

"DNA Origami-Templated Gold Nanorod Dimer Nanoantennas: Enabling Addressable Optical Hotspots for Single Cancer Biomarker SERS Detection"

Mridu Sharma, Charanleen Kaur, Priyanka Singhmar, Shikha Rai and Tapasi Sen*

Institute of Nano Science and Technology, Sector-81, Mohali, Punjab -140306, India

*E-mail: tapasi@inst.ac.in

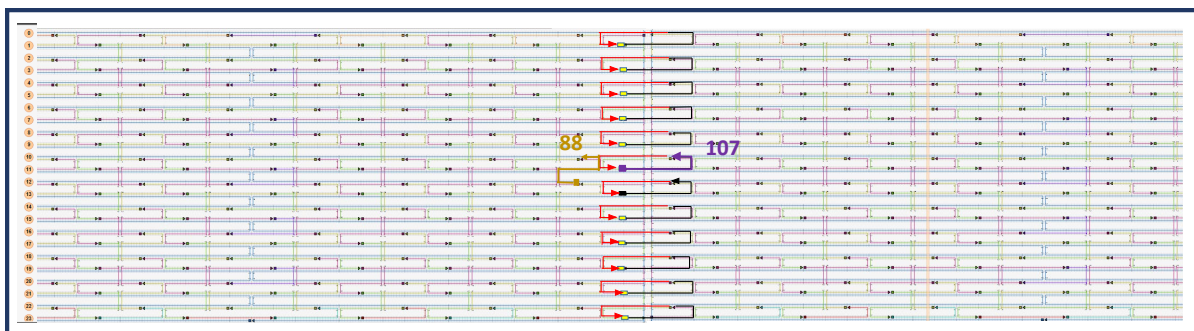


Figure S1. Position of staple strands modified with aptamer sequence; 88 (monomer) and 107 (Branching staple).

Name	Sequence 5' to 3'
88	GCGCATTAGCTTATCC TTTTTACCAGTGCGATGCTCAGTGCCGTTTCTTCTCTTTCGCTTTTTTTGCTTTTGAGCA TGCTGACGCATTGCGTTGACTTTT GGTATTCTAAATCAGA
107 (Branching staple)	TATAGAAGCTGTAGCTTTTTUGCCGCUAAUAAUGCACGGAUUUAAUCGCCGUAGAAAAGCAUG UCAAAAGCCGTTTTCAACATGTATTGCTGA

Table S1. Aptamer modified staple strand sequences. (Aptamer sequence is shown coloured).

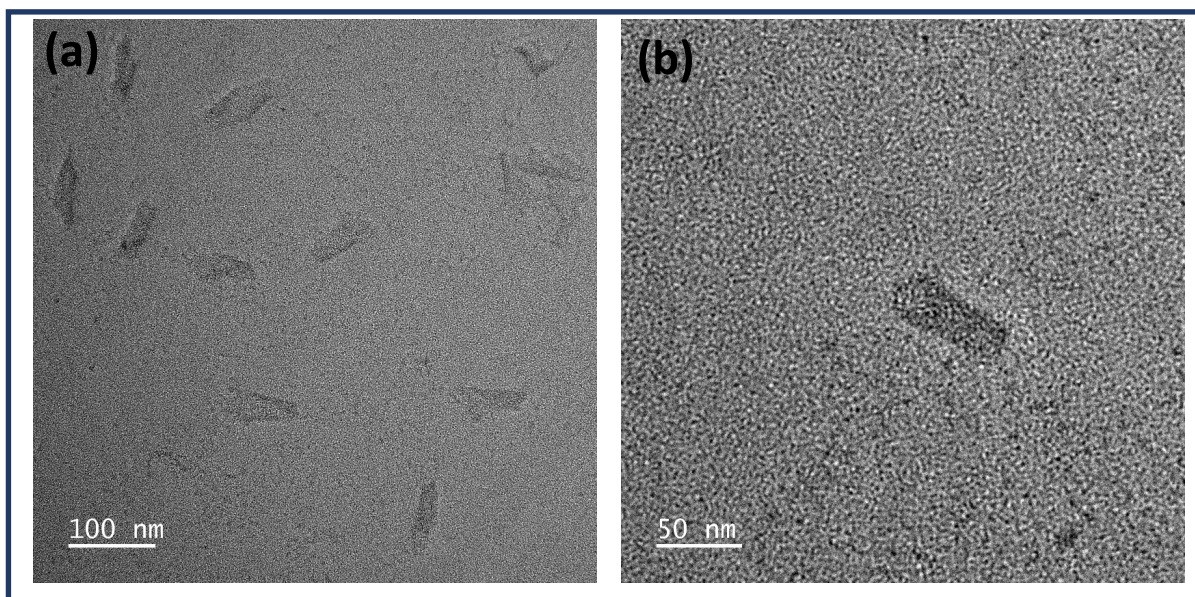


Figure S2. TEM images of (a) aptamer modified DNA origami monomers and, (b) single aptamer integrated DNA origami monomer. Scale bar: 100 nm(a); 50 nm(b)

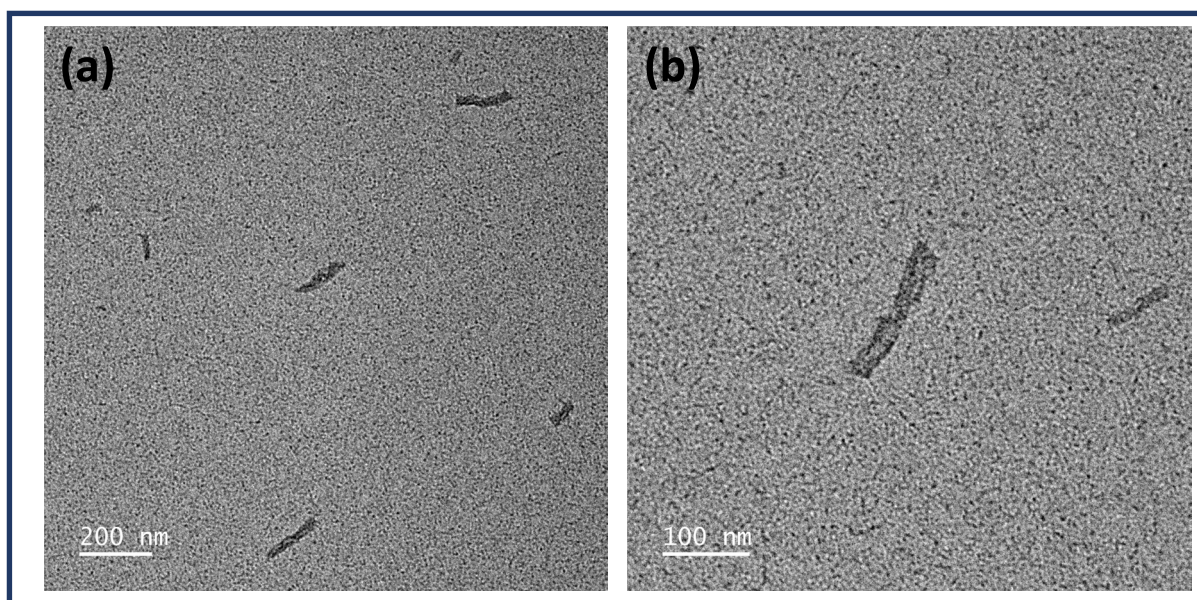


Figure S3. TEM images of (a) rectangular dimerized DNA origami integrated with aptamers and, (b) a single dimerized DNA origami. Scale bar: 200 nm(a), 100nm(b)

