Electronic supplementary information

Nanoparticle attachment on Ag nanorings nanoantenna for large increases of Surface-enhanced Raman scattering

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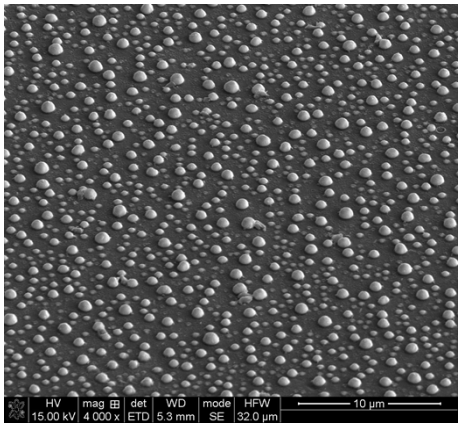

Figure S1: SEM image Ag nanoparticles prepared by the heat treatment of Ag^{+}/PVA/PVP composite film after reduction.

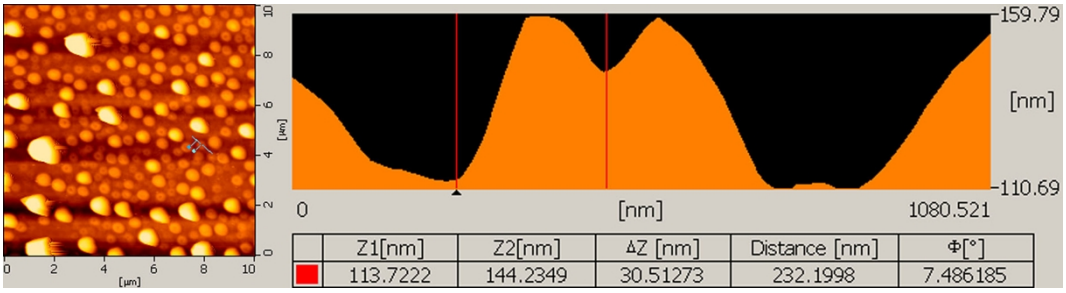

Figure S2: (Left) AFM images of height heat treatment of Ag^{+}/PVA composite film without reduction (sample 3). (Right) the section analysis obtained by AFM.

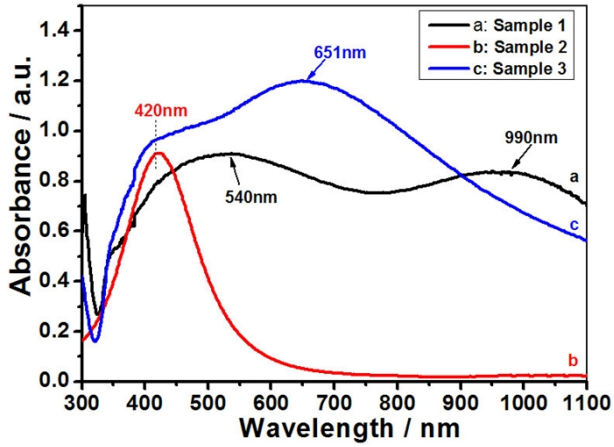

Figure S3: UV-Vis absorption spectra of Ag nanoparticles on quartz glass wafer with different experiment conditions: (a) sample 1, (b) sample 2, (c) sample 3.

The calculation of EF is followed:

To determine the enhancement effect of R6G on the nanoparticles quantitatively, the enhancement factor (EF) values of R6G in the nanoparticles is calculated the following expression:

$$EF = \frac{I_{SERS}}{I_{\mathrm{Re}f}} \bullet \frac{N_{\mathrm{Re}f}}{N_{SERS}}$$

I_{SERS} is the enhanced intensity of the adsorbed R6G molecules on the SERS substrate. The value of I_{SERS} mainly arises from a single molecule layer covering a nanoparticle array, from which other additional molecule layers of analytes on the SERS substrate, as previously reported [1], do not contribute to Raman gain and can be neglected. I_{Ref} is the spontaneous Raman scattering intensity from the bulk R6G molecules under the laser spot on the blank glass substrate. N_{SERS} is the number of the single-layer molecules covering the SERS substrate under the laser spot. N_{Ref} is the number of the bulk molecules excited by laser on the surface of the regular substrate. In order to obtain the values of these four parameters, we follow the same procedures based on the published literatures [2, 3]. Using the 100× objective lens, we determine the area of the laser spot size at around 1 μm^2. We also calculate the area of a single molecule of R6G to be approximately 1×10^4 nm^2. Thus, the value of N_{SERS} under the laser excitation is approximately 1×10^2 molecules. The focusing scope of laser beam is approximately 5 μm, thus scattering from all R6G molecules underneath the laser spot is detected. Assuming a uniform distribution of R6G over the droplet area of 2 mm^2, the value of N_{Ref} is approximately 1.5×10^7 molecules. Therefore, from the equation, the EF is simply $(1.5 \times 10^5) \cdot (I_{SERS}/I_{Ref})$. Then, the EF for the sample 1, sample 7 and sample 8 were roughly estimated by comparing the peak intensity at 1648 cm^{-1} to 1.9×10^{10}, 2.9×10^9 and 9.8×10^8, respectively.

Reference

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[2] Y. Zhao, X.J. Zhang, J. Ye, L.M. Chen, S.P. Lau, W.J. Zhang, S.T. Lee, ACS Nano 5 (2011) 3027.

[3] Z. Yi, X. L. Tan, G. Niu, X. B. Xu, X. B. Li, X. Ye, J. S. Luo, B. C. Luo, W. D. Wu, Y. J. Tang, Y. G. Yi, Appl. Surf. Sci. 258 (2012) 5429.