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Supplementary Information

Ultrasensitive Sensors Based on Aluminum Oxide-protected Reduced Graphene Oxide for Phosphate Ion Detection in Real Water

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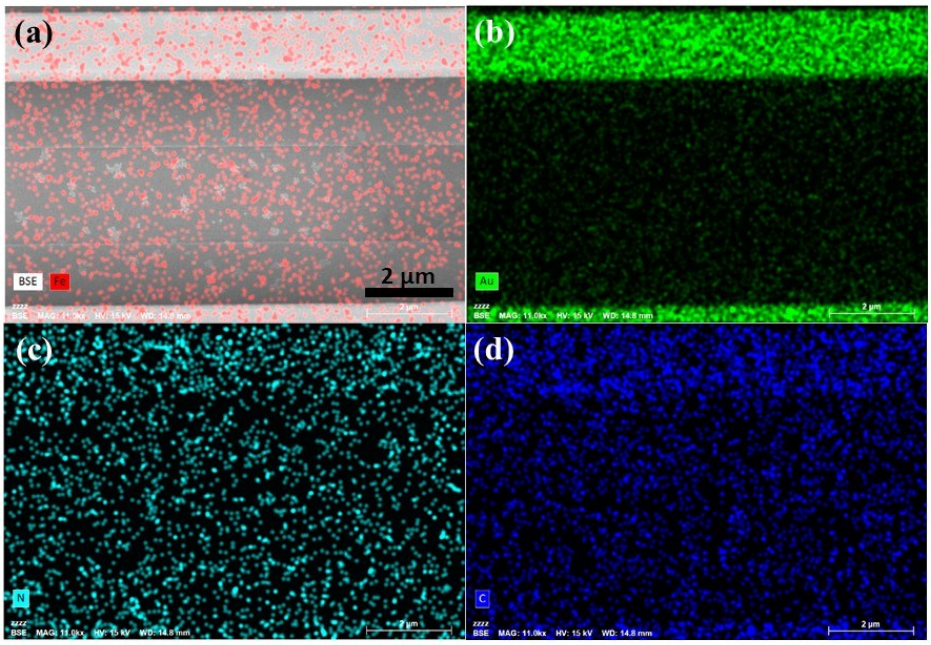


Figure S1. EDS mapping of a) Iron, b) Gold, c) Nitrogen, d) Carbon elements on the sensor surface.

