Supplementary Information

Single-molecule detection with enhanced Raman scattering of tungsten oxide nanostructure

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Supplementary information 1
Enhancement factor (EF) calculation

The enhancement factor for single-molecule CO adsorbed on WO_x was calculated according to general formula[1].

$$EF = \frac{I_{SERS}}{I_{bulk}} \times \frac{N_{bulk}}{N_{SERS}} \#(1)$$

In the formula (1), I_{bulk} and I_{SERS} represent intensity of CO peak in Raman measurement of gas phase CO and SERS measurement respectively. N_{bulk} and N_{SERS} represent number of CO molecules in scattering volume in Raman measurement of gas phase CO and SERS measurement respectively. The scattering volume in Raman measurement of gas phase CO was assumed to be a cylinder of 1μm diameter and 1μm height.

$$V_{bulk} = \pi r^2 h = 7.85 \times 10^{-17} \left(m^3\right) \#(2)$$

The number of CO molecules in scattering volume can be obtained from ideal gas law.

$$N_{bulk} = \frac{N_A p V_{bulk}}{RT} = 2.12 \times 10^7 \#(3)$$

Here, N_A, p, R, T represents Avogadro constant, pressure, molar gas constant, and absolute temperature. I_{SERS}=1411, I_{bulk}=2.4.

$$EF = \frac{1411}{2.4} \times \frac{2.12 \times 10^7}{1} = 1.2 \times 10^{10} \#(4)$$

Supplementary information 2

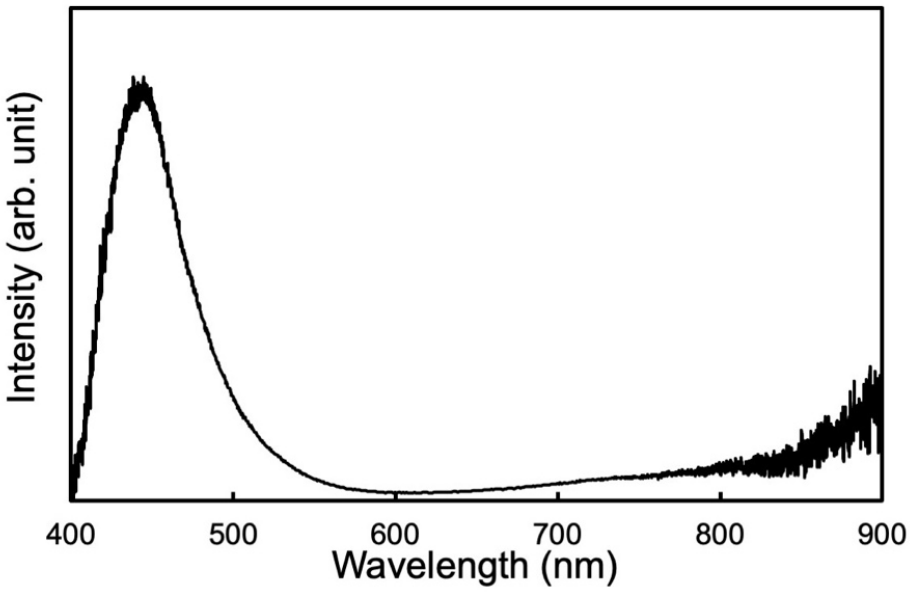

Figure S1 light scattering spectrum obtained from a single tungsten oxide nanorod in air. Using the same optics as Raman scattering spectroscopy, the light scattering spectrum from a WO_x nanorod was measured. A 100 W halogen lamp was used as a white light source.

Supplementary information 3

Electrical measurement of a single WO_x nanorod.

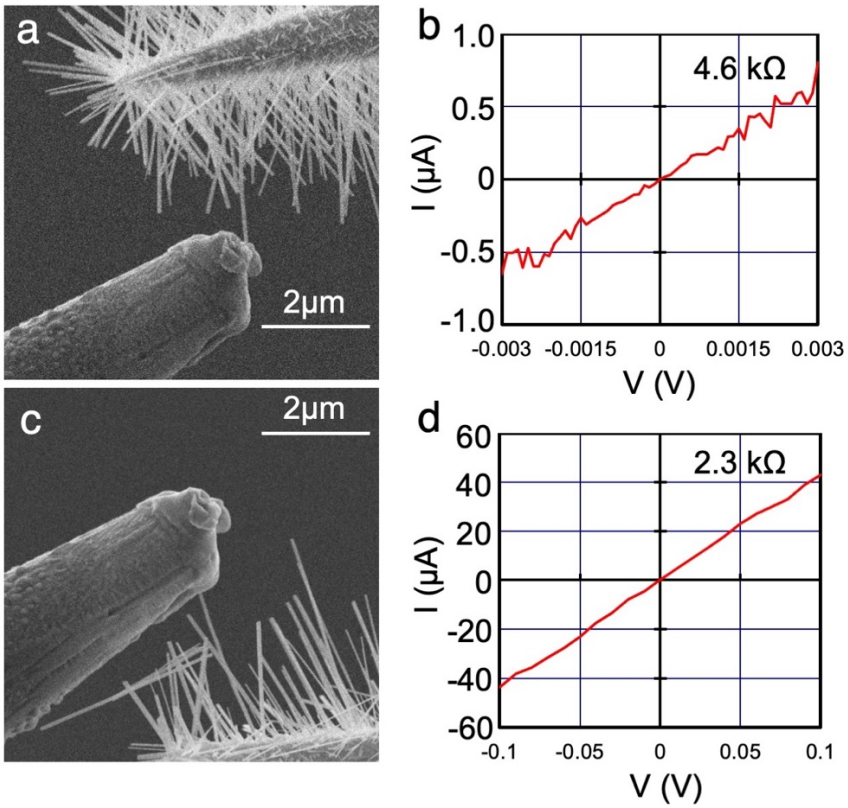

Figure S2 (a) and (c) show SEM images of WOx nanorods and piezo-driven probes during electrical measurements of a single WO_x nanorod. (b) and (d) show IV curves obtained by electrical measurements of a single WO_x nanorod shown in (a) and (c), respectively. The diameter, length and resistivity of measured nanorods are (a) D: 50 nm, L: 3.0 μm, ρ: 3.0×10^{-4} Ωcm (c) D: 68 nm, L: 2.9 μm, ρ: 2.9×10^{-4} Ωcm.

Reference

1. X. M. Lin, Y. Cui, Y. H. Xu, B. Ren and Z. Q. Tian. *Anal. Bioanal. Chem.* 2009, **394**, 1729-45.