Supporting Information

Plasmonic-Based Sensitivity Enhancement of Goos-Hänchen Shift Biosensor Using Transition Metal Dichalcogenides: A Theoretical Insight

Yan Guo^{*ab}, Nishtha Manish Singh^c, Chandreyee Manas Dasb^c, Qingling Ouyang^{bc}, Lixing Kang^{bc}, Kuanbiao Li^d, Philippe Coquet^{be}, and Ken-Tye Yong^{*bc}

^a School of Automation, Hangzhou Dianzi University, Hangzhou 310018, Zhejiang, China

guoyan@hdu.edu.cn

^b CINTRA CNRS/NTU/THALES, UMI 3288, Research Techno Plaza, 50 Nanyang Drive, Border X Block, Singapore, 637553

ktyong@ntu.edu.sg

^c School of Electrical and Electronic Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore, 639798

^d HANGZHOU HANGYANG Co. Ltd, Hangzhou 310014, Zhejiang, China

^e Institut d'Electronique, de Microélectronique et de Nanotechnologie (IEMN), CNRS UMR 8520 -Université de Lille 1, 59650 Villeneuve d'Ascq, France







Fig. S1 The change in differential GH shift as a function of the thickness of gold thin film for different number of MoS_2 layers but without graphene (L=0) at different excitation wavelengths coupled by the four prisms.







Fig. S2 The change in differential GH shift as a function of the thickness of gold thin film for different number of WS_2 layers but without graphene (L=0) at different excitation wavelengths coupled by the four prisms.

Table S1 Measured parameters- SPR angle, minimum reflectivity, FWTM, change in differential GH shift, sensitivity, FoM and enhancement factor- at the optimal Au thickness with different layers of graphene and MoS₂ at different prisms and excitation wavelengths for the fixed RI change of Δn =0.005.