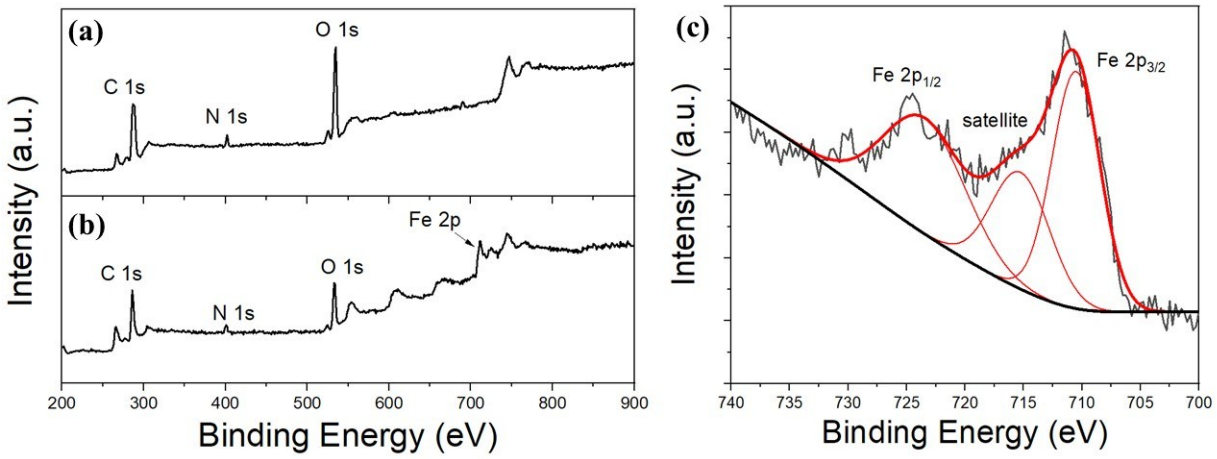


Figure S2. XPS spectra of the (a) as-prepared sample and (b) sample treated in Ar plasma. (c) High resolution XPS spectra of the Fe 2p level. The spectrum acquired before the etching process (a) indicates typical peaks for C 1s, N 1s and O 1s core levels. After plasma treatment (b), the Fe inside the ferritin was exposed. The visible emissions from Fe $2p_{3/2}$ (710.5 eV), Fe $2p_{3/2}$ (715.3 eV) ,and Fe $2p/_{1/2}$ (723.5 eV) are more evident.

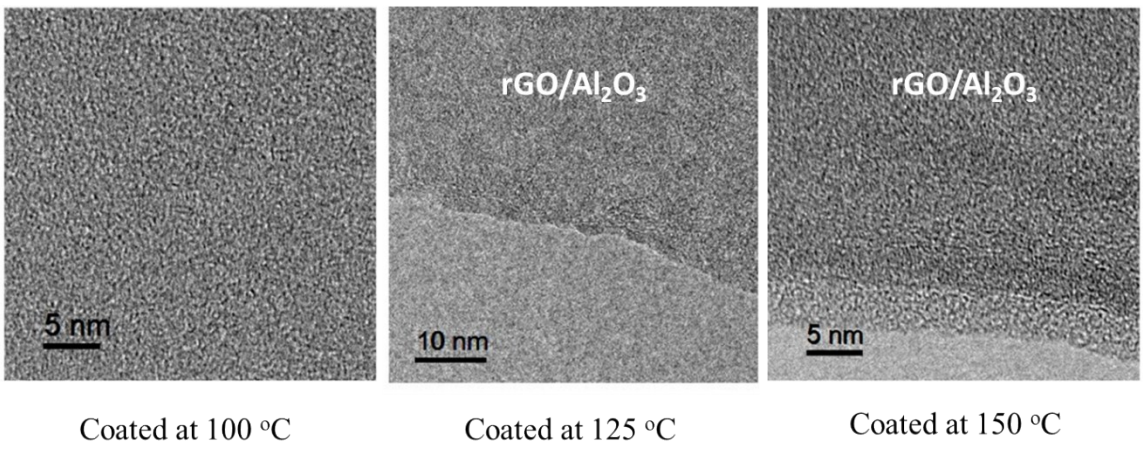
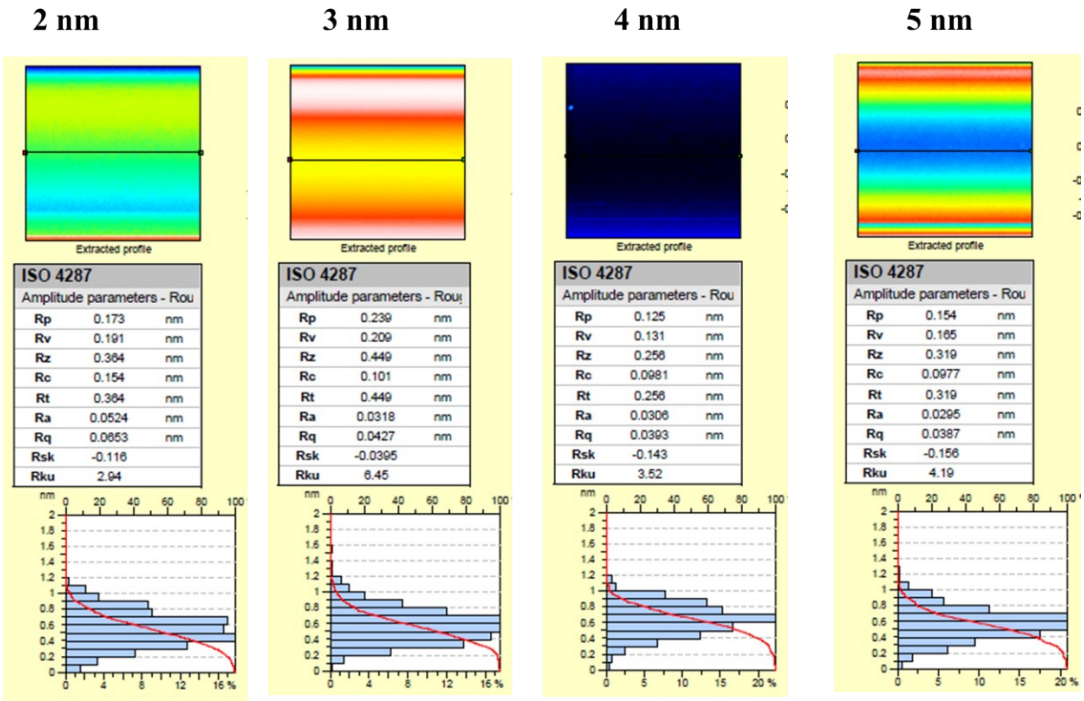


