Electronic Supplementary Material (ESI) for Analytical Methods.

Large scale preparation of surface enhanced Raman spectroscopy substrates based on silver nanowires for trace chemical detection

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The calculation of the enhancement factor:

The enhancement factor (EF) is calculated by the following equation:

$$\mathrm{EF}=\left(\frac{I_{\mathrm{SERS}}}{I_{\mathrm{Raman}}}\right)\left(\frac{N_{\mathrm{Raman}}}{N_{\mathrm{SERS}}}\right)$$

$$N_{\mathrm{Raman}}=\frac{A_{\mathrm{eff}}}{A_{\mathrm{sum}}}V_{\mathrm{Raman}}C_{\mathrm{Raman}}$$

$$N_{\mathrm{SERS}}=\frac{A_{\mathrm{eff}}}{A'_{\mathrm{sum}}}V_{\mathrm{SERS}}C_{\mathrm{SERS}}$$

$$\mathrm{EF}=\left(\frac{I_{\mathrm{SERS}}}{I_{\mathrm{Raman}}}\right)\left(\frac{\frac{A_{\mathrm{eff}}}{A_{\mathrm{sum}}}V_{\mathrm{Raman}}C_{\mathrm{Raman}}}{\frac{A_{\mathrm{eff}}}{A'_{\mathrm{sum}}}V_{\mathrm{SERS}}C_{\mathrm{SERS}}}\right)\approx\left(\frac{I_{\mathrm{SERS}}}{I_{\mathrm{Raman}}}\right)\left(\frac{C_{\mathrm{Raman}}}{C_{\mathrm{SERS}}}\right)$$

N_{SERS} is the number of crystal violet (CV) or 1,2-di(4-pyridyl)ethylene (BPE) molecules under laser radiation absorbed on the substrate;

N_{Raman} is the number of CV or BPE molecules under laser radiation for the non-SERS measurement;

A_{eff} is the effective area of spot size;

A_{sum} is the area of the substrate, 3.0×3.0 mm^2;

A'_{sum} is the area of the Si wafer, which is also cut into segmentations with areas of ca. 3.0×3.0 mm^2;

V_{Raman} is the volume that is spotted onto the Si wafer;

V_{SERS} is the volume that is spotted onto the substrate and it is set to be equal to V_{Raman};

C_{SERS} is the concentration of CV or BPE solution under SERS conditions;

C_{Raman} is the concentration of CV or BPE solution for the non-SERS measurement.

SERS-active as a SERS substrate

The surface cleanliness of the prepared SERS-active membrane was tested by recording the Raman spectrum before probe molecule loading (Fig. S1a), as the impurities on the surface of SERS substrates can interfere with the SERS analysis of trace or unknown samples. No distinguishable signal of Raman spectrum was observed, suggesting its high purity and applicability as a SERS substrate. The amount of Raman hotspots is another very critical parameter for evaluating the performance of SERS substrates. The 3D nanostructures of silver nanowires membrane can generate Raman hotspots stemming from the considerable electromagnetic fields induced from nanogaps inside the coupling of adjacent silver nanowires. The darkfield scattering spectrum of the prepared SERS-active membrane displayed that much stronger scattering intensity was obtained at ca. 633 nm rather than at ca. 532 and 785 nm. As illustrated in Fig. S1b and S1c, the SERS activity of the prepared SERS-active membrane displayed a strong excitation laser wavelength dependency when using CV and BPE as probe molecules. Quantitatively, the Raman intensity of CV at 1640 cm^{-1} with a 633nm laser is about 3.3 and 11.2 times higher than that with 532 and 785 nm laser, respectively (Fig. S1d), and the Raman intensity of BPE at 1608 cm^{-1} with a 633nm laser is about 1.7 and 2.2 times higher than that with 532 and 785 nm laser, respectively(Fig. S1e). Therefore, 633 nm laser was used for evaluating the performance of the prepared SERS-active membrane in the following experiments.