$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Fixed Pa	ramete	rs		Measured Parameters						
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	λ (nm)	Prism	d (nm)	Graphene (L)	MoS ₂ (M)	θ _{sm} (°)	Rain	FWTM	ספאא (אש)	S (µm/RIU)	FoM (×10 ⁴)	۶
632.8SF54201 60.47 4.1×10^{-7} 1.58 841 1.682×10^5 10.65 2.40 632.8SF53802 61.76 5×10^{-6} 2.74 591 1.182×10^5 4.31 1.68 632.8SF103461 59.42 1×10^{-6} 3.37 1014 2.028×10^5 6.02 3.34 632.8SF103053 62.33 1×10^{-6} 6.23 648 1.296×10^5 2.08 2.14 632.8SF114011 55.99 2×10^{-6} 2.62 878 1.756×10^5 6.7 1.74 632.8SF114011 55.99 7×10^{-6} 1.63 1.264×10^5 8.66 1.77 780BK74133 70.10 7×10^{-6} 2.20 692 1.384×10^5 2.41 1.65 780BK731121 57.10 3×10^{-6} 3.12 664 1.328×10^5 1.41^7 1.65 780BK731121 57.10 3×10^{-6} 3.12 664 1.328×10^5 1.47 1.65 780BK1031121 57.10 5×10^{-6} 2.47 721 1.442×10^5 5.84 2.00 780SF103482 57.05 5×10^{-6} 1.67 1.333 2.706×10^5 12.24 3.75	532	BK7	30	3	1	80.49	1×10^{-6}	5.21	420	8.4×10^4	1.6	5.53
632.8SF53802 61.76 5×10^{-6} 2.74 591 1.182×10^5 4.31 1.68 632.8SF103461 59.42 1×10^{-6} 5.37 1014 2.028×10^5 6.02 3.34 632.8SF103053 62.33 1×10^{-6} 6.23 648 1.296×10^5 6.02 3.34 632.8SF113641 55.99 2×10^{-6} 2.62 878 1.756×10^5 6.7 1.74 632.8SF114011 55.99 7×10^{-6} 1.73 834 1.668×10^5 9.64 1.65 780BK74412 68.58 2.4×10^{-5} 1.46 632 1.264×10^5 8.66 1.77 780BK739010 80.85 1×10^{-6} 4.89 589 1.178×10^5 2.41 1.65 780SF1031121 57.30 3×10^{-6} 1.12 664 1.328×10^5 1.44 1.64 780SF103482 57.05 5×10^{-6} 1.17 1.442×10^5 5.84 2.00 780SF103482 57.05 5×10^{-6} 1.17 1.442×10^5 5.84 2.00 780SF103662 56.56 7×10^{-6} 1.57 11.67 1.342×10^5 1.83 3.18 780<	632.8	SF5	42	0	1	60.47	4.1×10^{-7}	1.58	841	1.682×10^5	10.65	2.40
632.8SF5314365.10 1×10^{-6} 5.88678 1.356×10^5 2.311.93632.8SF103461 59.42 1×10^{-6} 3.37 1014 2.028×10^5 6.02 3.34 632.8SF113641 55.99 2×10^{-6} 2.62 878 1.756×10^5 6.7 1.74 632.8SF114011 55.99 7×10^{-6} 1.62 834 1.668×10^5 9.64 1.65 780BK74412 68.58 2.4×10^{-5} 1.46 632 1.264×10^5 8.66 1.77 780BK739010 80.85 1×10^{-6} 4.89 589 1.178×10^5 6.29 1.94 780SF1031121 57.30 3×10^{-6} 3.12 664 1.328×10^5 4.26 1.84 780SF103482 57.05 5×10^{-6} 2.21 73.53 2.706×10^5 11.47 1.61 780SF103482 56.56 7×10^{-6} 1.97 961 1.922×10^5 7.84 3.00 780SF103842 56.12 7×10^{-6} 1.57 1167 2.33×10^5 14.87 3.24 780SF10303 55.86 1.6×10^{-5} 1.05 1146 2.292×10^5 13.302 2.91	632.8	SF5	38	0	2	61.76	5×10^{-6}	2.74	591	1.182×10^{5}	4.31	1.68
632.8SF103461 59.42 1×10^{-6} 3.37 1014 2.028×10^5 6.02 3.34 632.8SF103053 62.33 1×10^{-6} 6.23 648 1.296×10^5 2.08 2.14 632.8SF114011 55.99 2×10^{-6} 2.62 878 1.756×10^5 6.7 1.74 632.8SF114011 55.99 2×10^{-5} 1.46 632 1.264×10^5 8.66 1.77 780BK74133 70.10 7×10^{-6} 4.20 692 1.384×10^5 6.29 1.94 780BK739010 80.85 1×10^{-6} 4.89 589 1.178×10^5 2.41 1.65 780BK1031121 57.30 3×10^{-6} 1.01 579 1.158×10^5 1.41 1.66 780SF103121 55.18 5×10^{-6} 1.01 579 1.142×10^5 5.84 2.00 780SF103482 57.05 5×10^{-6} 1.97 721 1.442×10^5 5.84 2.00 780SF103393 55.66 1×10^{-6} 1.57 1167 2.33×10^{-6} 1.47 3.14 3.16 780SF103393 56.53 5×10^{-6} 1.61 1048 2.096×10^5 13.02	632.8	SF5	31	4	3	65.10	1×10^{-6}	5.88	678	1.356×10^5	2.31	1.93
