

Supplementary Information

Micron Scale Gold Flowers as SERS Substrates for the Detection of Rhodamine 6G

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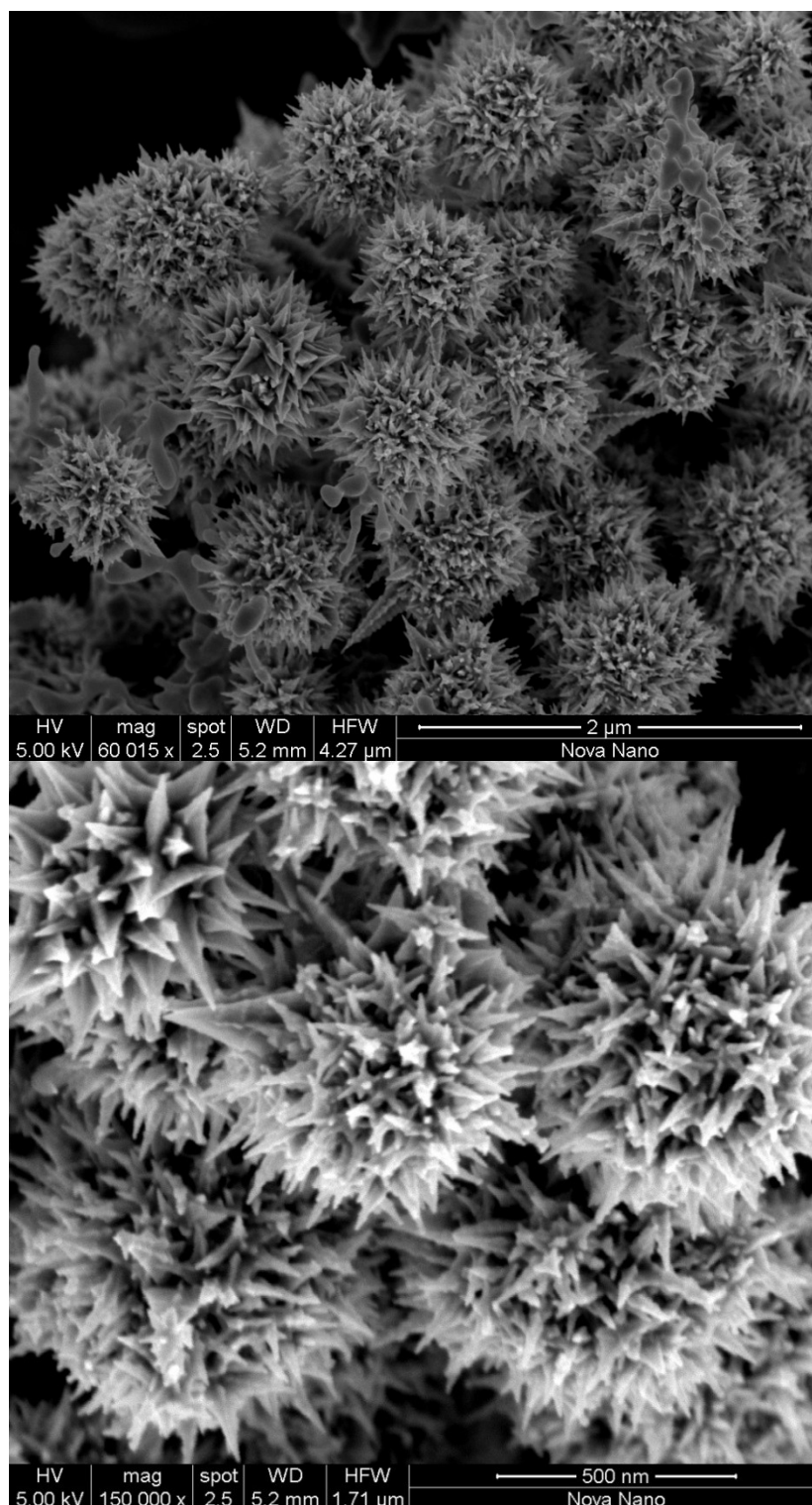


