

Article

An Optimized Graphene-Based SPR Biosensor for Detecting SARS-CoV-2

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Supplementary Figures

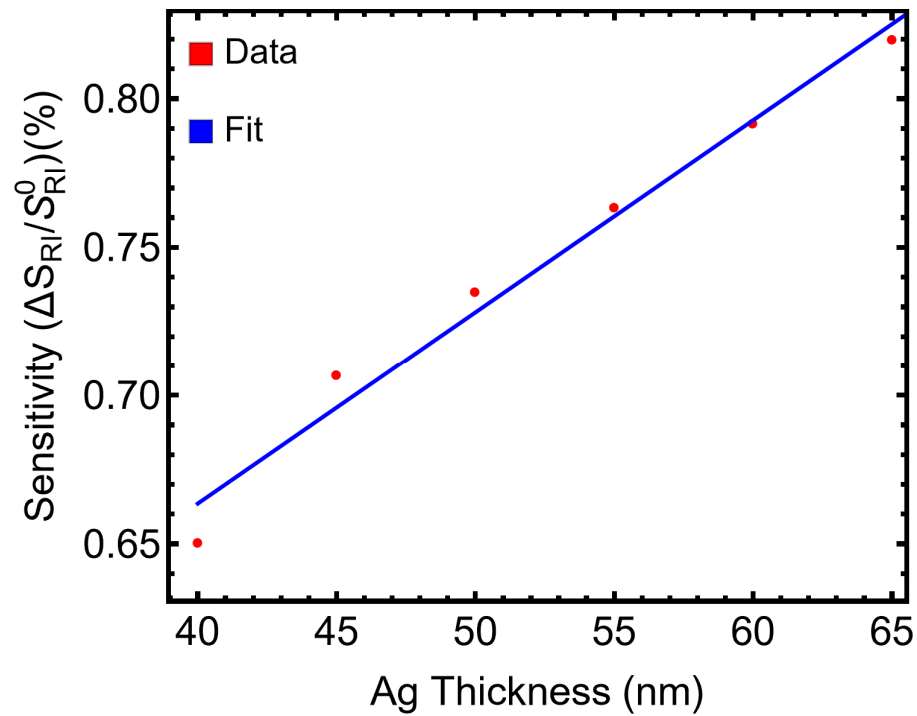


Figure S1. Ag thickness: Linear fit of the sensitivity enhancement data

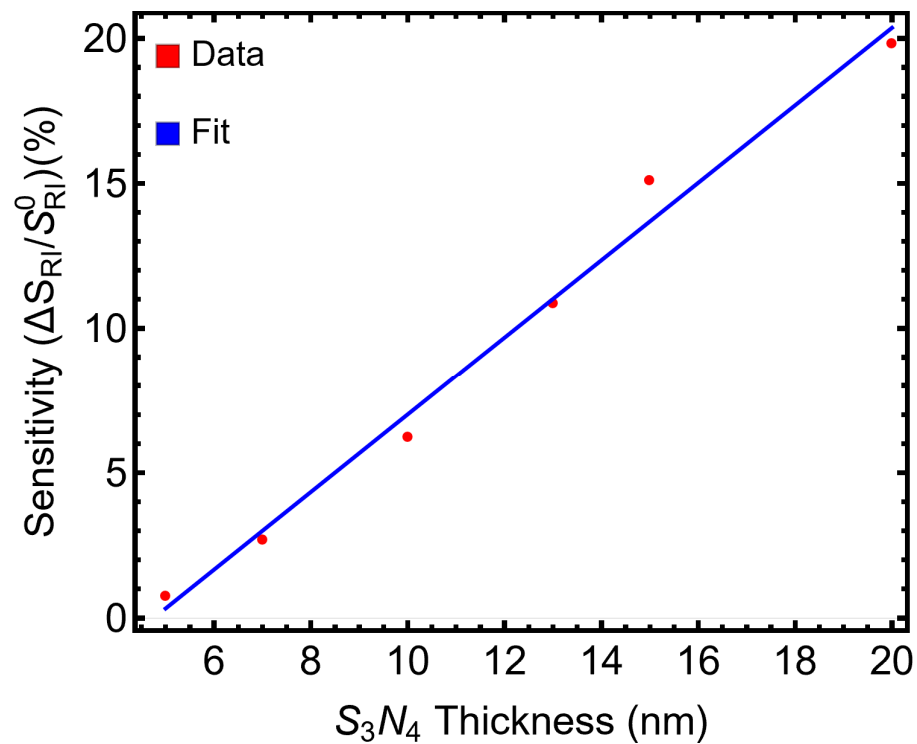


Figure S2. Silicon nitride thickness: Linear fit of the sensitivity enhancement data

