Tip-Enhanced Surface Enhanced Raman Scattering on Gold Nanoparticle Decorated Silicon Microcone Array Substrate for DNA Sensing

B.G. Quan, J.J. Li, Y.J. Wang, C.Z. Gu
Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, No.8, 3rd South Street, Zhongguancun, Haidian District, Beijing, 100190, China
jjli@iphy.ac.cn

Over the past few decades, surface-enhanced Raman spectroscopy (SERS) has grown dramatically for its ability to act as an analytical tool for sensitive and selective detection of chemical and biological molecules absorbed on noble metal nanostructures. SERS is now widely used to identify the chemical fingerprints by taking full advantage of the magnitude enhancement of local field induced by plasmonic coupling, which is called electromagnetic "hot spots". The plasmonic coupling between adjacent noble metal nanoparticles can produce strong electromagnetic focusing effect with a concomitant local field enhancement, and hence are favorable for a large increase of optical response [1]. In order to promote SERS enhancement factor and the Raman signal strength, kinds of complex structures as SERS substrates have been designed, in which silicon conical structures decorated with noble metal nanoparticles were reported to show good SERS properties due to increased density of "hot spots" and strengthen electromagnetic field induce by cone tip[2].

In this study, we show that Au nanoparticles (AuNPs) decorated silicon microcone has a superior SERS property over that of Au nanoparticles on flat silicon. The silicon microcone array with nano-size tip was fabricated using electron beam lithography and a two-step anisotropic wet etching method. Each silicon microcone has eight facets forming the lower part of the cone and four facets forming a sharp top part with nano-tip. Then electron beam evaporation and rapid thermal annealing processes were carried out in sequence to get AuNPs on Si microcone. Figure 1a shows a SEM image of silicon cone decorated with AuNPs. Surface enhanced Raman spectra of 4-NBT molecules on AuNPs decorated Si microcone and flat substrates (Figure 1b) reveal that Si microcone decorated with AuNPs has an enhanced SERS capability than that of AuNPs on flat substrate. Moreover, the AuNPs decorated Si microcone is then employed as a sensor for hairpin DNA with an enhancement factor about 5×10^7. Our results indicate that the AuNPs decorated Si microcone array with nano-tip is a promising bio-analytical platform for SERS bio-sensing applications.

---

[1] Y. Chen, E. R. Cruz-Chu, J.C. Woodard, M.R. Gartia, K. Schulten, and L. Liu, ACS Nano **6**, 8847 (2012).
[2] Y.S. Hu, J. Jeon, T.J. Seok, S. Lee, J.H. Hafner, R.A. Drezek, and H. Choo, ACS Nano 4, 5721 (2010).

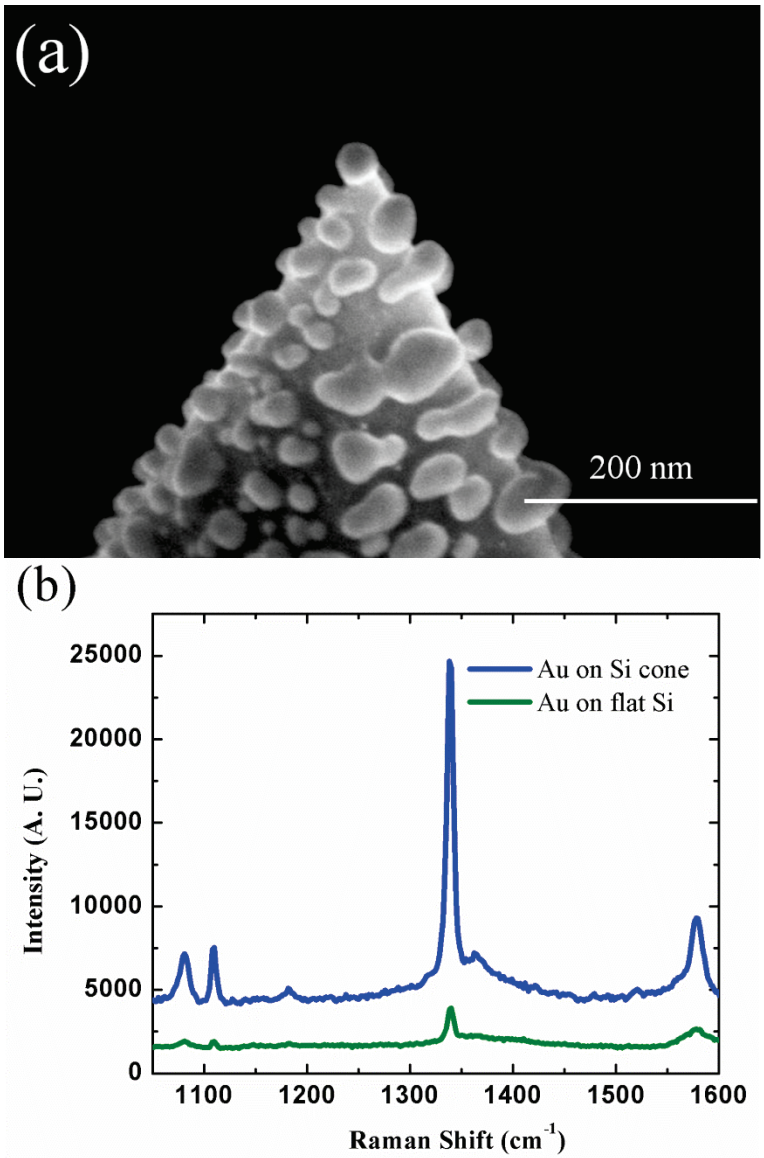

Figure 1: (a) High resolution SEM image of gold nanoparticle decorated silicon tip used as SERS substrate. (b) Surface enhanced Raman spectra of 4-NBT molecule measured on silicon cone and flat substrate decorated with gold nanoparticles.