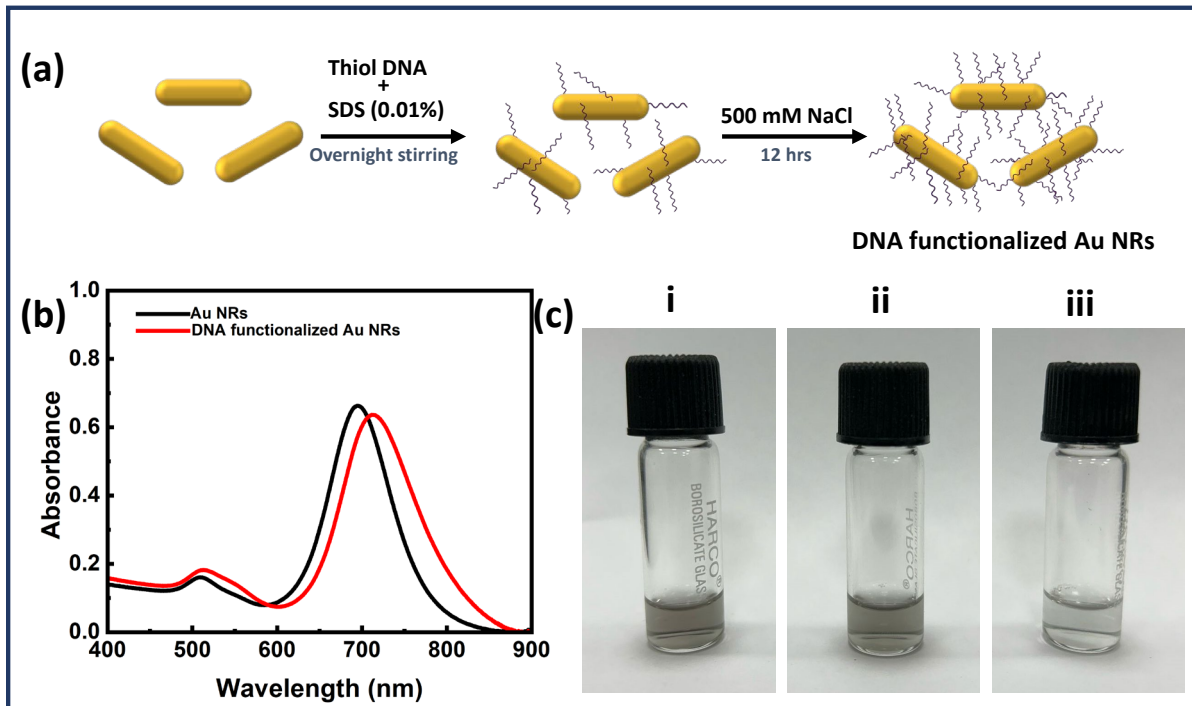


Figure S4. (a) Schematic illustration representing DNA functionalization of Au NRs, (b) UV-Vis spectra of Au NRs before and after DNA functionalization, and (c) (i) Au NRs, (ii) DNA functionalized Au NRs in presence of PBS, 500 mM NaCl, and (iii) Au NRs in presence of PBS, 500 mM NaCl.

Name	Sequence 5' to 3'
Monomer A	
81	CAAAAATCATTGCTCCTTTTGATAAGTTTCATCCACCACCACCA
82	TCAGAAGCCTCCAACAGGTCAGGATCTGCGAACCACCACCACCA
83	AAGAGGAACGAGCTTCAAAGCGAAGATACATTCCACCACCACCA
84	CCTAATTTACGCTAACGAGCGTCTATATCGCGCCACCACCACCA
85	ATTATTTAACCCAGCTACAATTTTCAAGAACGCCACCACCACCA
Monomer B	
83	AAGAGGAACGAGCTTCAAAGCGAAGATACATTCTAAGCTATCGA
84	CCTAATTTACGCTAACGAGCGTCTATATCGCGCTAAGCTATCGA
85	ATTATTTAACCCAGCTACAATTTTCAAGAACGCTAAGCTATCGA
86	TTTTGTTTAAGCCTTAAATCAAGAATCGAGAACTAAGCTATCGA
87	CTTTACAGTTAGCGAACCTCCCGACGTAGGAACTAAGCTATCGA

Table S2. Modified staple strand sequences on DNA origami.

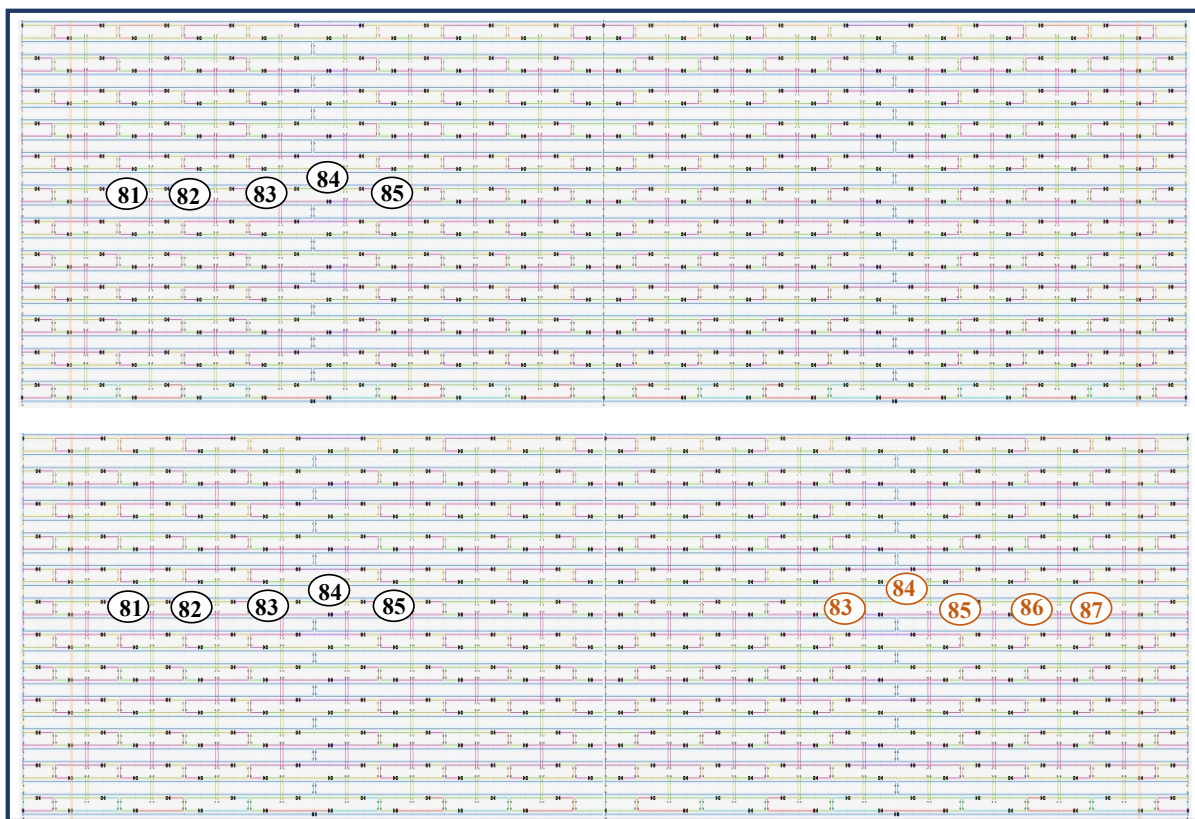


Figure S5. Position of capturing strands for immobilization of Au NRs in (a) monomer, and (b) dimer configuration on DNA origami.