	632.8	SF10	34	6	1	59.42	1×10^{-6}	3.37	1014	2.028×10^5	6.02	3.34
	632.8	SF10	30	5	3	62.33	1×10^{-6}	6.23	648	1.296×10^{5}	2.08	2.14
632.8SF11401155.09 7×10^{-6} 1.73834 1.668×10^5 9.641.65780BK7441268.58 2.4×10^{-5} 1.46632 1.264×10^5 8.661.77780BK7413370.10 7×10^{-6} 2.20692 1.384×10^5 6.291.94780BK73112157.30 3×10^{-6} 4.89589 1.178×10^5 2.411.65780SF103112157.30 3×10^{-6} 1.21664 1.328×10^5 2.411.65780SF10348257.05 5×10^{-6} 1.01579 1.158×10^5 11.471.61780SF10357256.80 1×10^{-6} 2.21 1353 2.706 \times 10^512.243.75780SF10384256.56 7×10^{-6} 1.6711672.334 \times 10^514.873.24780SF10384256.56 7×10^{-6} 1.5711672.34 \times 10^51.3022.91780SF10339356.53 5×10^{-6} 1.6110482.096 \times 10^513.022.91780SF113013155.02 1×10^{-6} 3.21671 1.342×10^5 1.3022.91780SF113013155.02 1×10^{-6} 1.26	632.8	SF11	36	4	1	55.99	2×10^{-6}	2.62	878	1.756×10^{5}	6.7	1.74
780BK74412 68.58 2.4×10^{-5} 1.46 632 1.264×10^{5} 8.66 1.77 780BK74133 70.10 7×10^{-6} 2.20 692 1.384×10^{5} 6.29 1.94 780BK739010 80.85 1×10^{-6} 4.89 589 1.178×10^{5} 2.41 1.65 780SF1031121 57.30 3×10^{-6} 3.12 664 1.328×10^{5} 4.26 1.84 780SF104121 55.18 5×10^{-6} 1.01 579 1.158×10^{5} 11.47 1.61 780SF103482 57.05 5×10^{-6} 1.247 721 1.442×10^{5} 5.84 2.00 780SF103662 56.56 7×10^{-6} 1.97 961 1.922×10^{5} 9.76 2.61 780SF103842 56.12 7×10^{-6} 1.57 1167 2.334×10^{5} 14.87 3.24 780SF103393 58.12 4×10^{-6} 3.21 671 1.342×10^{5} 4.18 1.66 780SF1030135 61.75 1×10^{-6} 3.21 671 1.342×10^{5} 1.302 2.91 780SF1130131 55.26 1×10^{-6} 3.25 1.256×10^{5} 2.0 1.74	632.8	SF11	40	1	1	55.09	7×10^{-6}	1.73	834	1.668×10^{5}	9.64	1.65
780BK7413370.10 7×10^{-6} 2.20 692 1.384×10^5 6.29 1.94 780BK739010 80.85 1×10^{-6} 4.89 589 1.178×10^5 2.41 1.65 780SF1031121 57.30 3×10^{-6} 3.12 664 1.328×10^5 4.26 1.84 780SF104421 55.18 5×10^{-6} 2.17 77 1.158×10^5 11.47 1.61 780SF103482 57.05 5×10^{-6} 2.47 721 1.442×10^5 5.84 2.07 780SF103662 56.56 7×10^{-6} 1.97 961 1.922×10^5 9.76 2.61 780SF103842 56.12 7×10^{-6} 1.57 1167 2.334×10^5 14.87 3.24 780SF103393 58.86 1.6×10^{-5} 1.05 1146 2.92×10^5 21.83 3.18 780SF1030135 61.75 1×10^{-6} 3.21 671 1.342×10^5 4.18 1.66 780SF1130135 51.7 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF1130131 55.02 1×10^{-6} 3.25 1285 3.048×10^5 15.55 3.69 <td>780</td> <td>BK7</td> <td>44</td> <td>1</td> <td>2</td> <td>68.58</td> <td>2.4×10^{-5}</td> <td>1.46</td> <td>632</td> <td>1.264×10^{5}</td> <td>8.66</td> <td>1.77</td>	780	BK7	44	1	2	68.58	2.4×10^{-5}	1.46	632	1.264×10^{5}	8.66	1.77
780BK73901080.85 1×10^{-6} 4.89589 1.178×10^{5} 2.411.65780SF103112157.30 3×10^{-6} 3.12 664 1.328×10^{5} 4.261.84780SF10412155.18 5×10^{-6} 1.01579 1.158×10^{5} 11.471.61780SF10348257.05 5×10^{-6} 2.47721 1.442×10^{5} 5.842.00780SF10357256.80 1×10^{-6} 2.2113532.706 \times 10^{5}12.243.75780SF10366256.56 7×10^{-6} 1.979611.922 \times 10^{5}9.762.61780SF10384256.12 7×10^{-6} 1.5711672.334 \times 10^{5}14.873.24780SF10339358.12 4×10^{-6} 3.21671 1.342×10^{5} 4.181.86780SF103013561.75 1×10^{-6} 6.26628 1.256×10^{5} 2.01.74780SF10301355.02 1×10^{-6} 3.2512852.57 \times 10^{5}7.913.11780SF113013155.02 1×10^{-6} 3.2512852.57 \times 10^{5}7.913.11780SF11348153.89 $3 \times 10^{-$	780	BK7	41	3	3	70.10	7×10^{-6}	2.20	692	1.384×10^{5}	6.29	1.94
