Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Large-area grown ultrathin molybdenum oxide for label-free sensitive biomarker detection

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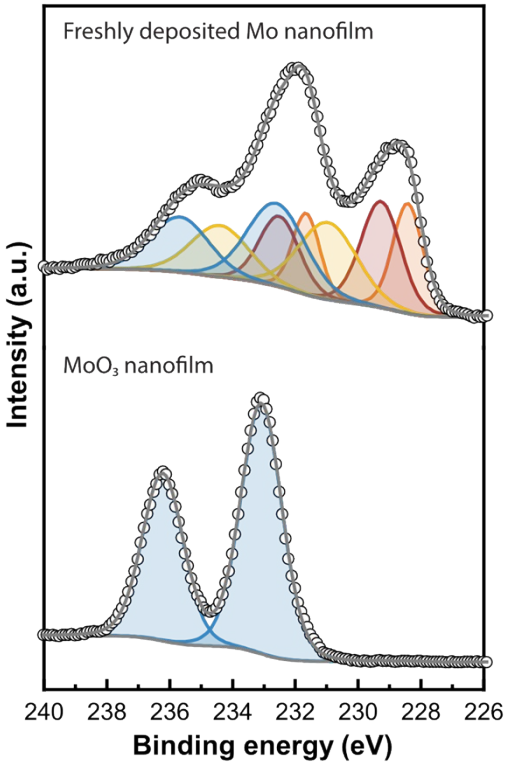

Figure S1. The XPS spectra of freshly deposited ultrathin Mo film (top) and MoO_3 nanofilm after oxidation process (bottom). The fitted molybdenum metal peaks (228.4 eV and 231.6 eV), Mo^{4+} peaks (229.2 eV and 232.4 eV), Mo^{5+} peaks (231.0 eV and 234.2 eV), and Mo^{6+} peaks (232.7 eV and 235.8 eV) are indicated in the graph.

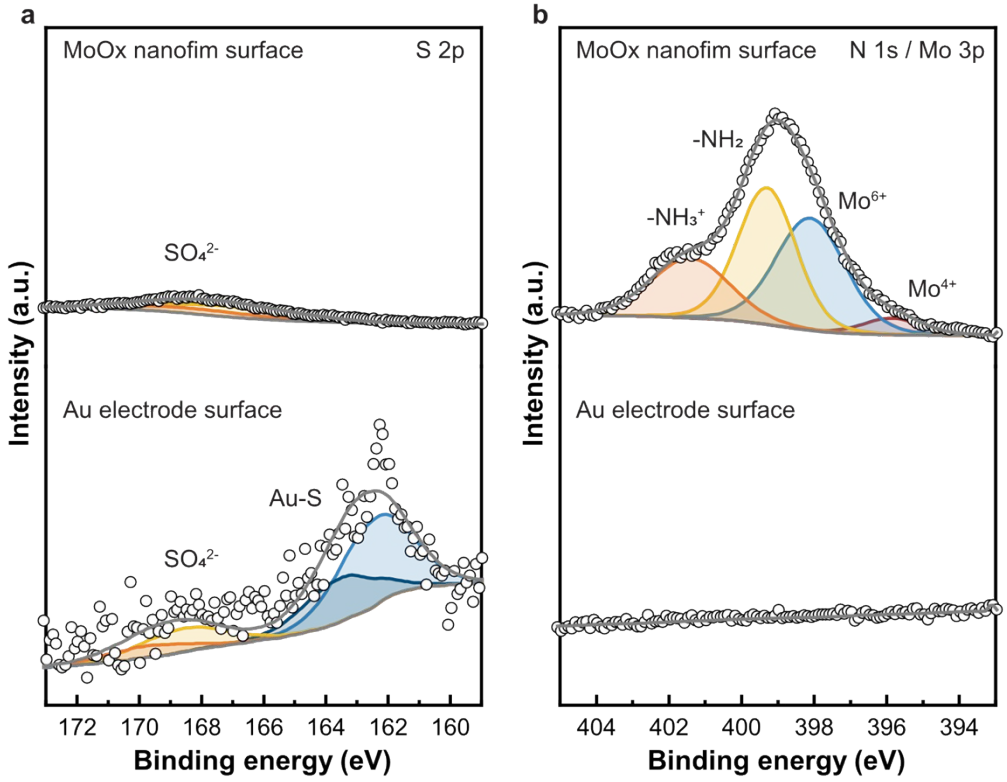

Figure S2. Comparation of high resolution XPS spectra of MoO_x nanofilm surface (top) and Au electrode surface (bottom) after functionalization with APTES for (a) N 1s; (b) S 2p. The low signal-to-noise ratio of S2p is due to the dual factors of sole S atom in each 1-Dodecanethiol molecule[1] and low concentration (10 mM) of 1-Dodecanethiol molecule incubated in ethanol solution [1, 2].