Name	Sequence 5' to 3'
1	5'-SH- CGTCGATT CGATAGCTTAG
2	5'-SH-TTGGTGGTGGTGGTGGTGGT

Table S3. Thiol modified DNA sequences.

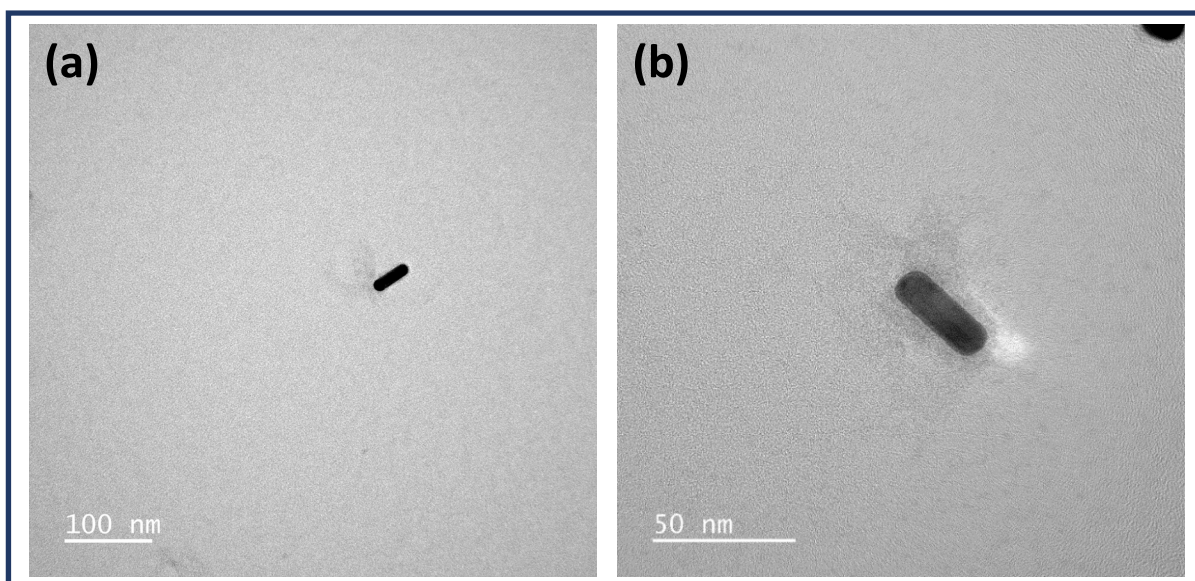


Figure S6. TEM images of a Au NR immobilized on dimerized rectangular DNA origami. Scale bar: 100 nm(a), 50 nm(b).

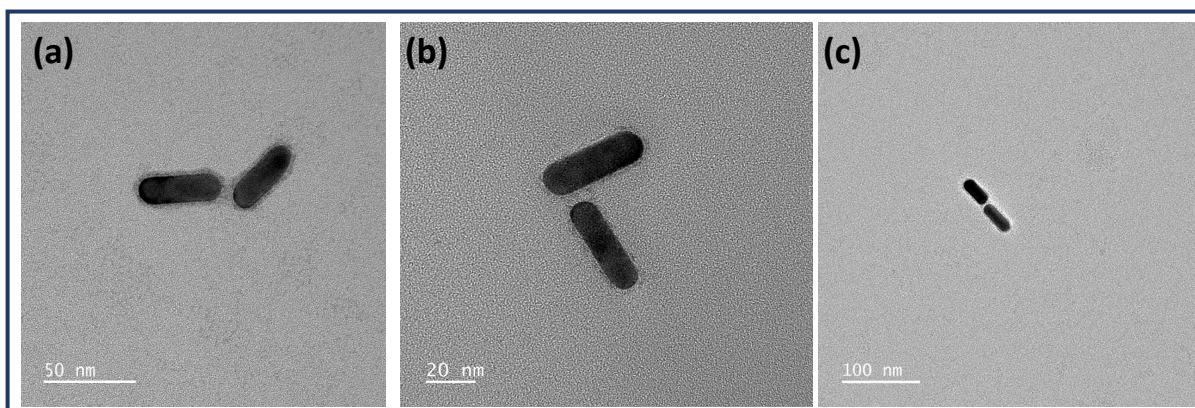


Figure S7. TEM images of Au NR dimers immobilized on dimerized rectangular DNA origami. Scale bars: 50 nm(a), 20 nm(b), 100nm(c).

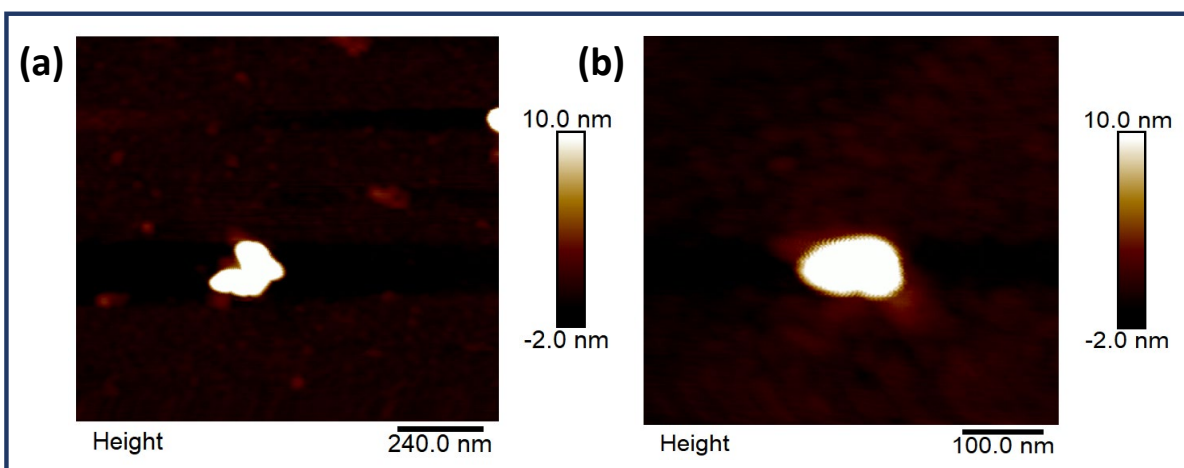


Figure S8. AFM images of Au NR dimers immobilized on dimerized rectangular DNA origami.