780SF103112157.30 3×10^{-6} 3.12 664 1.328×10^{5} 4.26 1.84 780SF104421 55.18 5×10^{-6} 1.01 579 1.158×10^{5} 11.47 1.61 780SF103482 57.05 5×10^{-6} 2.47 721 1.442×10^{5} 5.84 2.00 780SF103572 56.80 1×10^{-6} 2.21 1353 2.706×10^{5} 12.24 3.75 780SF103662 56.56 7×10^{-6} 1.97 961 1.922×10^{5} 9.76 2.61 780SF103842 56.12 7×10^{-6} 1.57 11.67 2.334×10^{5} 14.87 3.44 780SF103393 55.86 1.6×10^{-5} 1.05 1146 2.292×10^{5} 21.83 3.18 780SF103933 56.53 5×10^{-6} 1.61 1048 2.096×10^{5} 13.02 2.91 780SF1130131 55.02 1×10^{-6} 6.26 628 1.256×10^{5} 2.0 1.74 780SF113481 53.89 3×10^{-6} 1.96 1.812×10^{5} 14.38 2.19 780SF113481 55.13 7×10^{-6} 1.26 906 1.812×10^{5} 14.38 <	780	BK7	39	0	10	80.85	1×10^{-6}	4.89	589	1.178×10^5	2.41	1.65
780SF10412155.18 5×10^{-6} 1.01579 1.158×10^5 11.47 1.61780SF10348257.05 5×10^{-6} 2.47721 1.442×10^5 5.842.00780SF10357256.80 1×10^{-6} 2.2113532.706 \times 10^512.243.75780SF10366256.56 7×10^{-6} 1.97961 1.922×10^5 9.762.61780SF10384256.12 7×10^{-6} 1.5711672.334 \times 10^514.873.24780SF10339355.86 1.6×10^{-5} 1.0511462.292 \times 10^52.1833.18780SF1039356.53 5×10^{-6} 1.6110482.096 \times 10^513.022.91780SF1130135 61.75 1×10^{-6} 6.26628 1.256×10^5 2.01.74780SF113013155.02 1×10^{-6} 3.251285 2.57×10^5 7.913.11780SF11348153.89 3×10^{-6} 1.961.94 \times 10^523.662.35780SF11348155.13 7×10^{-5} 0.829701.94 \times 10^523.662.35780SF11347556.74 3×10^{-6} 0.441.608 \times 10^5	780	SF10	31	12	1	57.30	3×10^{-6}	3.12	664	1.328×10^{5}	4.26	1.84
780SF10348257.05 5×10^{-6} 2.47721 1.442×10^5 5.842.00780SF10357256.80 1×10^{-6} 2.211353 2.706×10^5 12.243.75780SF10366256.56 7×10^{-6} 1.97961 1.922×10^5 9.762.61780SF10384256.12 7×10^{-6} 1.5711672.334 $\times 10^5$ 14.873.24780SF10430355.86 1.6×10^{-5} 1.0511462.292 $\times 10^5$ 21.833.18780SF10339356.53 5×10^{-6} 1.6110482.096 $\times 10^5$ 13.022.91780SF103013561.75 1×10^{-6} 6.26628 1.256×10^5 2.01.74780SF11440152.45 4.2×10^{-5} 0.68895 1.79×10^5 26.322.17780SF113013155.02 1×10^{-6} 3.2512852.57 $\times 10^5$ 7.913.11780SF11348153.89 3×10^{-6} 1.9615243.048 $\times 10^5$ 15.553.69780SF11348155.13 7×10^{-5} 0.829701.94 $\times 10^5$ 13.811.57780SF11437556.74 3×10^{-6} <	780	SF10	41	2	1	55.18	5×10^{-6}	1.01	579	$1.158 imes 10^5$	11.47	1.61
780SF10357256.80 1×10^{-6} 2.211353 2.706×10^5 12.243.75780SF10366256.56 7×10^{-6} 1.97961 1.922×10^5 9.762.61780SF10384256.12 7×10^{-6} 1.571167 2.334×10^5 14.873.24780SF10430355.86 1.6×10^{-5} 1.051146 2.292×10^5 21.833.18780SF10339358.12 4×10^{-6} 3.21671 1.342×10^5 4.181.86780SF103013561.75 1×10^{-6} 1.611048 2.096×10^5 13.022.91780SF11440152.45 4.2×10^{-5} 0.68895 1.79×10^5 26.322.17780SF113013155.02 1×10^{-6} 3.251285 2.57×10^5 7.913.11780SF11348153.89 3×10^{-6} 1.961.524 3.048×10^5 15.553.69780SF11348152.62 1.9×10^{-5} 0.82970 1.94×10^5 23.662.35780SF11348155.77 1×10^{-5} 0.82970 1.94×10^5 13.811.57780SF11437556.77 1×10^{-5} </td <td>780</td> <td>SF10</td> <td>34</td> <td>8</td> <td>2</td> <td>57.05</td> <td>5×10^{-6}</td> <td>2.47</td> <td>721</td> <td>1.442×10^{5}</td> <td>5.84</td> <td>2.00</td>	780	SF10	34	8	2	57.05	5×10^{-6}	2.47	721	1.442×10^{5}	5.84	2.00