Figure S3. TEM images of 2nm Al_2O_3 film deposited on the rGO layer at 100 °C, 125 °C and 150 °C.

Table S1. Arithmetic mean deviation of roughness profile (Ra) of 2 nm Al_2O_3 film deposited on the rGO layer at 100 °C and 125 °C

Temperature	150 °C	125 °C	100 °C
Ra (nm)	0.435	0.062	0.246



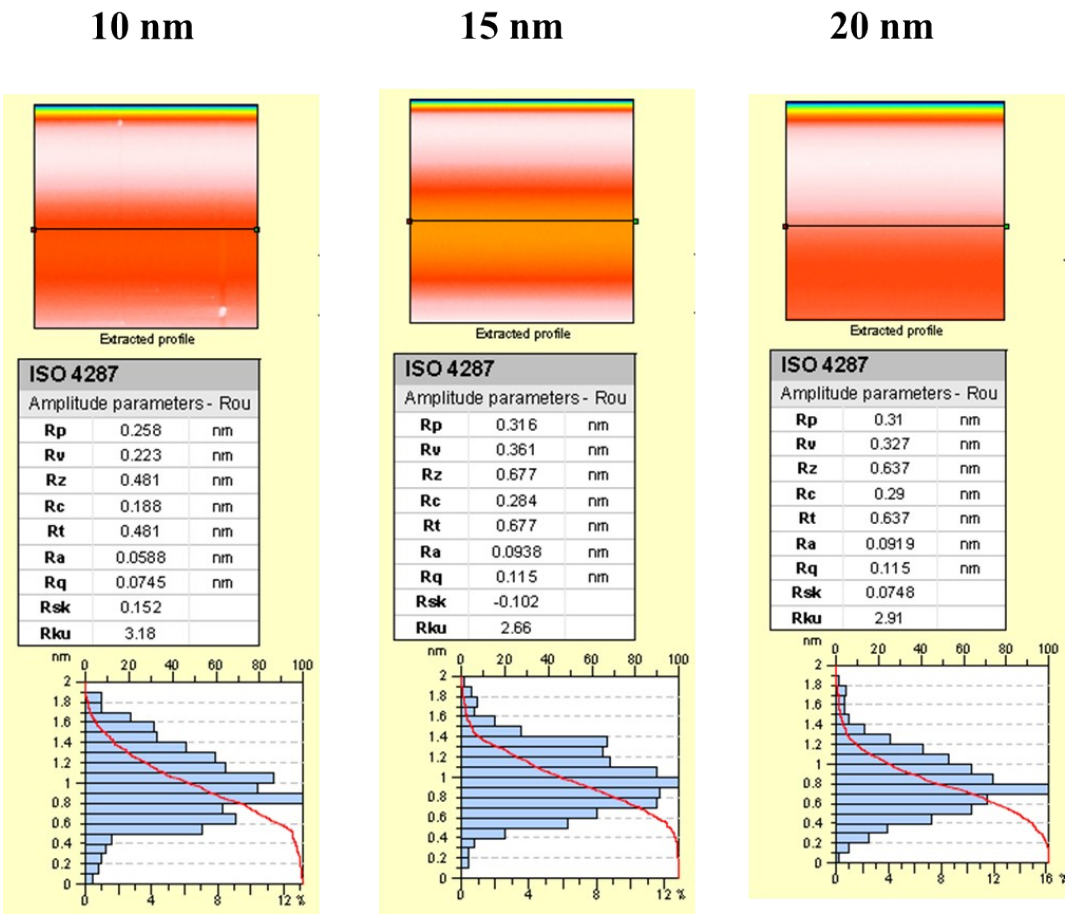


Figure S4. Roughness profiles of ALD processed Al_2O_3 films with thicknesses ranging from 2 nm to 20 nm.

Here, based on the standard ISO 4287 [F. Blateyron, Profile Parameters, https://guide.digitalsurf.com/en/guide-profile-parameters.html]

Rp: Maximum Peak Height of the roughness profile;
Rv: Maximum Valley Depth of the roughness profile;
Rz: Maximum Height of roughness profile;
Rc: Mean Height of the roughness profile elements;
Rt: Total Height of roughness profile;
Ra: Arithmetic Mean Deviation of the roughness profile;
Rq: Root-Mean-Square (RMS) Deviation of the roughness profile;