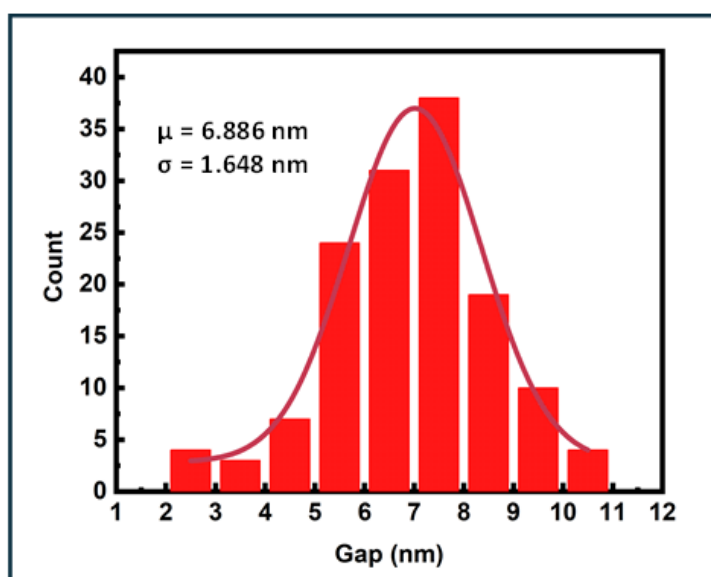


Figure S9. Gap size distribution. The red curves represent gaussian fits, with a mean (μ) and standard deviation σ .

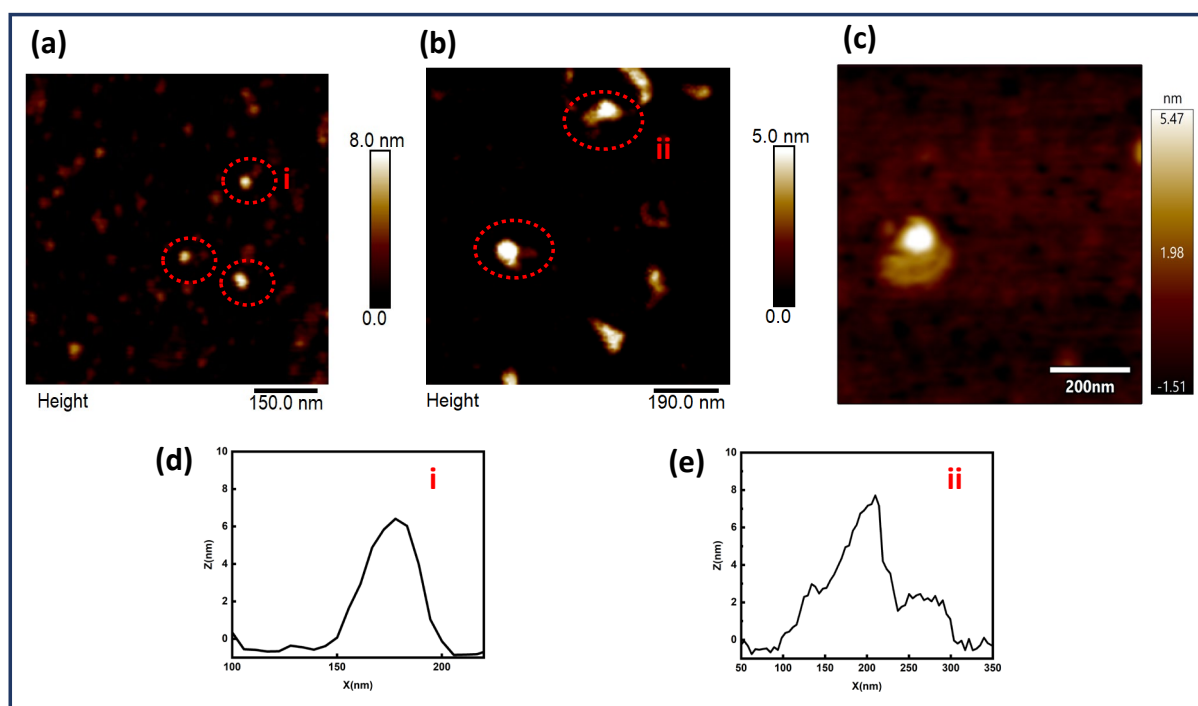


Figure S10. (a) AFM images of single EGFR proteins with corresponding height profile presented in (d), (b) AFM images of DNA origami dimer bound to single EGFR with corresponding height profile presented in (e) and, (c) AFM image of a single origami dimer bound to the protein.

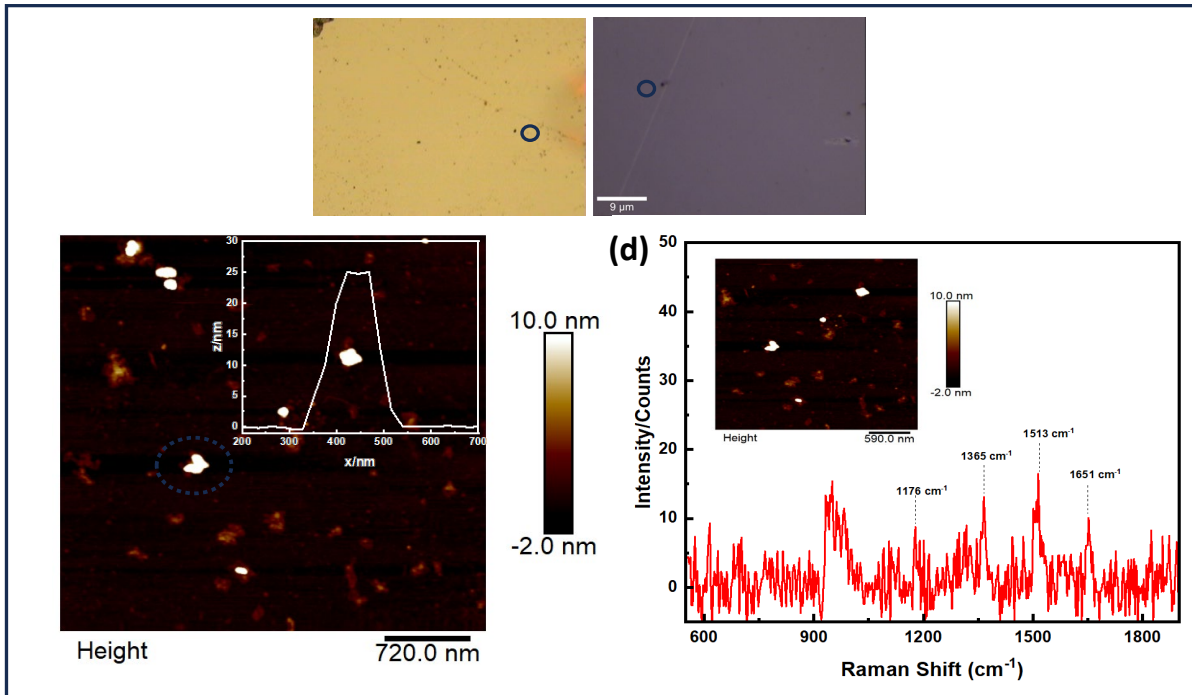


Figure S11. Single molecule SERS measurements of EGFR protein immobilized in the Au NR dimer nanoantenna system, (a,b) Optical images recorded using AFM and confocal Raman microscopes, respectively, (c) AFM images of Au NR dimer with corresponding height profile in inset and (d) Corresponding SERS spectrum of EGFR with high resolution AFM image of single nanoantenna in inset.