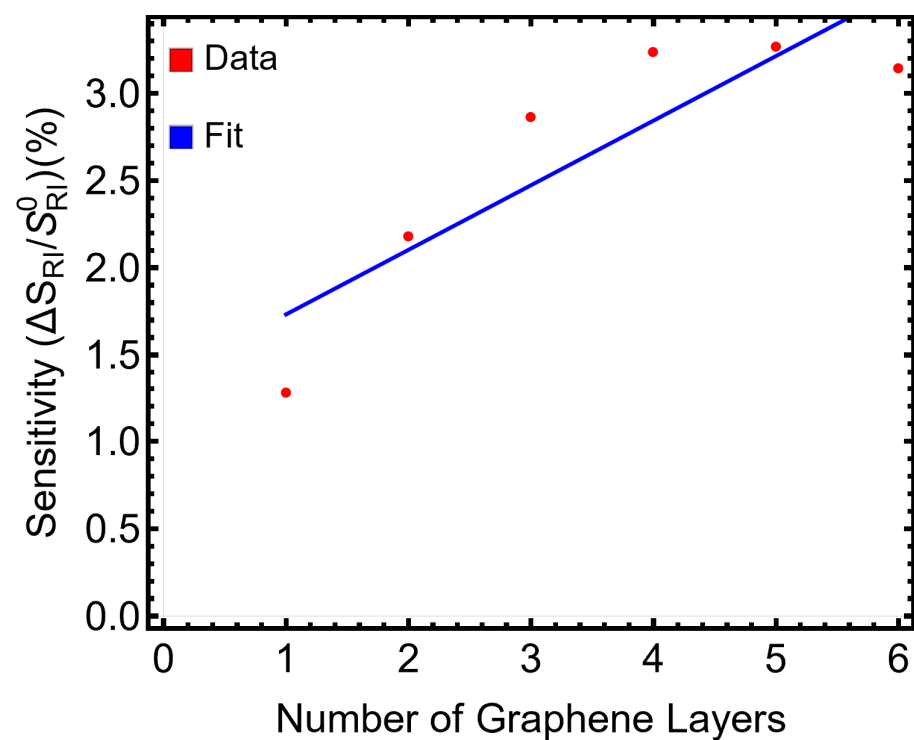


Figure S3. Graphene layers: Linear fit of the sensitivity enhancement data

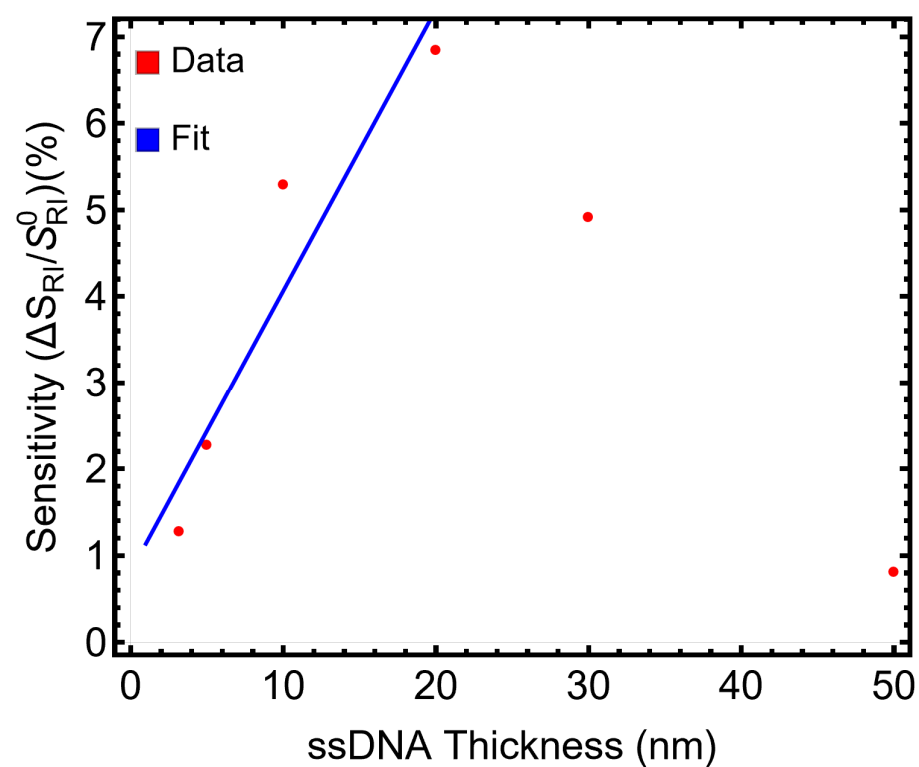


Figure S4. ssDNA layer: Linear fit of the sensitivity enhancement data

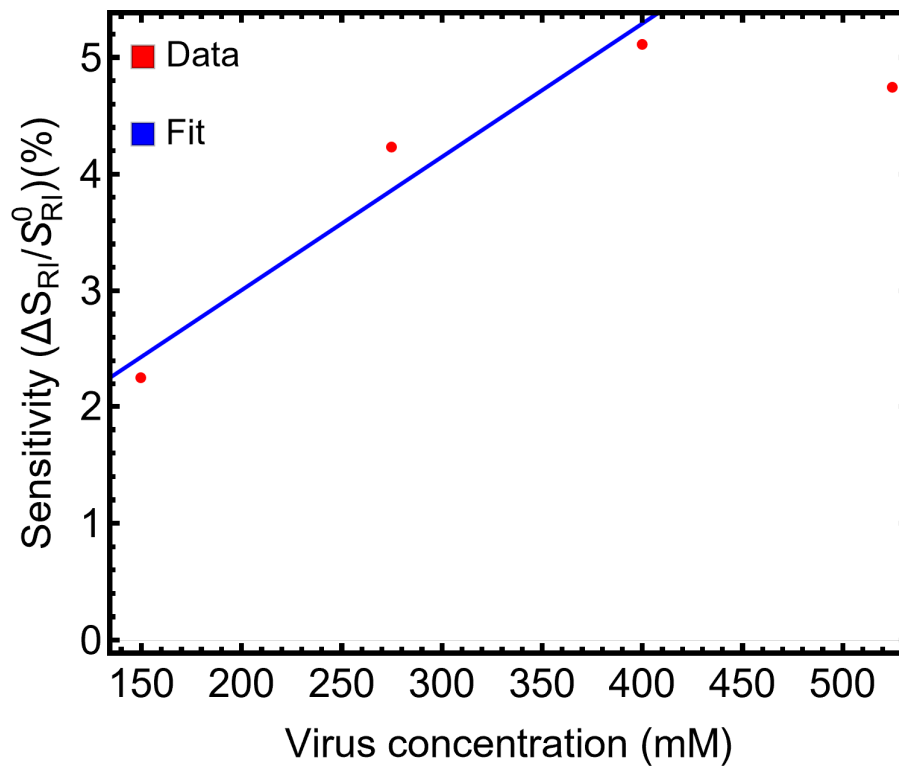


Figure S5. SARS-CoV-2: Linear fit of the sensitivity enhancement data

Supplementary Tables

Table S1. The configuration of the systems analyzed in this study

Sys No.	Code	Full Name	Nick Name
1	Sys ₀	Prism/Silver/Medium	P/Ag/M _{H₂O}
1	Sys ₁	Prism/Silver/Medium	P/Ag/M _{PBS}
2	Sys ₂	Prism/Silver/S ₃ N ₄ /Medium	P/Ag/SN/M _{PBS}
3	Sys ₃	Prism/Silver/S ₃ N ₄ /ssDNA/Medium	P/Ag/SN/T/M _{PBS}
4	Sys ₄	Prism/Silver/Graphene/Medium	P/Ag/G/M _{PBS}
5	Sys ₅	Prism/Silver/Graphene/ssDNA/Medium	P/Ag/G/T/M _{PBS}
6	Sys ₆	Prism/Silver/S ₃ N ₄ /Graphene/Medium	P/Ag/SN/G/M _{PBS}
7	Sys ₇	Prism/Silver/Graphene/S ₃ N ₄ /Medium	P/Ag/G/SN/M _{PBS}
8	Sys ₈	Prism/Silver/S ₃ N ₄ / Graphene/ssDNA/Medium	P/Ag/SN/G/T/M _{PBS}
9	Sys ₉	Prism/Silver/Graphene/S ₃ N ₄ /ssDNA/Medium	P/Ag/G/SN/T/M _{PBS}