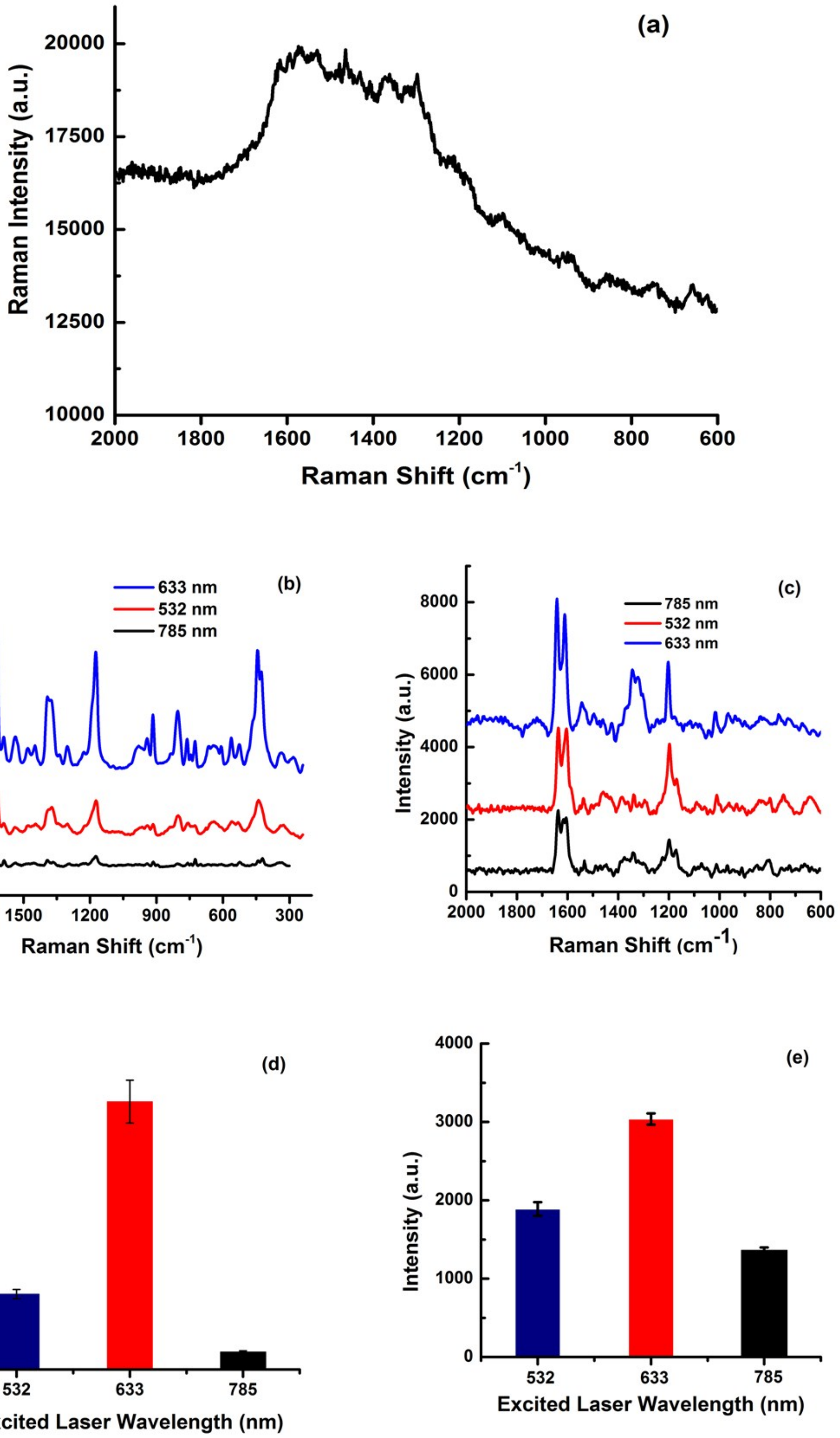

Fig. S1 (a) Raman spectrum recorded on a blank prepared SERS-active membrane. (b) Surface enhanced Raman spectra of CV on a prepared SERS-active membrane. (c) Surface enhanced Raman spectra of BPE on a prepared SERS-active membrane. (d) Raman Intensity of CV at 1640 cm^{-1} with different laser wavelengths. (e) Raman Intensity of BPE at 1608 cm^{-1} with different laser wavelengths.