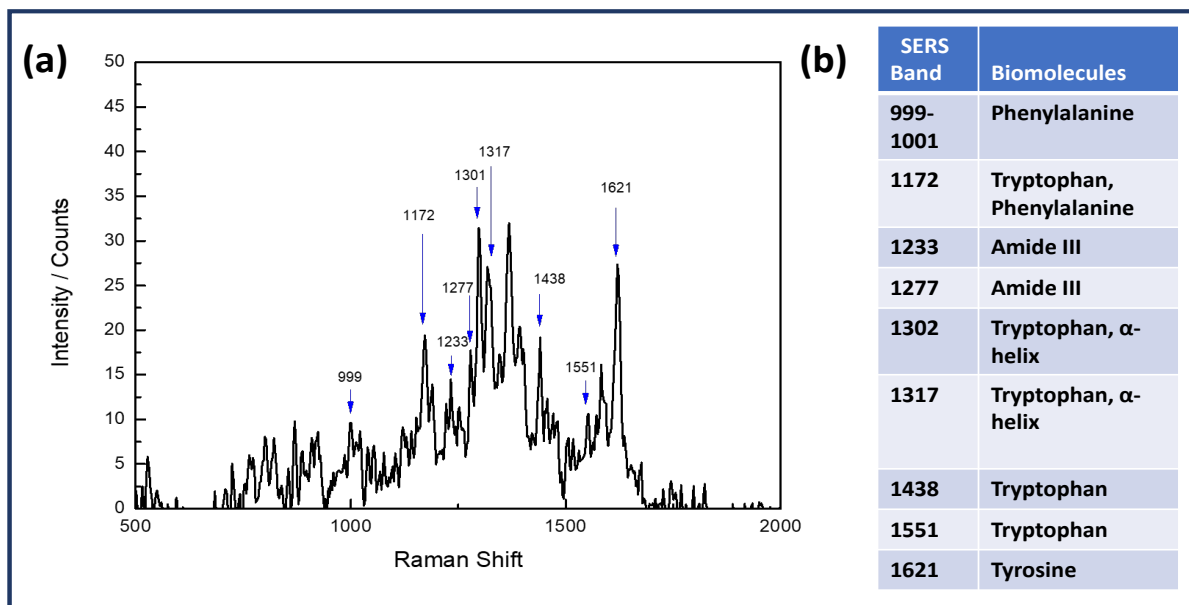


Figure S12. Reference Raman spectrum of EGFR protein (1 μM) dropcasted on AuNPs immobilized on Si wafer.

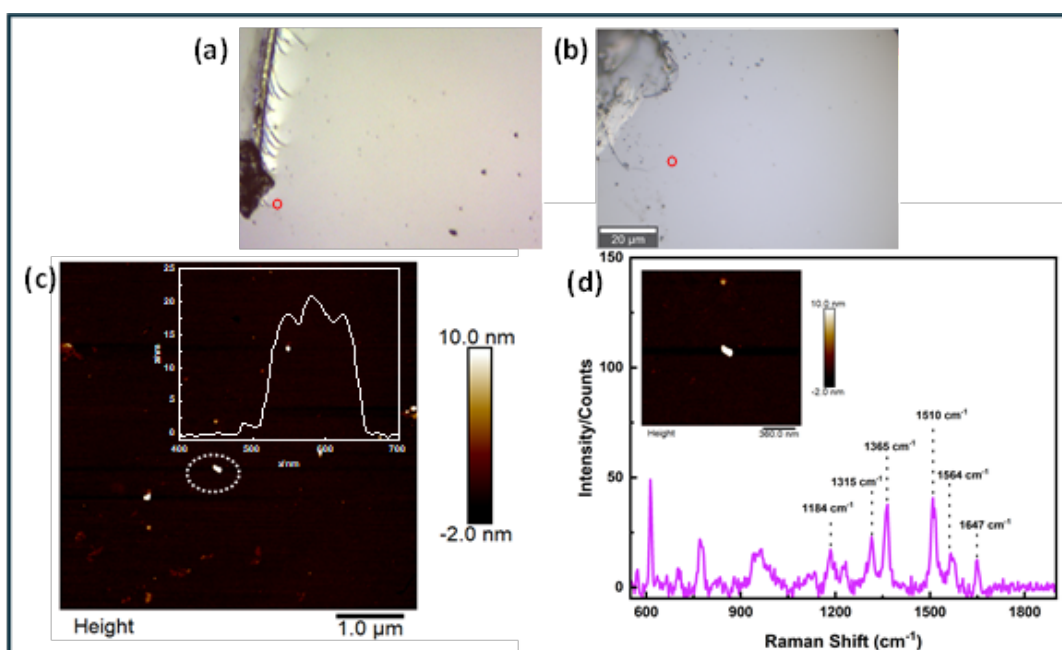


Figure S13. AFM-correlated Raman measurements for single EGFR molecule using 633 nm laser source. (a) Optical image taken using AFM. (b) Optical image taken using 100× objective of confocal Raman microscope. (c) AFM images of Au nanorod dimer and its corresponding height profile. (d) Single molecule SERS spectrum of EGFR bound to Au nanorod dimer on DNA origami with high resolution image of dimer assembly in the inset.

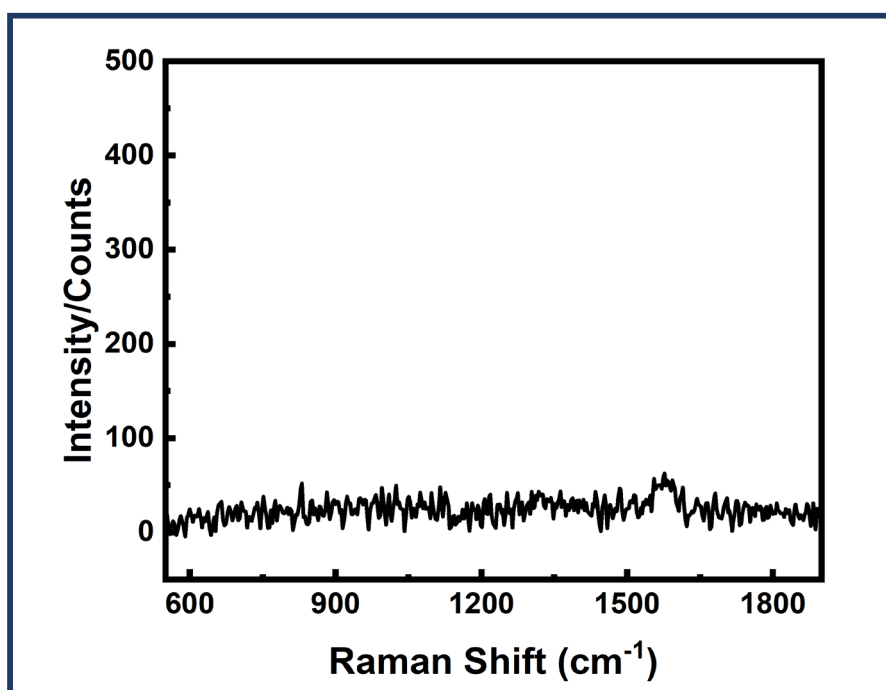


Figure S14. Raman spectrum of EGFR (1 μM).