Figure S1. SEM images of gold nanostar seeds

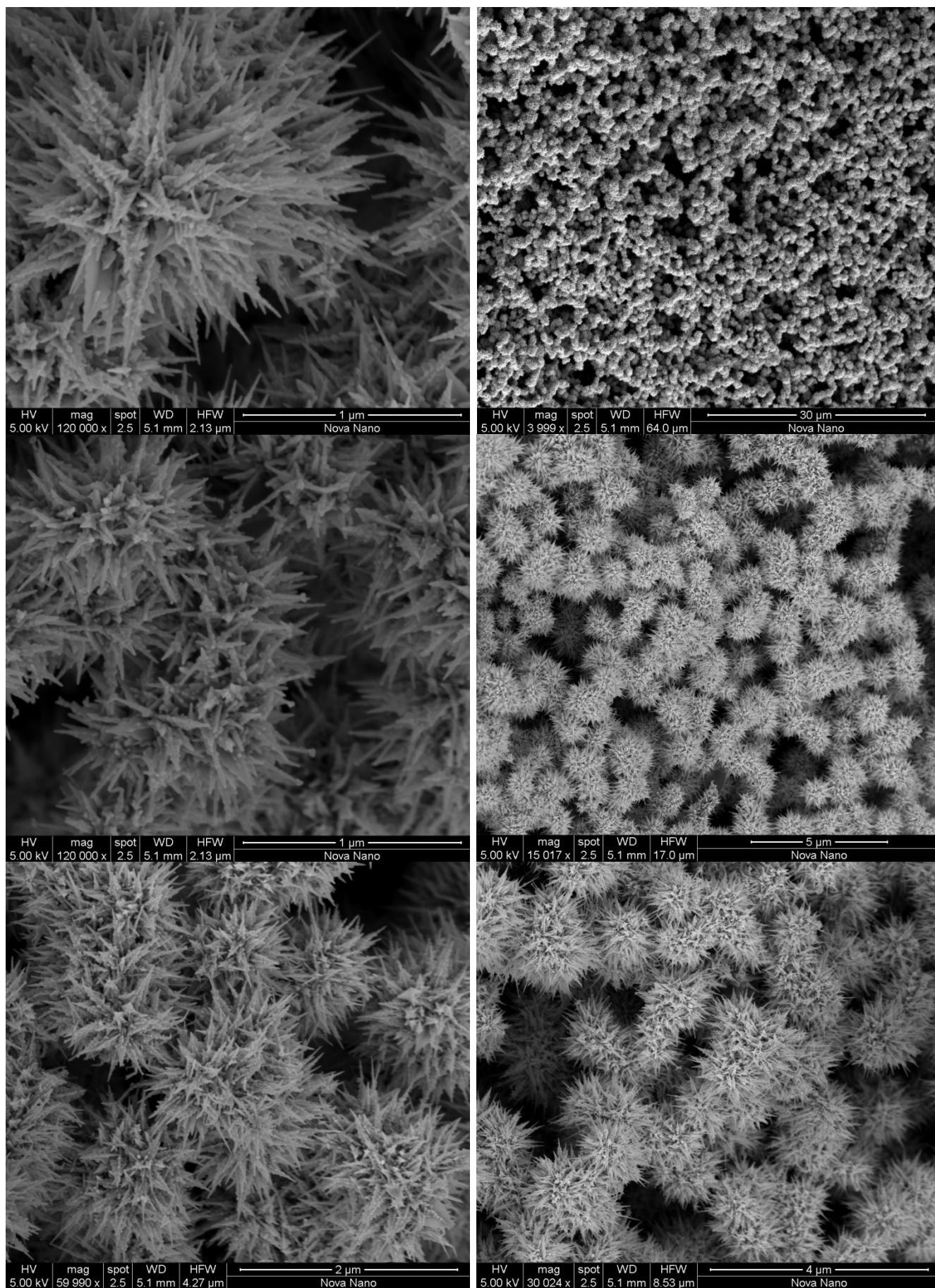


Figure S2. SEM images of gold microflowers Au1.

