Supporting Information

Highly monodispersed Ag embedded SiO$_2$ nanostructured thin film for Sensitive SERS substrate: Growth, characterization and Detection of dye molecules

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![XRD pattern of SiO$_2$ nanospheres](image)

**Fig. S1.** XRD pattern of SiO$_2$ nanospheres
Fig. S2 Growth process of SiO₂ nanospheres a) absence of water b) 5 ml H₂O+pH 6 c) 5 ml H₂O +pH 7 d) 10 ml H₂O +pH 8

Fig. S3. Particle size distribution for A) Silver hydrosol A (19nm) B) Silver hydrosol B (5nm)
The quantitative size distribution for normal curve fit shows sizes of silver hydrosol A and B.
**Fig. S4.** Silver (HydrosolA) coated silica nanospheres by varying silica size  a) 50 nm b) 100 nm and c) 130 nm

As the size of Silica nanospheres increases the gap and hot spot increases for SERS.

Case 1: Distance between Silica and Silver is more than 70 nm

Case 2: Distance between Silica and silver is between 25-30 nm somewhere near to 15 nm but monodispersity is less

Case 3: Ag nanoparticles around 15 nm and nano gap between silica and silver about 20 nm

**Fig. S5.** Silver (hydrosol B) coated silica nanospheres
Fig. S6. Zeta potential of SiO$_2$ nanospheres prepared at a) pH 7  b) pH 8  c) pH 9 and d) pH 10.
Fig. S7. Zeta potential variation of SiO$_2$ nanospheres

When the pH of SiO$_2$ increases zeta potential decreases and high negativity of silica spheres results in larger nanoparticles through faster nucleation.
Fig. S8. Zeta potential of a) Ag hydrosol A  b) Ag hydrosol B

Fig. S9. FESEM images of silica nanospheres a) After putting Dye b) Magnified Image
Fig. S10. A) Ag nanoparticle of size 80 nm on Ag@SiO2 nanospheres  B) Silver (Hydrosol A) with PVP 1 molar.

Fig 10 represents the bigger silver nanoparticles which can’t adhere exactly in between the silica spheres and the agglomeration of silver spheres takes place. Moreover the probe molecule can’t be fit tightly in between this nanogaps tends to less SERS.

Fig.11. a) Normal Raman spectra R6G $10^{-3}$ and b) SERS spectra of R6G using $10^{-11}$ molar for prepared thin films
**Enhancement factor calculation**

Where $C_{surf}$ is the concentration of R6G solution for SERS, $C_{surf} = 10^{-11}$ M, $v$ is the volume of R6G solution used for SERS detection, $v = 20 \, \mu$L, $r$ is the radius of 20 $\mu$L of R6G solution formed on the SERS substrate, $r = 4$ mm.

From fig. 10 $I_{bulk}$ (1365 cm$^{-1}$) and $I_{surf}$ (1361 cm$^{-1}$) are 24.10 and 5748.09 cps, respectively. Here considering the incident laser power for normal Raman spectrum and SERS spectrum acquisition, are same. Hence $I_{surf} / I_{bulk} = 5748.09 / 24.10$

Finally, the EF of this Ag@SiO$_2$ SERS substrate can be calculated as $7.79 \times 10^8$