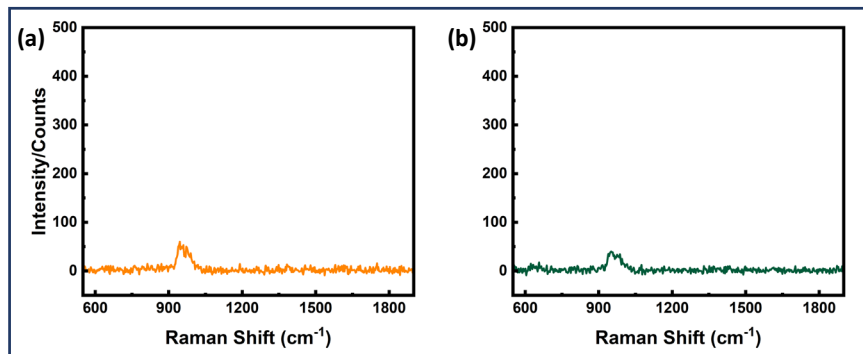


Figure S15. Control Raman measurements (a) SERS spectrum of DNA origami (with integrated aptamers) based Au NR nanoantenna but no EGFR protein and, (b) SERS spectrum of DNA origami (without integrated aptamers) based Au NR with EGFR added to the mixture.

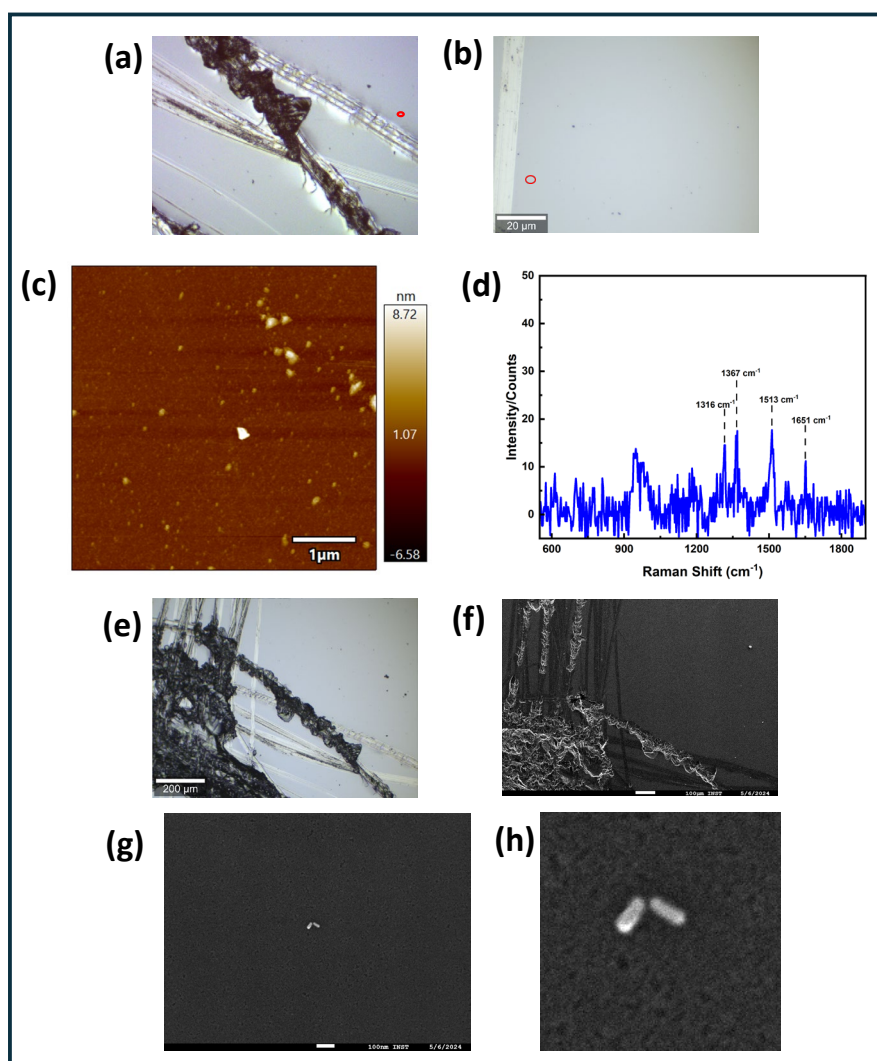


Figure S16. Effect of orientation of dimer structure on single molecule SERS of the protein. (a) Optical image in AFM (10x objective), (b) Optical image in Raman instrument (100x objective) (scale bar: 20 μm), (c) AFM image of the dimer structure, (d) the corresponding single molecule SERS spectrum, (e) Optical image in Raman instrument (10x objective) (scale bar: 200 μm), (f) FESEM image of the correlated area (scale bar: 100 μm), (g) FESEM image of a single dimer assembly. (scale bar: 100 nm) and (h) High resolution image of the dimer structure.