780SF10366256.56 7×10^{-6} 1.97961 1.922×10^5 9.762.61780SF10384256.12 7×10^{-6} 1.571167 2.334×10^5 14.873.24780SF10430355.86 1.6×10^{-5} 1.051146 2.292×10^5 21.833.18780SF10339358.12 4×10^{-6} 3.21671 1.342×10^5 4.181.86780SF1030135 61.75 1×10^{-6} 1.611048 2.096×10^5 13.022.91780SF114401 52.45 4.2×10^{-5} 0.68895 1.79×10^5 26.322.17780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.913.11780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.553.69780SF113481 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.662.35780SF114303 53.40 3.4×10^{-5} 0.94649 1.298×10^5 13.811.57780SF114475 56.74 3×10^{-6} 0.73 194×10^5 23.662.35780SF113475 56.74 3×1	780	SF10	35	7	2	56.80	1×10^{-6}	2.21	1353	2.706×10^{5}	12.24	3.75
780SF103842 56.12 7×10^{-6} 1.57 1167 2.334×10^5 14.87 3.24 780SF104303 55.86 1.6×10^{-5} 1.05 1146 2.292×10^5 21.83 3.18 780SF103393 58.12 4×10^{-6} 3.21 671 1.342×10^5 4.18 1.86 780SF1030135 61.75 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.32 2.17 780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113481 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF11 42 1 1 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF11 43 03 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF11 34 75 56.74 3×10^{-6} 0.94 649 1.298×10^5 13.81 <	780	SF10	36	6	2	56.56	7×10^{-6}	1.97	961	1.922×10^{5}	9.76	2.61
780SF10430355.86 1.6×10^{-5} 1.05 1146 2.292×10^5 21.83 3.18 780SF10339358.12 4×10^{-6} 3.21 671 1.342×10^5 4.18 1.86 780SF103933 56.53 5×10^{-6} 1.61 1048 2.096×10^5 13.02 2.91 780SF1030135 61.75 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.32 2.17 780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113481 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF11 42 1 1 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF11 34 75 56.74 3×10^{-6} 0.94 649 1.298×10^5 13.81 1.57 780SF11 34 75 56.74 3×10^{-6} 0.73 1956 3.912×10^5 53.59 <	780	SF10	38	4	2	56.12	7×10^{-6}	1.57	1167	2.334×10^{5}	14.87	3.24
780SF10339358.12 4×10^{-6} 3.21 671 1.342×10^5 4.18 1.86 780SF1030135 61.75 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.32 2.17 780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113481 55.02 1×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF113481 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF114211 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 13.81 1.57 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 0.73 1956 3.912×10^5 53.59 2.55 1152 SF53171 55.77 1×10^{-5} 0.78 1952 3.904×10^5 50.05 2.5	780	SF10	43	0	3	55.86	1.6×10^{-5}	1.05	1146	2.292×10^{5}	21.83	3.18
780SF10393356.53 5×10^{-6} 1.611048 2.096×10^5 13.022.91780SF1030135 61.75 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.32 2.17 780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF114211 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 1152SF53173 56.11 5×10^{-6} 0.73 1956 3.912×10^5 50.05 2.55	780	SF10	33	9	3	58.12	4×10^{-6}	3.21	671	1.342×10^{5}	4.18	1.86