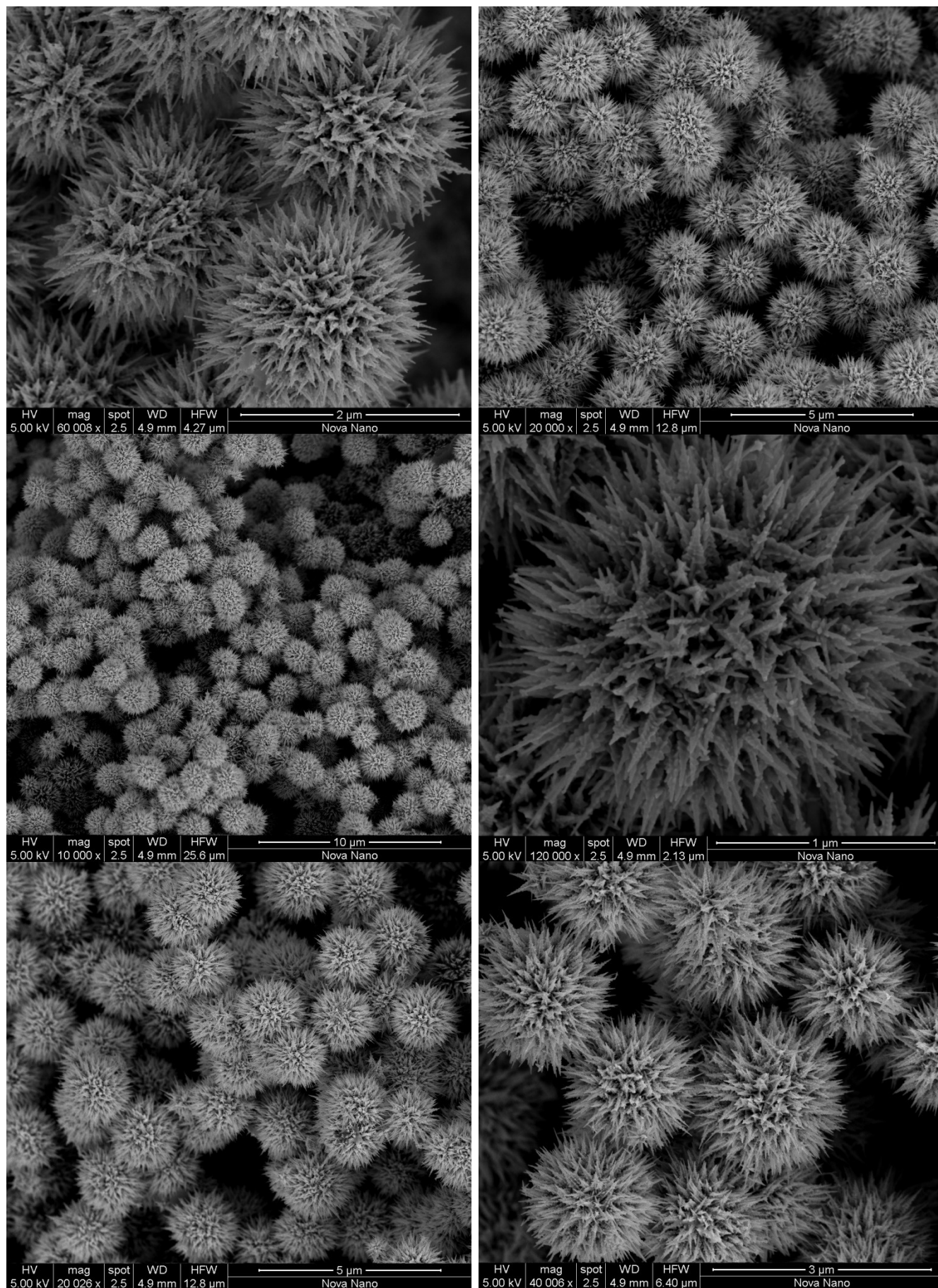


Figure S3. SEM images of gold microflowers Au2.

