gold ball was detected and its Raman-tag can be identified as BT.

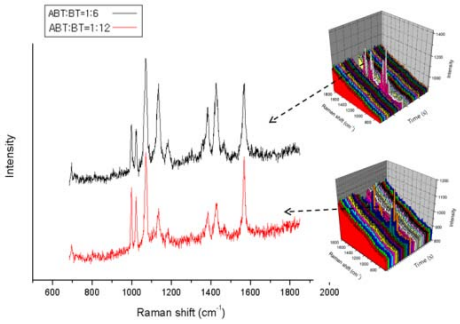

Figure 4. SERS spectra details of the functionalized gold balls with mixture of 4-ABT and BT in different concentration ratio in a microfluidic channel. The measured SERS spectra have specific peaks of both 4-ABT and BT with different relative intensity, which can be useful for SERS decoding.

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