780SF1030135 61.75 1×10^{-6} 6.26 628 1.256×10^5 2.0 1.74 780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.32 2.17 780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF11421 1 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 152SF53432 55.54 2.8×10^{-5} 0.78 1952 3.904×10^5 50.05 2.55 1152SF53173 56.11 5×10^{-6} 1.94 1566 3.132×10^5 30.12 <th< td=""><td>780</td><td>SF10</td><td>39</td><td>3</td><td>3</td><td>56.53</td><td>5×10^{-6}</td><td>1.61</td><td>1048</td><td>2.096×10^{5}</td><td>13.02</td><td>2.91</td></th<>	780	SF10	39	3	3	56.53	5×10^{-6}	1.61	1048	2.096×10^{5}	13.02	2.91
780SF114401 52.45 4.2×10^{-5} 0.68 895 1.79×10^5 26.322.17780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF11421 1 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 1152SF53432 55.54 2.8×10^{-6} 0.78 1952 3.904×10^5 50.05 2.55 1152SF53173 56.11 5×10^{-6} 1.19 2576 5.152×10^5 43.29 3.36 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 $2.$	780	SF10	30	13	5	61.75	1×10^{-6}	6.26	628	1.256×10^{5}	2.0	1.74
780SF1130131 55.02 1×10^{-6} 3.25 1285 2.57×10^5 7.91 3.11 780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF114211 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 1152SF53431 55.40 8×10^{-6} 0.73 1956 3.912×10^5 53.59 2.55 1152SF53173 56.11 5×10^{-6} 1.19 2576 5.152×10^5 43.29 3.36 1152SF531710 57.69 1×10^{-6} 1.04 1566 3.132×10^5 30.12 2.04 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 <t< td=""><td>780</td><td>SF11</td><td>44</td><td>0</td><td>1</td><td>52.45</td><td>4.2×10^{-5}</td><td>0.68</td><td>895</td><td>1.79×10^{5}</td><td>26.32</td><td>2.17</td></t<>	780	SF11	44	0	1	52.45	4.2×10^{-5}	0.68	895	1.79×10^{5}	26.32	2.17
780SF113481 53.89 3×10^{-6} 1.96 1524 3.048×10^5 15.55 3.69 780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^5 14.38 2.19 780SF114211 52.62 1.9×10^{-5} 0.82 970 1.94×10^5 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^5 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 1152SF53431 55.40 8×10^{-6} 0.73 1956 3.912×10^5 53.59 2.55 1152SF53173 56.11 5×10^{-6} 1.19 2576 5.152×10^5 43.29 3.36 1152SF53173 56.15 3×10^{-6} 1.04 1566 3.132×10^5 30.12 2.04 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 2.13	780	SF11	30	13	1	55.02	1×10^{-6}	3.25	1285	2.57×10^{5}	7.91	3.11
780SF113841 55.13 7×10^{-6} 1.26 906 1.812×10^{5} 14.38 2.19 780SF11421 52.62 1.9×10^{-5} 0.82 970 1.94×10^{5} 23.66 2.35 780SF114303 53.40 3.4×10^{-5} 0.94 649 1.298×10^{5} 13.81 1.57 780SF113475 56.74 3×10^{-6} 3.45 804 1.608×10^{5} 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^{5} 42.37 2.88 1152SF53431 55.40 8×10^{-6} 0.73 1956 3.912×10^{5} 53.59 2.55 1152SF53432 55.54 2.8×10^{-5} 0.78 1952 3.904×10^{5} 50.05 2.55 1152SF53173 56.11 5×10^{-6} 1.19 2576 5.152×10^{5} 43.29 3.36 1152SF53345 56.15 3×10^{-6} 1.04 1566 3.132×10^{5} 30.12 2.04 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^{5} 17.07 2.13	780	SE11	34	8	1	53.89	3×10^{-6}	196	1524	3.048×10^{5}	15 55	3 69