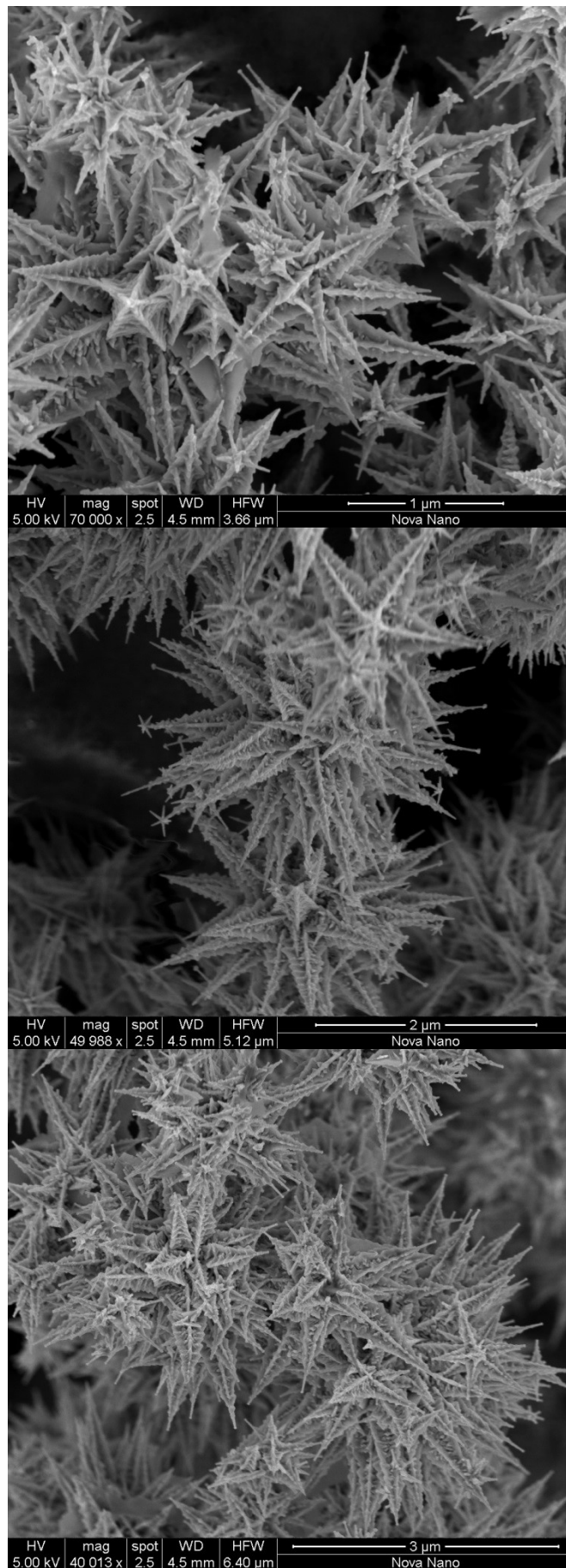
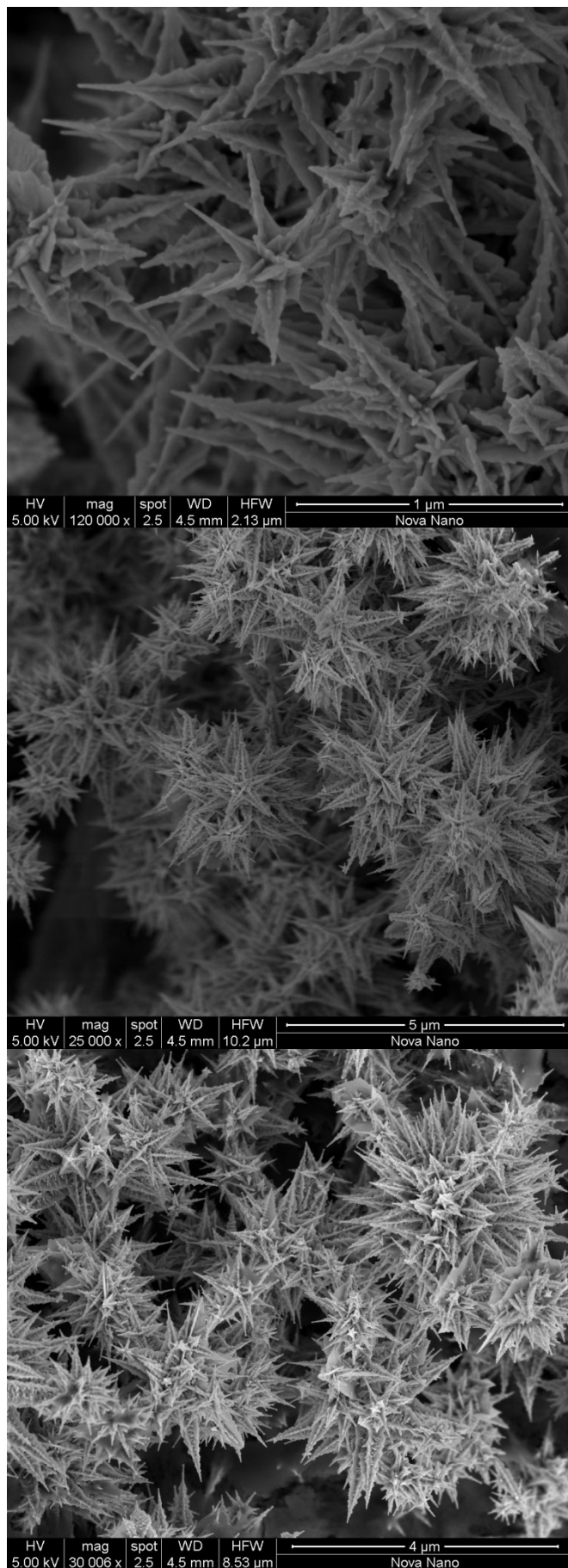


Figure S4. SEM images of gold microflowers Au₃.