Rsk: Skewness of the roughness profile;
and Rku: Kurtrosis of the roughness profile, i.e., sharpness of the height distribution, defined on the sampling length.

Table S2: The roughness profile of ALD Al2O3 films of various thicknesses

Thickness	2 nm	3 nm	4 nm	5 nm	10 nm	15 nm	20 nm
Rp (nm)	0.173	0.239	0.125	0.154	0.258	0.316	0.31
Rv (nm)	0.191	0.209	0.131	0.165	0.223	0.361	0.327
Rz (nm)	0.364	0.449	0.256	0.319	0.481	0.677	0.637
Rc (nm)	0.154	0.101	0.0981	0.0977	0.188	0.284	0.29
Rt (nm)	0.364	0.449	0.256	0.319	0.481	0.677	0.637
Ra (nm)	0.0524	0.0318	0.0306	0.0295	0.0588	0.0938	0.0919
Rq (nm)	0.0653	0.0427	0.0393	0.0387	0.0745	0.115	0.115
Rsk	0.116	0.0395	0.143	0.156	0.152	0.102	0.0748
Rku	2.94	6.45	3.52	4.19	3.18	2.66	2.91

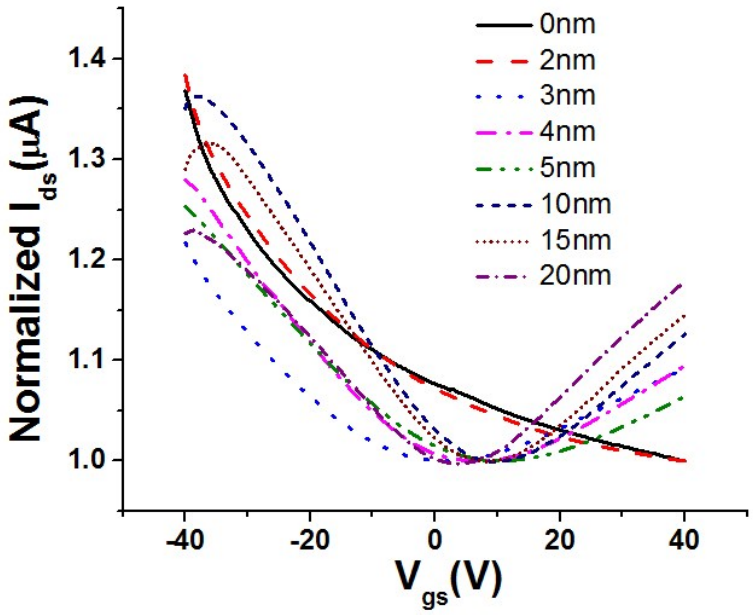


Figure S5. Semiconducting property of the FET sensor with an ALD Al_2O_3 film of various thicknesses.