780 $SF11$ 42 1 1 52.62 1.9×10^{-5} 0.82 970 1.94×10^{5} 23.66 2.35 780 $SF11$ 43 0 3 53.40 3.4×10^{-5} 0.94 649 1.298×10^{5} 13.81 1.57 780 $SF11$ 34 7 5 56.74 3×10^{-6} 3.45 804 1.608×10^{5} 4.66 1.94 1152 $SF5$ 31 7 1 55.77 1×10^{-5} 1.04 2203 4.406×10^{5} 42.37 2.88 1152 $SF5$ 34 3 1 55.40 8×10^{-6} 0.73 1956 3.912×10^{5} 53.59 2.55 1152 $SF5$ 34 3 2 55.54 2.8×10^{-5} 0.78 1952 3.904×10^{5} 50.05 2.55 1152 $SF5$ 31 7 3 56.11 5×10^{-6} 1.19 2576 5.152×10^{5} 43.29 3.36 1152 $SF5$ 31 7 3 56.15 3×10^{-6} 1.04 1566 3.132×10^{5} 30.12 2.04 1152 $SF5$ 31 7 10 57.69 1×10^{-6} 1.91 1630 3.26×10^{5} 17.07 2.13	780	SF11	38	4	1	55.13	7×10^{-6}	1.26	906	1.812×10^{5}	14 38	2.19
780SF11430353.40 3.4×10^{-5} 0.94649 1.298×10^{5} 13.811.57780SF11347556.74 3×10^{-6} 3.45 804 1.608×10^{5} 4.661.941152SF5317155.77 1×10^{-5} 1.04 2203 4.406×10^{5} 42.37 2.88 1152SF5343155.40 8×10^{-6} 0.73 1956 3.912×10^{5} 53.59 2.55 1152SF5343255.54 2.8×10^{-5} 0.78 1952 3.904×10^{5} 50.05 2.55 1152SF5317356.11 5×10^{-6} 1.19 2576 5.152×10^{5} 43.29 3.36 1152SF5334556.15 3×10^{-6} 1.04 1566 3.132×10^{5} 30.12 2.04 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^{5} 17.07 2.13	780	SF11	42	1	1	52.62	1.9×10^{-5}	0.82	970	1.94×10^{5}	23.66	2.35
780SF11347556.74 3×10^{-6} 3.45 804 1.608×10^5 4.66 1.94 1152SF53171 55.77 1×10^{-5} 1.04 2203 4.406×10^5 42.37 2.88 1152SF53431 55.40 8×10^{-6} 0.73 1956 3.912×10^5 53.59 2.55 1152SF53432 55.54 2.8×10^{-5} 0.78 1952 3.904×10^5 50.05 2.55 1152SF53173 56.11 5×10^{-6} 1.19 2576 5.152×10^5 43.29 3.36 1152SF53345 56.15 3×10^{-6} 1.04 1566 3.132×10^5 30.12 2.04 1152SF531710 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 2.13	780	SF11	43	0	3	53.40	3.4×10^{-5}	0.94	649	1.298×10^{5}	13.81	1.57
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	780	SF11	34	7	5	56.74	3×10^{-6}	3.45	804	1.608×10^{5}	4.66	1.94
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	1152	SF5	31	7	1	55.77	1×10^{-5}	1.04	2203	4.406×10^{5}	42.37	2.88
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	1152	SF5	34	3	1	55.40	8×10^{-6}	0.73	1956	3.912×10^{5}	53.59	2.55
1152 SF5 31 7 3 56.11 5×10^{-6} 1.19 2576 5.152×10^5 43.29 3.36 1152 SF5 33 4 5 56.15 3×10^{-6} 1.04 1566 3.132×10^5 30.12 2.04 1152 SF5 31 7 10 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 2.13	1152	SF5	34	3	2	55.54	2.8×10^{-5}	0.78	1952	3.904×10^{5}	50.05	2.55
1152 SF5 33 4 5 56.15 3×10^{-6} 1.04 1566 3.132×10^5 30.12 2.04 1152 SF5 31 7 10 57.69 1×10^{-6} 1.91 1630 3.26×10^5 17.07 2.13	1152	SF5	31	7	3	56.11	5×10^{-6}	1.19	2576	5.152×10^{5}	43.29	3.36
1152 SF5 31 7 10 57.69 1×10^{-6} 1.91 1630 3.26×10^{5} 17.07 2.13	1152	SF5	33	4	5	56.15	3×10^{-6}	1.04	1566	3.132×10^{5}	30.12	2.04
	1152	SF5	31	7	10	57.69	1×10^{-6}	1.91	1630	3.26×10^{5}	17.07	2.13
1152 SF11 36 0 1 50.61 7.7×10^{-5} 0.47 1728 3.456×10^{5} 73.53 1.54	1152	SF11	36	0	1	50.61	7.7×10^{-5}	0.47	1728	3.456×10^{5}	73.53	1.54
1152 SF11 31 6 1 51.08 3×10^{-6} 0.84 2694 5.388 $\times 10^{5}$ 64.14 2.41	1152	SF11	31	6	1	51.08	3×10^{-6}	0.84	2694	5.388×10^{5}	64.14	2.41
1152 SF11 34 2 3 51.01 6×10^{-6} 0.66 2257 4.514×10^{5} 68.39 2.02	1152	SF11	34	2	3	51.01	6×10^{-6}	0.66	2257	$4.514 imes 10^5$	68.39	2.02
1152 SF11 33 3 3 51.10 3.7×10^{-5} 0.74 1760 3.52×10^{5} 47.57 1.57	1152	SF11	33	3	3	51.10	3.7×10^{-5}	0.74	1760	3.52×10^{5}	47.57	1.57
1152 SF11 33 3 5 51.39 4×10^{-6} 0.84 2132 4.264×10^{5} 50.76 1.91	1152	SF11	33	3	5	51.39	4×10^{-6}	0.84	2132	4.264×10^5	50.76	1.91