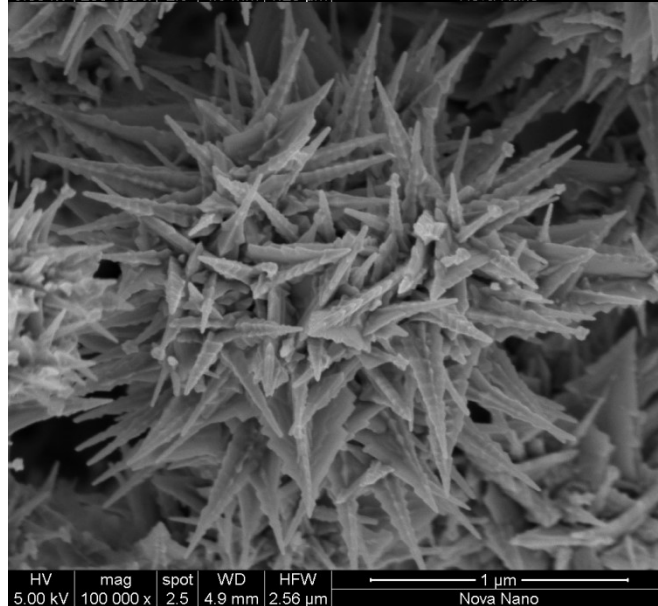
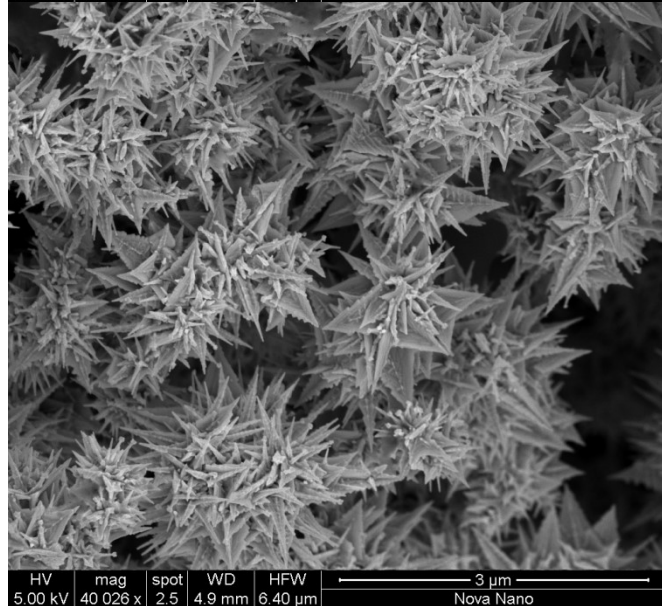
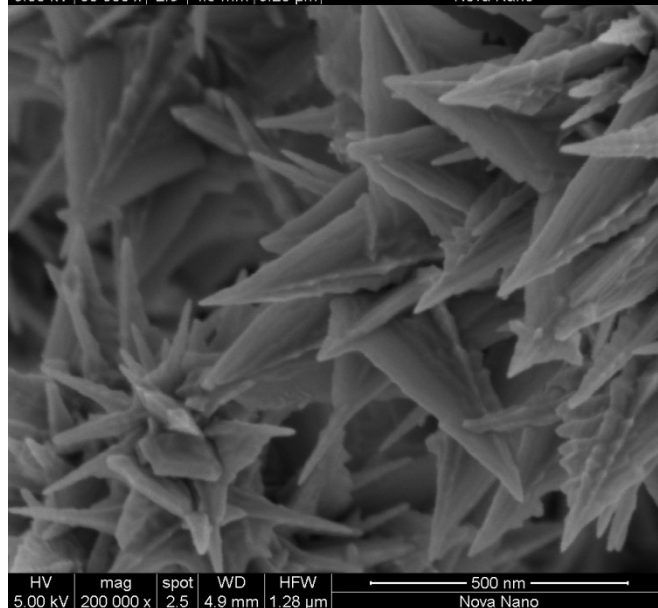