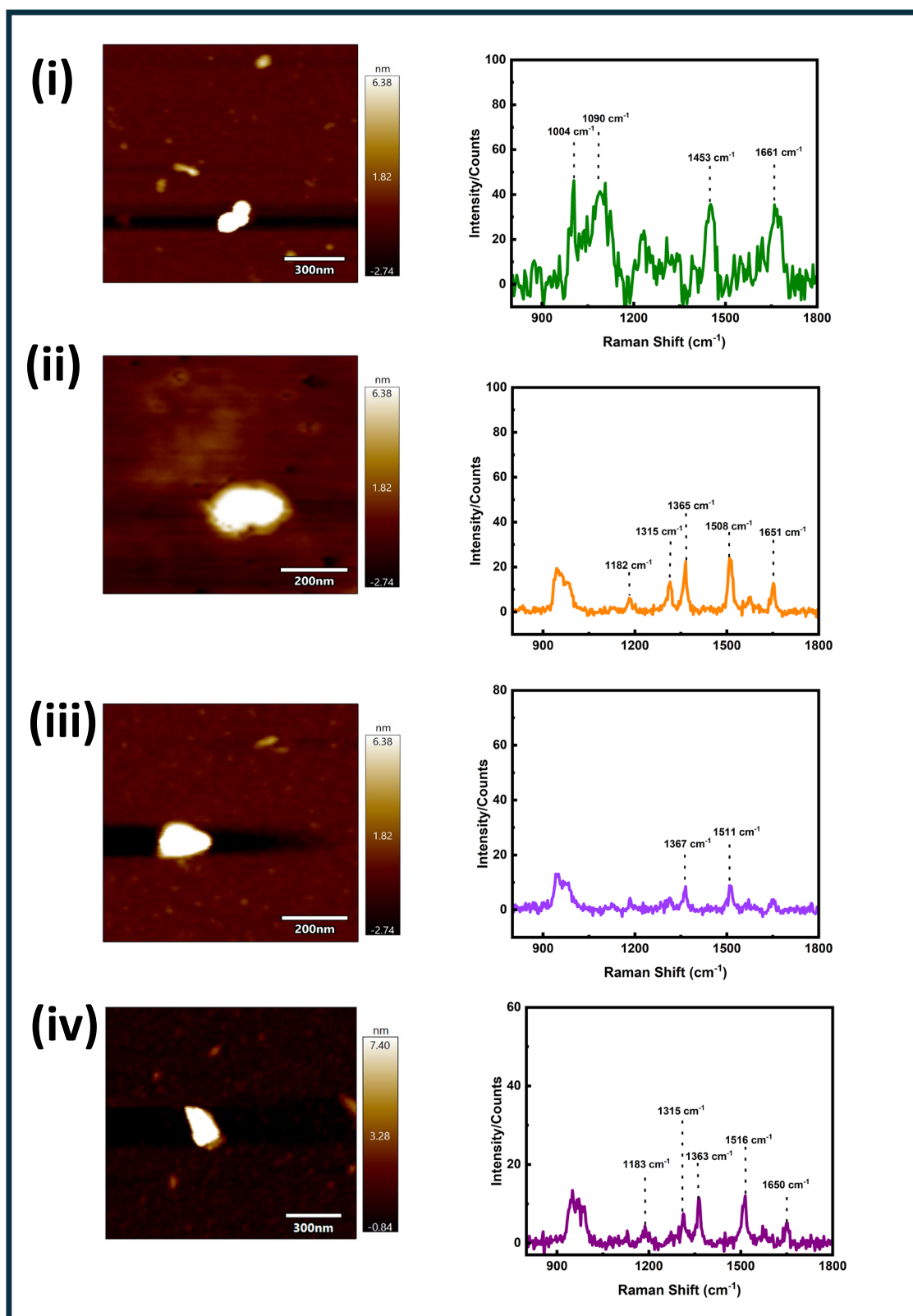


Figure S17. AFM correlated single molecule SERS measurements of dimer assemblies in different orientations.

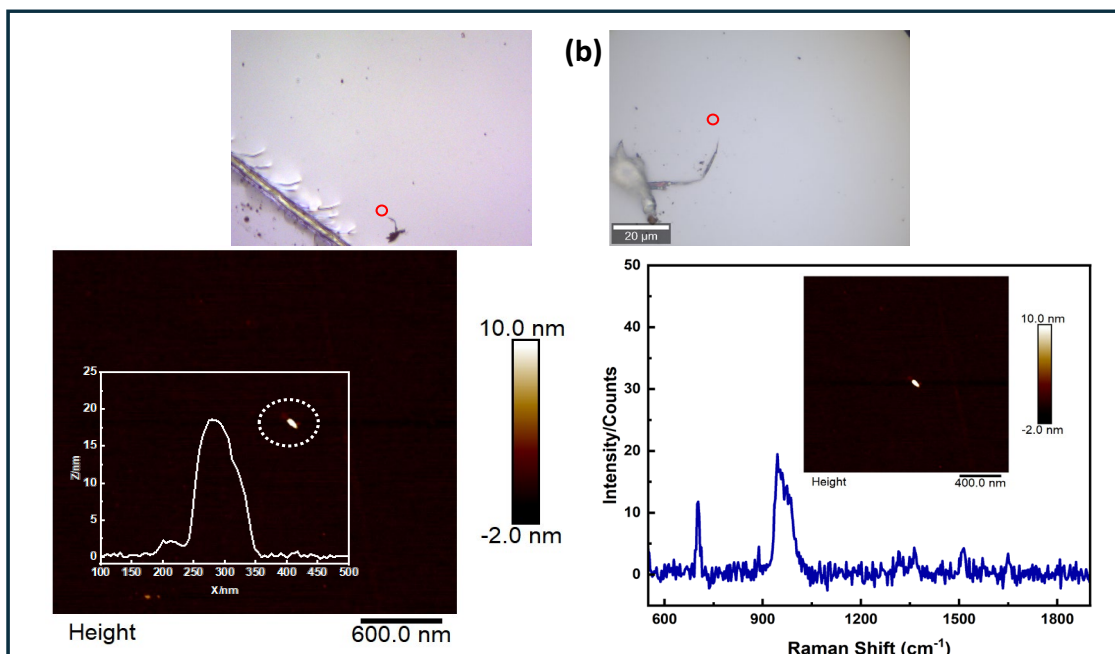


Figure S18. AFM-correlated Raman measurements using 633 nm laser source. (a) Optical image taken using AFM. (b) Optical image taken using 100× objective of confocal Raman microscope. (c) AFM images of Au nanorod monomer and its corresponding height profile. (d) Single molecule SERS spectrum of EGFR bound to Au nanorod monomer on DNA origami with high resolution image of monomer assembly in the inset.

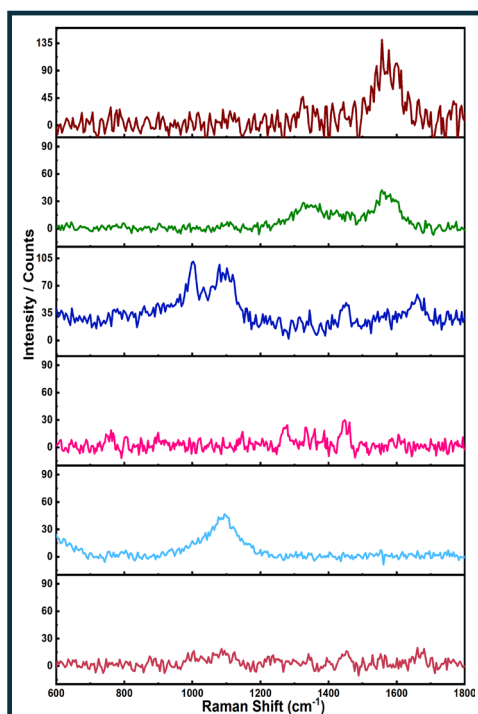


Figure S19. Few representative single molecule SERS spectra of the EGFR protein bound to Au NR monomer-DNA origami assemblies.