Table S2 Measured parameters- SPR angle, minimum reflectivity, FWTM, changes in differential GH shift, sensitivity, FoM and enhancement factor- at the optimal Au thickness along with different layers of graphene and WS₂ at different prisms and excitation wavelengths for the fixed RI change of Δn =0.005.

	Fixed Pa	ramete	ers		Measured Parameters						
۲ (uu)	Prism	d (nm)	Graphene (L)	WS ₂ (M)	θ _{SPR} (°)	R _{min}	FWTM	∆GHs (µm)	S (µm/RIU)	FoM (×10 ⁴)	Ē
532	BK7	31	2	1	81.0	6×10^{-6}	4.99	211	4.22×10^4	0.85	2.78
532	SF11	33	2	2	62.42	1×10^{-6}	5.82	496	9.92×10^{4}	1.7	1.43
632.8	SF5	39	2	3	65.17	4×10^{-6}	3.63	463	9.26×10^4	2.55	1.32
632.8	SF10	35	7	1	59.98	1×10^{-7}	3.49	1059	2.118×10^5	6.67	3.50
632.8	SF11	36	5	2	58.11	1×10^{-6}	3.51	1724	3.448×10^{5}	9.82	3.41
780	BK7	40	4	1	68.80	1×10^{-6}	1.95	1729	3.458×10^5	17.73	4.86
780	BK7	33	11	2	72.33	1×10^{-7}	4.49	870	1.74×10^5	3.88	2.44
780	BK7	43	1	2	69.14	9×10^{-6}	1.71	918	1.836×10^{5}	10.74	2.58
780	SF10	41	0	3	56.51	$3.1 imes 10^{-5}$	1.43	559	1.118×10^5	7.82	1.55
780	SF10	36	0	10	70.82	1×10^{-7}	8.51	652	1.304×10^{5}	1.53	1.81
780	SF10	38	4	1	55.73	1.5×10^{-5}	1.41	688	1.376×10^{5}	9.76	1.91
780	SF10	39	3	1	55.54	7×10^{-6}	1.25	1323	2.646×10^{5}	21.17	3.68
780	SF10	36	5	2	56.81	7×10^{-6}	2.08	665	1.33×10^{5}	6.39	1.85
780	SF10	30	12	3	60.16	1×10^{-7}	5.31	539	1.078×10^5	2.03	1.50
780	SF11	42	0	2	53.24	5×10^{-6}	1.00	813	1.626×10^{5}	16.26	1.97
780	SF11	41	0	3	54.0	1.6×10^{-5}	1.32	689	1.378×10^{5}	10.44	1.67
780	SF11	40	2	1	52.94	$1.3 imes 10^{-5}$	1.02	1345	2.69×10^{5}	26.37	3.25
780	SF11	30	12	2	56.14	1×10^{-7}	4.05	1613	3.226×10^{5}	7.97	3.91
780	SF11	38	3	2	53.85	4×10^{-6}	1.51	850	1.7×10^{5}	11.26	2.06
780	SF11	34	5	5	57.91	1×10^{-6}	4.25	873	1.746×10^{5}	4.11	2.11
1152	BK7	34	6	1	64.57	2×10^{-6}	1.21	2735	$5.47 imes 10^5$	45.21	1.61
1152	BK7	36	3	2	64.51	6×10^{-6}	1.03	2961	5.922×10^{5}	57.5	1.74
1152	SF5	36	0	3	55.59	$4.4 imes 10^{-5}$	0.70	1449	2.898×10^{5}	41.4	1.89
1152	SF5	33	4	1	55.55	1×10^{-6}	0.83	3035	6.07×10^5	73.13	3.96
1152	SF5	35	1	2	55.49	3×10^{-5}	0.70	1475	2.95×10^{5}	42.14	1.92
1152	SF5	30	8	3	56.46	4×10^{-6}	1.45	2726	5.452×10^{5}	37.6	3.56
1152	SF5	33	3	5	56.42	4×10^{-6}	1.18	2713	5.426×10^5	45.98	3.54
1152	SF11	33	3	1	50.89	9×10^{-6}	0.68	2264	4.528×10^{5}	66.59	2.02
1152	SF11	32	4	2	51.16	2.4×10^{-5}	0.82	1889	3.778×10^{5}	46.07	1.69







Fig. S3 Optimization the layer numbers of MS₂ to achieve large differential GH shift change with respect to the RI change of biomolecular samples for the four configurations.



Fig. S4 Differential GH shift *GHs* with respect to the RI change of biomolecular solutions for the configuration of monolayer WS₂ with four-layer graphene structured on 33 nm Au illuminated by 1152 nm coupled by SF5 prism.