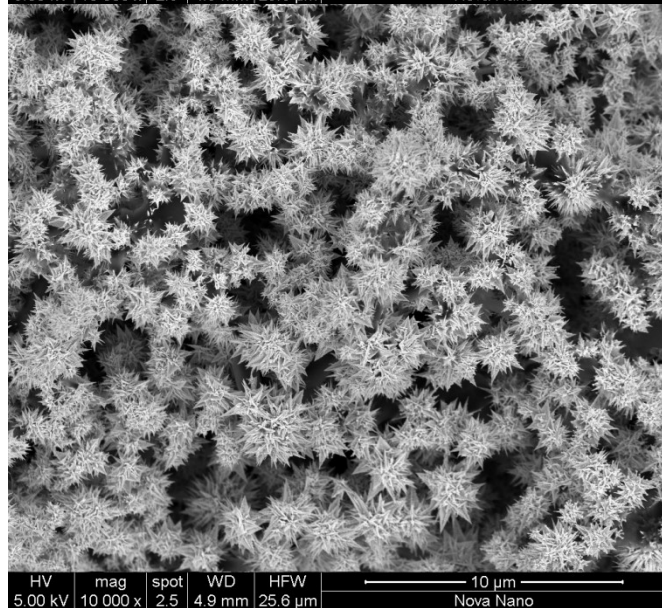
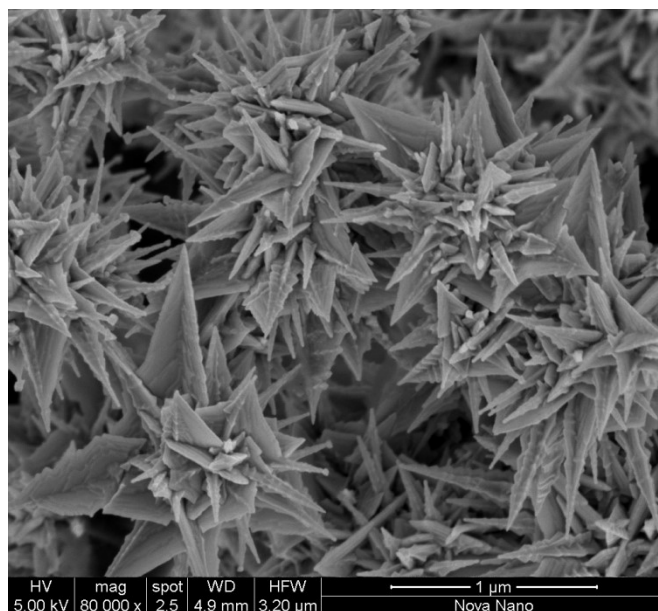
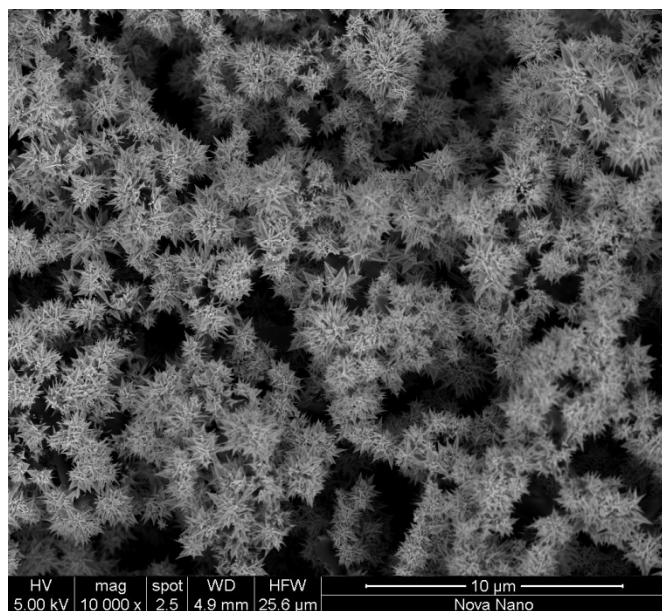