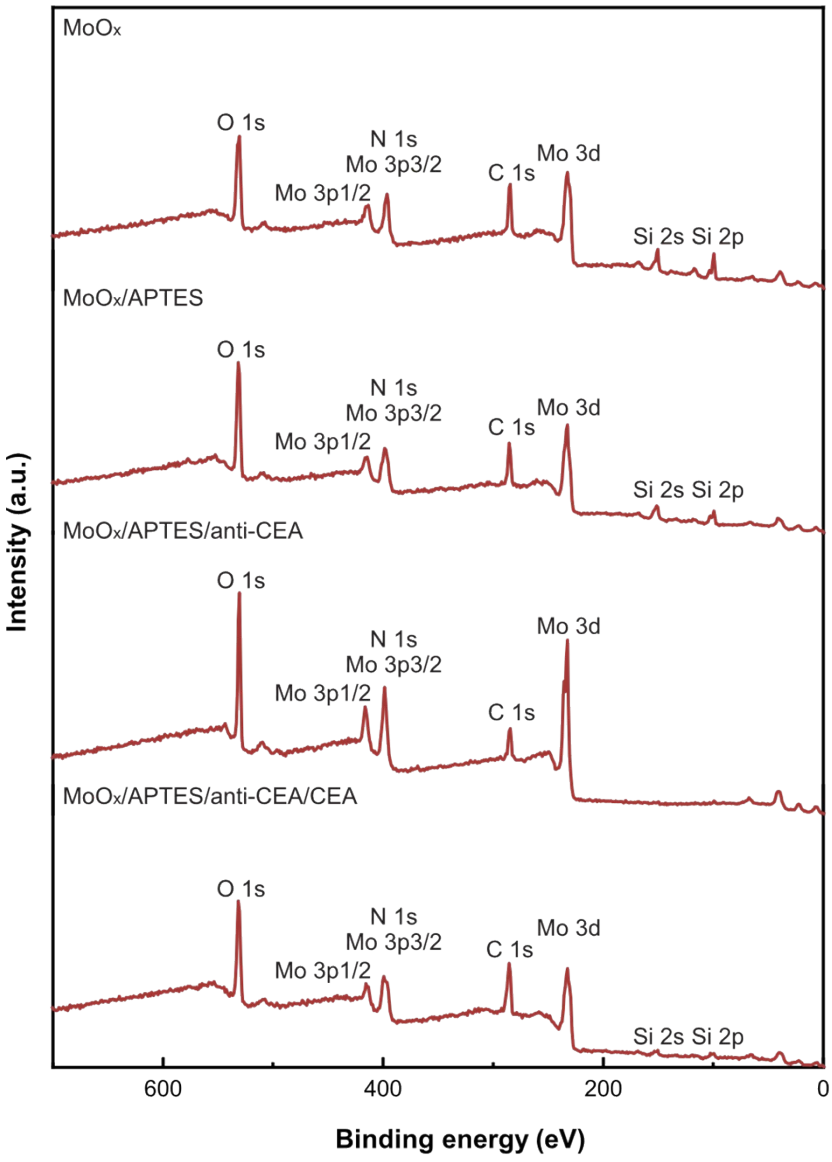

Figure S3. XPS survey for MoO_x, MoO_x/APTES, MoO_x/APTES/anti-CEA, and MoO_x/APTES/anti-CEA/CEA.