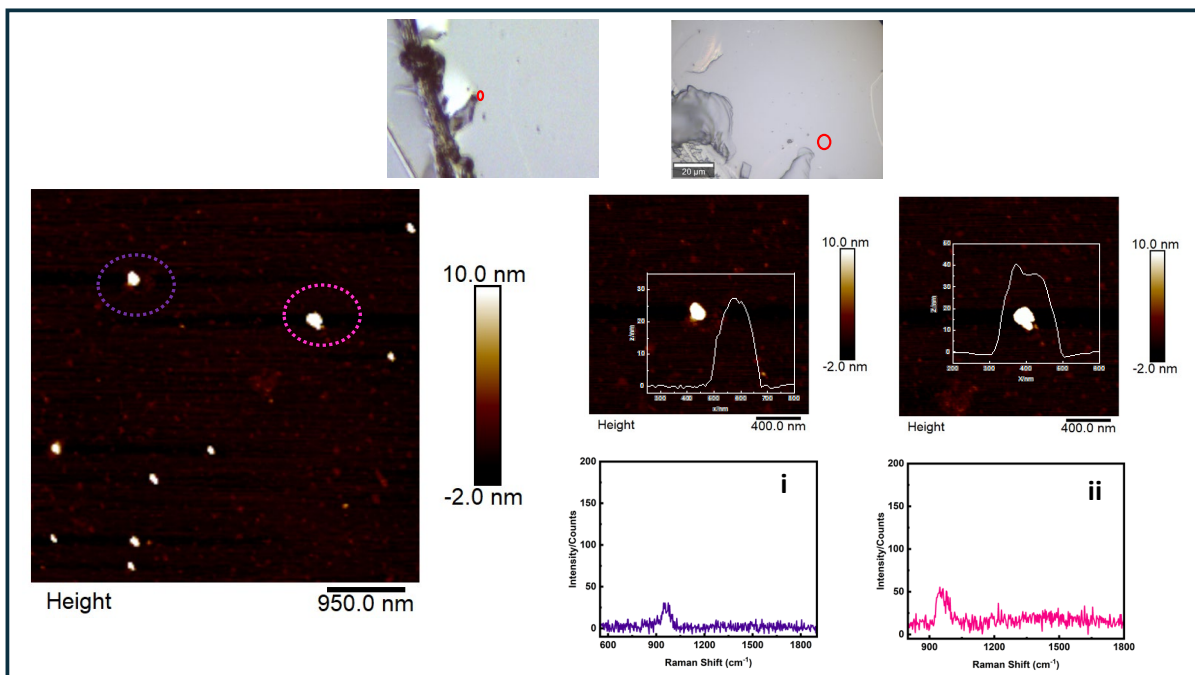


Figure S20. AFM-correlated Raman measurements using 633 nm laser source. (a) Optical image taken using AFM. (b) Optical image taken using 100× objective of confocal Raman microscope. (c) AFM images of Au nanorod dimer assemblies bound to BSA protein. (d) High resolution images of dimer assemblies with their corresponding height profiles. (e) The corresponding single molecule SERS spectra of BSA protein bound to Au NR dimers.

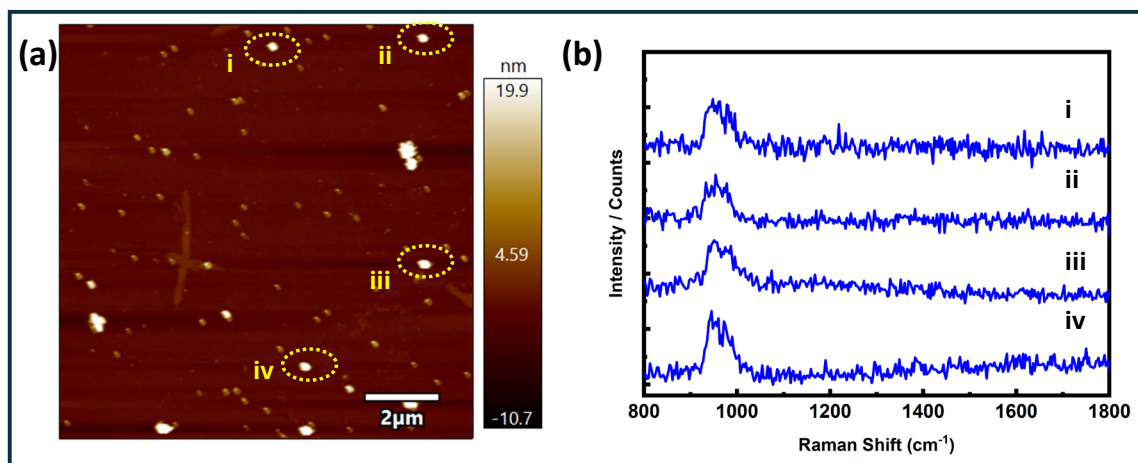


Figure S21. (a) AFM images of Au NR dimer assemblies bound to myoglobin and (b) single molecule SERS spectra of the protein.

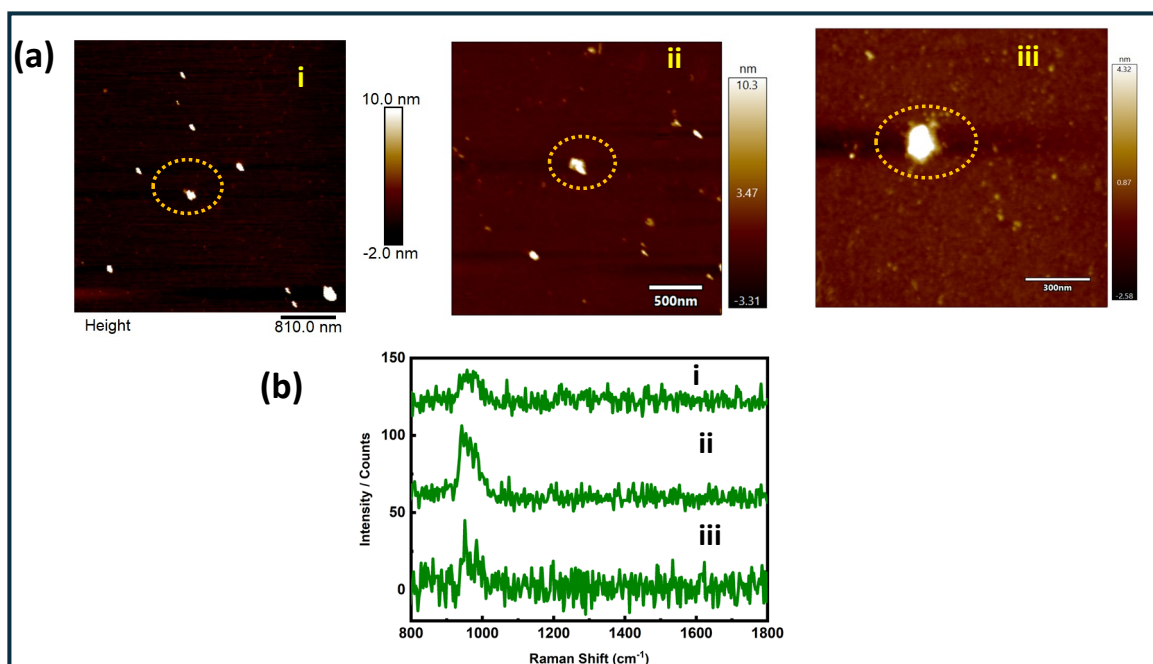


Figure S22. (a) AFM images of Au NR dimer assemblies bound to VEGF and (b) single molecule SERS spectra of the protein.