Figure S5. SEM images of gold microflowers Au4.

The calculation for SERS enhancement factors

$$EFs = \frac{I_{SERS}}{I_{Raman}} \times \frac{C_{Raman}}{C_{SERS}}$$

I_{SERS} : Intensity of enhanced band

I_{Raman} : Intensity of corresponding band in the control solution without AuNPs

C_{SERS} : Concentration of R6G in the mixture

C_{Raman} : Concentration of R6G in the control solution without AuNPs.

1) Gold nanostar seeds R=280 nm (radius of core)

Tip-to-tip distance = 817 nm

Diameter of cone $2r = 46.2$ nm (± 14.7) $r = 23.1$

$h = 128$ nm

Core surface area : 246300 nm²

Base surface area of one cone : 1676 nm²

Number of tips in one urchin : 146

Lateral Surface area of one cone : 9439 nm²

Total surface area of one urchin : 1378094 nm²

Volume of one cone : $\frac{1}{3} \pi r^2 h = 71525$ nm³

Volume of one urchin : $91952322 + 10442650 = 102394972$ nm³

Au unit cell : 0.408 nm

4 Au in one unit cell

Mass of Au in one urchin : $1.9731574 \times 10^{-12}$ g

Total Mass of Au in the Raman experiment: 1.14390×10^{-6} g (30 μ L was taken out of total reaction solution)

The number of nanourchins in Raman experiment : $1.14390 \times 10^{-6} / 1.9731574 \times 10^{-12} = 579730 \times 1/8 = 72466$

The number of R6G on one Au microflower: total surface area of one urchin 1378094 nm²

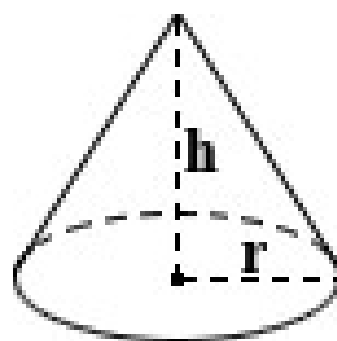
X The packing density of R6G: 6.25×10^{13} molecules/cm² = 861308

Number of R6G which was adsorbed on all Au microflowers: $861308 \times 72466 = 62415545528$

Then EF at 614 cm⁻¹ = $19.0 \times 3.612 \times 10^{15} / 62415545528^{8/5} = 1.759 \times 10^6$

EF at 1505 cm⁻¹

= $10.5 \times 3.612 \times 10^{15} / 62415545528^{8/5} = 9.722 \times 10^5$



2) Au1

R=363 nm (radius of core)

Tip-to-tip distance = 1.31 μm

Diameter of cone $2r = 96.4 \text{ nm}$ (± 32.1) $r = 42.9$

$h = 292 \text{ nm}$

Core surface area : 413964 nm^2

Base surface area of one cone : 5782 nm^2

Number of tips in one urchin : 72

Lateral Surface area of one cone : 39776 nm^2

Total surface area of one urchin : 2847774 nm^2

Volume of one cone : $\frac{1}{3} \pi r^2 h = 562763 \text{ nm}^3$

Volume of one urchin : $200358828 + 40518984 = 240877812 \text{ nm}^3$

Au unit cell : 0.408 nm

4 Au in one unit cell

Mass of Au in one urchin : $196.97 / (6.02 \times 10^{23}) \times 4 \times 240877812 \times 1000 / (0.408)^3 = 4.647 \times 10^{-12} \text{ g}$

Total Mass of Au in the Raman experiment: $1.14390 \times 10^{-6} \text{ g}$

The number of nanourchins in Raman experiment : $1.14390 \times 10^{-6} / 4.6396649 \times 10^{-12} \times 1/8 = 30765$

The number of R6G on one Au microflower: total surface area of one urchin 2847774 nm^2

X The packing density of R6G: $6.25 \times 10^{13} \text{ molecules/cm}^2 = 1779858$

Number of R6G which was adsorbed on all Au microflowers: $1779858 \times 30818 = 54757354443.75$

Then EF at $614 \text{ cm}^{-1} = 37 \times 3.612 \times 10^{15} / 54757354443.75 \times 8/5 = 3.905 \times 10^6$

EF at 1505 cm^{-1}

$= 20.8 \times 3.612 \times 10^{15} / 54757354443.75 \times 8/5 = 2.195 \times 10^6$

3) Au₂

R=642 nm (radius of core)

Tip-to-tip distance = 1.84 μm

Diameter of cone $2r = 95.1 \text{ nm}$ (± 16.8) $r = 47.55$

$h = 278 \text{ nm}$

Core surface area : 1294851 nm^2

Base surface area of one cone : 7103 nm^2

Number of tips in one urchin : 182

Lateral Surface area of one cone : 42131 nm^2

Total surface area of one urchin : 7667842 nm^2

Volume of one cone : $\frac{1}{3} \pi r^2 h = 658225 \text{ nm}^3$

Volume of one urchin : $1108392793 + 119796950 = 1228189743 \text{ nm}^3$

Au unit cell : 0.408 nm

4 Au in one unit cell

Mass of Au in one urchin : $2.3667292 \times 10^{-11}$

Total Mass of Au in the Raman experiment: 1.14390×10^{-6}

The number of nanourchins in Raman experiment : $1.14390 \times 10^{-6} / 2.3667292 \times 10^{-11} = 48332$