Table S2. Initial parameters of the proposed SPR Biosensor for sensing SARS-CoV-2

Material	Refractive Index	Thickness (nm)	Ref.
BK-7 (P)	1.5151	---	[22]
Silver (Ag)	0.056253 + 4.2760 i	55.0	[23]
S ₃ N ₄ (SN)	2.0394	5.00	[24]
Graphene (G)	2.7611 + 1.6987 i	0.34	[25]
ssDNA (Thiol-Tethered, T)	1.462	3.20	[19]
Water (H ₂ O)	1.33	---	[19]
PBS (M)	1.334	---	[19]

Table S3. Metric values of proposed SPR Biosensors

Sys No.	Code	Attenuation (%)	FWHM	Sensitivity Enhancement (%)
0	Sys ₀	0.023	0.88	0
1	Sys ₁	0.023	0.90	0.68
2	Sys ₂	0.024	1.24	4.45
3	Sys ₃	0.022	1.31	5.19
4	Sys ₄	6.07	1.27	1.04
5	Sys ₅	6.10	1.34	1.60
6	Sys ₆	7.81	1.82	4.89
7	Sys ₇	6.46	1.76	4.92
8	Sys ₈	7.93	1.91	5.66
9	Sys ₉	6.59	1.85	5.69

Table S4. Metric values of Sys_s configuration by changing the silver thickness

Thickness (nm)	Attenuation (%)	FWHM	Enhancement (%)
40	13.65	3.56	0.65
45	2.52	2.76	0.71
50	0.43	2.24	0.74
55	7.93	1.91	0.76
60	22.17	1.72	0.79
65	38.87	1.64	0.82

Table S5. Metric values of Sys_s by changing the silicon nitride thickness

Thickness (nm)	Attenuation (%)	FWHM	Enhancement (%)
5	0.44	2.25	0.74
7	0.69	2.59	2.69
10	1.45	3.24	6.22
13	3.57	4.14	10.85
15	8.30	4.99	15.09
20	90.64	14.16	19.82

Table S6. Metric values of Sys_s by increasing the number of graphene layers

Layers	Attenuation (%)	FWHM	Enhancement (%)
L1	8.30	4.99	1.28
L2	24.45	6.43	2.18
L3	39.06	7.65	2.86
L4	50.74	8.68	3.23
L5	59.60	9.58	3.27
L6	66.15	13.8	3.14

Table S7. Metric values of Sys_s by changing the ssDNA thickness

Thickness (nm)	Attenuation %	FWHM	Enhancement (%)
3.2	8.30	4.99	1.28
5.0	10.34	5.20	2.27
10.0	22.10	5.91	5.29
20.0	80.48	9.29	6.84
30.0	93.32	18.27	4.91
50.0	96.93	53.86	0.81

Table S8. Optimized parameters of Sys_s and refractive index at different SARS-CoV-2 concentrations

Material	Refractive Index	Thickness (nm)
BK7 (P)	1.5151	---
Ag	0.056253 + 4.2760	50.0
S ₃ N ₄ (SN)	2.0394	15.0
Graphene (G)	2.7611 + 1.6987	0.34
ssDNA (Thiol-Tethered, T)	1.462	5.00
PBS (M)	1.334	---
SARS-CoV-2 in PBS	1.340 (150 mM) 1.345 (275 mM) 1.350 (400 mM) 1.355 (525 mM)	---

Table S9. Metric values of optimized Sys_s configuration after SARS-CoV-2 adsorption at different concentrations

Concentration (mM)	PBS + SARS-CoV-2	Enhancement (%)	Attenuation %	FWHM
150	1.340	2.25	18.11	5.64
275	1.345	4.23	33.01	6.14
400	1.350	5.11	58.92	7.01
525	1.355	4.74	78.47	8.62

Table S10. Performance metrics of optimized Sys_s configuration after the SARS-CoV-2 adsorption at different concentrations

Concentration (mM)	PBS + SARS-CoV-2	$\Delta\theta$	$S (^{\circ}/RIU)$	DA	QF (RIU ⁻¹)
150	1.340	1.85	308.33	0.33	54.66
275	1.345	3.48	315.91	0.57	51.42
400	1.350	4.2	262.50	0.60	37.45
525	1.355	3.9	185.71	0.45	21.55