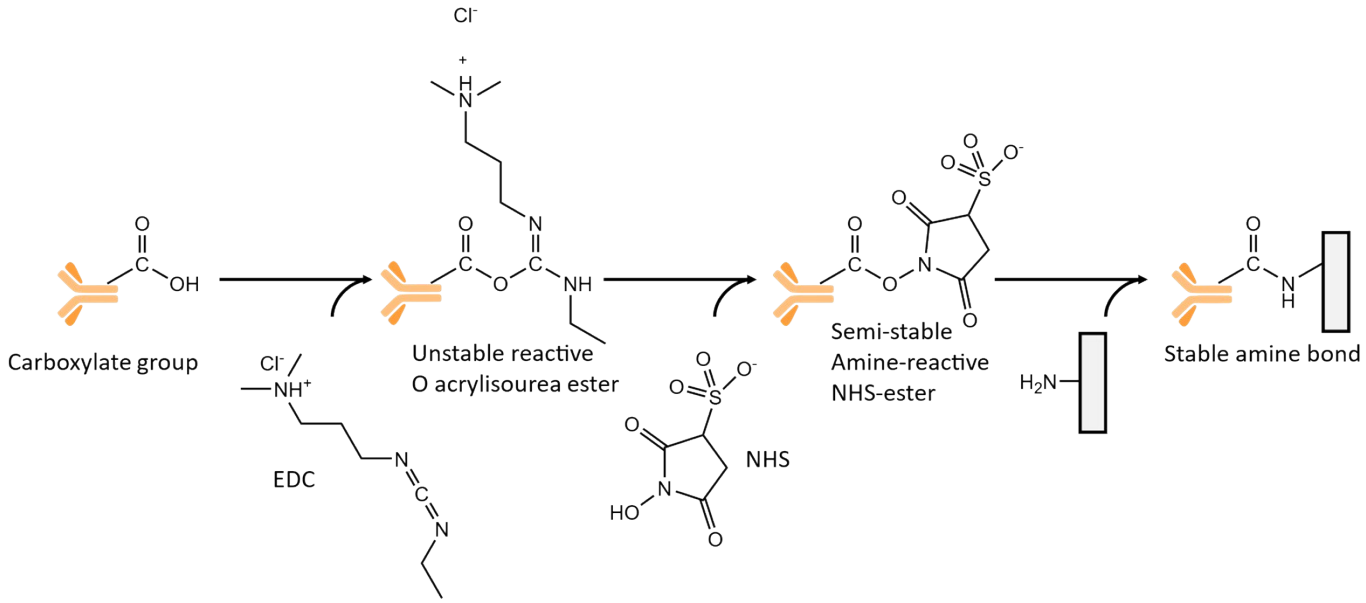

Figure S4. Immobilization of anti-CEA on an amine group functionalized surface mediated by EDC and NHS coupling.

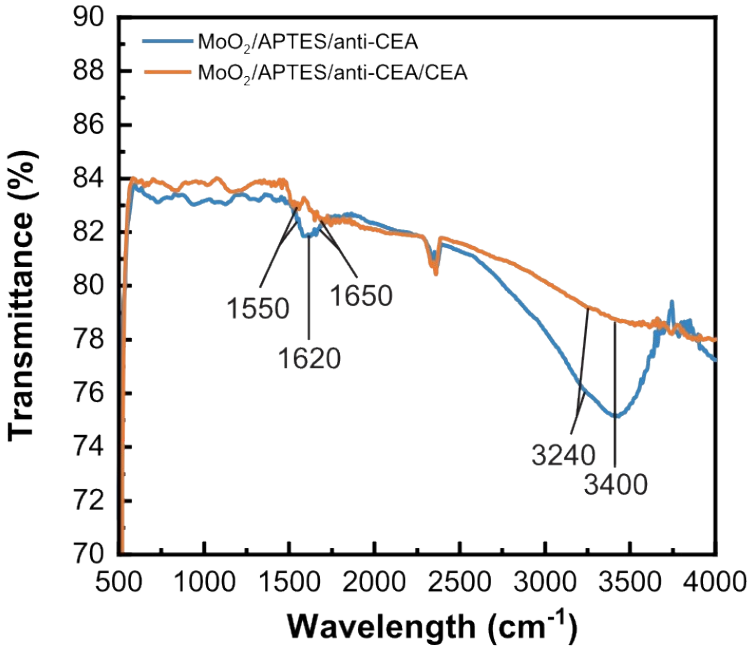

Figure S5. FTIR spectra of MoO_x/APTES/anti-CEA, and MoO_x/APTES/anti-CEA/CEA.