The number of R6G on one Au microflower: total surface area of one urchin 7667842 nm^2

X The packing density of R6G: $6.25 \times 10^{13} \text{ molecules/cm}^2 = 4792401$

Number of R6G which was adsorbed on all Au microflowers: $4792401 \times 48332 \times \frac{1}{8}$
 $= 28953290641.5$

Then EF at $614 \text{ cm}^{-1} = 25.7 \times 3.612 \times 10^{15} / 28953290641.5 \times \frac{8}{5} = 5.130 \times 10^6$

EF at 1505 cm^{-1}

$= 13.2 \times 3.612 \times 10^{15} / 33834617230 \times \frac{8}{5} = 2.634 \times 10^6$

4) Au₃

R=440 nm (radius of core)

Tip-to-tip distance = 1.40 μm

Diameter of cone $2r = 105.0 \text{ nm } (\pm 20.8) \text{ } r = 52.5$

$h = 259 \text{ nm}$

Core surface area : 608212 nm^2

Base surface area of one cone : 8659 nm^2

Number of tips in one urchin : 70

Lateral Surface area of one cone : 43586 nm^2

Total surface area of one urchin : 3051020 nm^2

Volume of one cone : $\frac{1}{3} \pi r^2 h = 747561 \text{ nm}^3$

Volume of one urchin : $356817904 + 52329312 = 409147216 \text{ nm}^3$

Au unit cell : 0.408 nm

4 Au in one unit cell

Mass of Au in one urchin : $7.8842919 \times 10^{-12} \text{ g}$

Total Mass of Au in the Raman experiment: $1.14390 \times 10^{-6} \text{ g}$

The number of nanourchins in Raman experiment : $1.14390 \times 10^{-6} / 7.8842919 \times 10^{-12} \times 1/8 = 18135$

The number of R6G on one Au microflower: total surface area of one urchin 3051020 nm^2

X The packing density of R6G: $6.25 \times 10^{13} \text{ molecules/cm}^2 = 1906887.5$

Number of R6G which was adsorbed on all Au microflowers: $1906887.5 \times 18135 = 16446404812.5$

Then EF at $614 \text{ cm}^{-1} = 8.3 \times 3.612 \times 10^{15} / 16446404812.5 \times 8/5 = 2.916 \times 10^6$

EF at 1505 cm^{-1}

$= 3.76 \times 3.612 \times 10^{15} / 16446404812.5 \times 8/5 = 1.321 \times 10^6$

5) Au₄

R=415 nm (radius of core)

Tip-to-tip distance = 1.478 μm

Diameter of cone $2r = 125 \text{ nm}$ (± 76.5) $r = 62.5$

$h = 324 \text{ nm}$

Core surface area : 541060 nm^2

Base surface area of one cone : 12271 nm^2

Number of tips in one urchin : 44

Lateral Surface area of one cone : 64790 nm^2

Total surface area of one urchin : 2850760 nm^2

Volume of one cone : $\frac{1}{3} \pi r^2 h = 1325359 \text{ nm}^3$

Volume of one urchin : $299386973 + 58315813 = 357702786 \text{ nm}^3$

Au unit cell : 0.408 nm

4 Au in one unit cell

Mass of Au in one urchin : $196.97 / (6.02 \times 10^{23})^4 \times 357702786 \times 1000 / ((4.08)^3) = 6.8929546 \times 10^{-12} \text{ g}$

Total Mass of Au in the Raman experiment: $1.14390 \times 10^{-6} \text{ g}$

The number of nanourchins in Raman experiment : $1.14390 \times 10^{-6} / 6.8929546 \times 10^{-12} = 20744$

The number of R6G on one Au microflower: total surface area of one urchin 2850760 nm^2

X The packing density of R6G: $6.25 \times 10^{13} \text{ molecules/cm}^2 = 1781725$

Number of R6G which was adsorbed on all Au microflowers: $1781725 \times 20744 = 36960103400$

Then EF at $614 \text{ cm}^{-1} = 24.9 \times 3.612 \times 10^{15} / 36960103400^{8/5} = 3.893 \times 10^6$

EF at 1505 cm^{-1}

$= 14.4 \times 3.612 \times 10^{15} / 36960103400^{8/5} = 2.252 \times 10^6$