Table S1. Detailed composition of ultrathin MoO_x film in different functionalization stage calculated from the XPS

	Ref	MoO_x/APTES	MoO_x/APTES/anti-CEA	MoO_x/APTES/anti-CEA/CEA
Mo^{6+} [%]	16.55	25.83	12.94	11.01
Mo^{5+} [%]	28.64	21.77	24.55	25.12
Mo^{4+} [%]	54.80	52.4	62.52	63.87
x	2.31	2.37	2.25	2.24

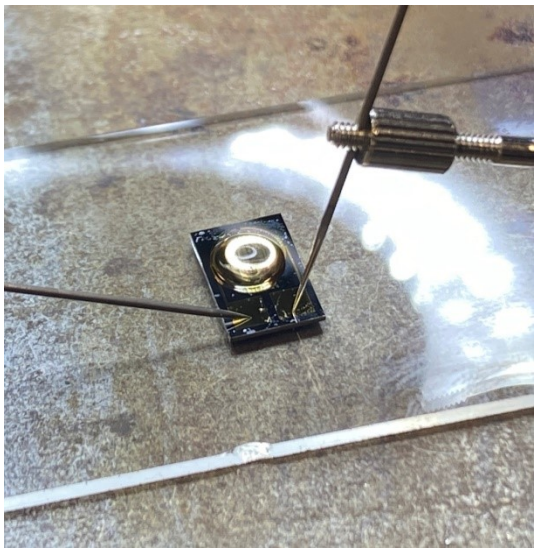

Figure S6. Electrical measurements on the developed MoO_x-IDE biosensing chip with output characteristic at a fixed 0.1 V source voltage.

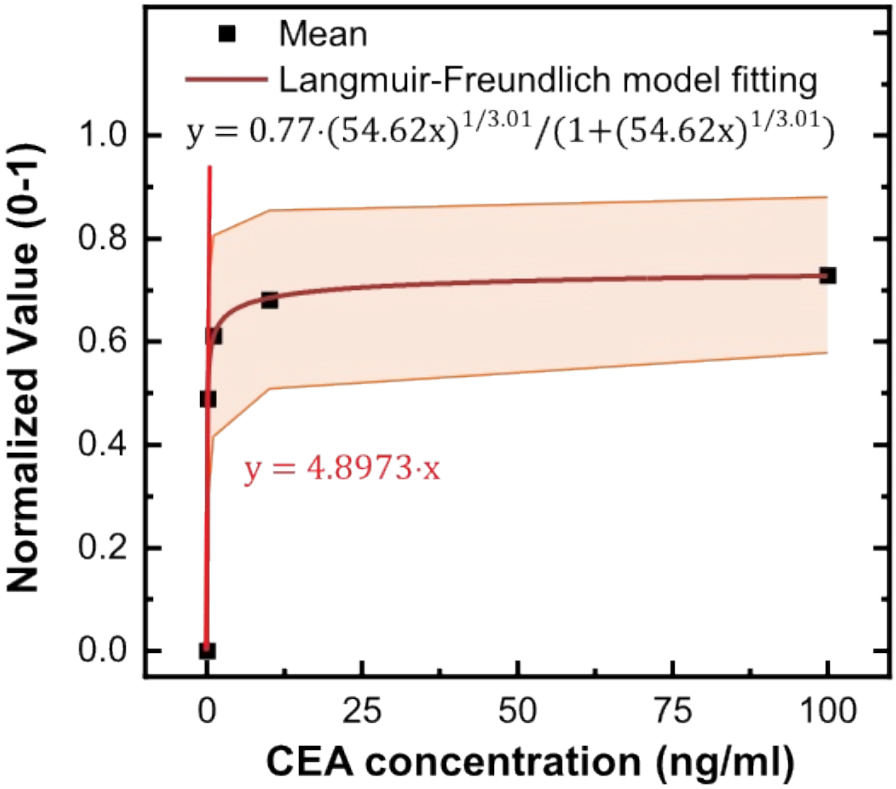

Figure S7. the slope of the linear region of the Langmuir-Freundlich model fitted curve.

Table S2. Comparisons of the sensing performance of developed electronic biosensing chip with other methods for the detection of CEA biomarker.

Device	Detection Type	Linear range (ng/ mL)	Detection limit (ng/ mL)	Reference
anti-CEA/ADA-COOH/APTES/SiO2/IDE	Labeled	0.1 - 1000	0.007	[3]
Si3N4/Au/IDE	Label-free	0.0001 - 10	0.0001	[4]
anti-CEA/PRY-NHS/Graphene/FET	Label-free	0.1 - 100	0.1	[5]
anti-CEA/denatured-BSA/Graphene/FET	Labeled	0.01 - 100	0.00034	[6]
anti-CEA/MoS2-Au/GCE	Labeled	0.001 - 50	0.00027	[7]
Anti-CEA/APTES/MoO_x/IDE	Label-free	0.1-100	0.015	This work

Reference

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