Supporting Information for

An observation of physisorption in high–performance FET–type oxygen gas sensor operating at room temperature

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ESI Fig. S1. Key fabrication process steps of FET-type sensor.
**ESI Fig. S2.** Characterization of the sensing material. (a) SEM micrograph (×100 k) and (b) EDS spectrum of the 1 wt% Pt–In$_2$O$_3$ nanoparticles.
ESI Fig. S3. Schematic of the gas measurement system.
ESI Fig. S4. Equivalent circuit of FET-type sensor. (a) Cross-sectional schematic view cut along channel width direction. (b) Equivalent circuit of the device cut along A–A’ in (a). $R_C$ and $R_s$ represent the resistances of the contact and sensing layer, respectively. $C_s$, $C_{pass}$, $C_p$, and $C_{FG}$ denote the sensing layer capacitance, the capacitance between the sensing layer and the FG, the parasitic capacitance between the FG and the Si substrate, and the capacitance between the FG and the Si channel, respectively. Here, the overlap and fringing capacitances between the FG and the source/drain are ignored because they are too small.
### Coupling ratio ($\gamma$)

| $\frac{(C_s/C_{\text{pass}})}{(C_s/C_{\text{pass}}) + C_p + C_{\text{FG}}}$ |

### Drain current ($I_D$)

- **(subthreshold)**
  \[
  -\mu C_{\text{FG}} \frac{W}{L} \frac{qN_d}{4\phi_B} \left( \frac{kT}{q} \right)^{\frac{q}{2}} e^{-\frac{q}{2kT}(V_{\text{GS}} - V_{\text{th}})}
  \]

- **(Linear)**
  \[
  \mu C_{\text{FG}} \frac{W}{L} \left( |V_{\text{GS}} - V_{\text{th}}| + \frac{1}{2} V_{DS} \right) V_{DS}
  \]

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**ESI Table S1.** Formula of coupling ratio ($\gamma$) and drain current ($I_D$) in our FET-type sensor. Here, the effects of $R_c \ll 1$ and $R_s \gg 1$ in Supplementary Fig. 1(b) are ignored. In order to ensure high sensitivity, $\gamma$ needs to be close to 1, which indicates that $C_s/C_{\text{pass}}$ should be much larger than $C_p + C_{\text{FG}}$. Because the CG and FG have an interdigitated pattern, the $\gamma$ value of the platform sensor is generally higher than that of a conventional gas sensor having an air gap between the CG and the FG.
ESI Fig. S5. Humidity sensing characteristics in fabricated FET-type sensor. (a) Humidity responses of 1 wt% Pt-In$_2$O$_3$ FET-type sensor with relative humidity (RH) changed from 17.5 RH% to 78.0 RH% at room temperature (25 °C). $V_{GS}$ - $V_{th}$ is set to 0.3 V at $V_{DS} = -0.1$ V. (b) Humidity response versus RH%. As the RH% increases to 78.0 RH%, H$_2$O molecules act as an electron donor, and then work-function of the In$_2$O$_3$ layer decreases. As a result, $|I_d|$ decreases, resulting in decreasing response.
ESI Fig. S6. Stability of the fabricated FET-type sensor. (a) Transfer ($I_D-V_{CG}$) curves and (b) Transient responses to 20% and 30% $O_2$ gas measured after 5 months (red line) at 25 °C, compared to the reference (black line). After 5 months, the transfer curve in (a) shifts to the right and the off-current in (a) is increased by about 1 order. As a result, the reference $I_D$ level is changed (~ 1.55 μA), but there is not meaningful difference in the $O_2$ sensing characteristics.
ESI Fig. S7. $V_{th}$ change of FET-type sensor with temperature ($T$) change in O$_2$ ambience. (a) Transfer ($I_D$–$V_{CG}$) curves measured by applying $V_{CG}$ pulses and (b) $V_{th}$ changes for fabricated FET-type sensor in pure N$_2$ and 30% O$_2$ ambience as a parameter of $T$. At 25 °C, the transfer curve is shifted to the left when the chamber environment is changed from pure N$_2$ to 30% O$_2$. At 200 °C, on the other hand, the transfer curve is shifted to the right. These results demonstrate that $T$ determines the dominance between the two sensing mechanisms, i.e., physisorption and chemisorption.
ESI Fig. 5S. Pulse scheme to apply pre-bias to FET-type sensor. Control-gate and drain are biased by pulse generator, and source is grounded. Red line represents a series of pulses applied to the CG and drain. The pre-bias time ($t_{pb}$) and read pulse width ($t_{read}$) are fixed to 5 s and 500 μs, respectively.
**ESI Fig. S9.** SEM image of the resistor-type sensor. The sensing layer prepared by inkjet-printing is indicated by a dash-dot line.
ESI Fig. S10. Responses of the fabricated sensor to the eight target gases (O₂, H₂, NO₂, H₂S, CO, CO₂, NH₃, and CH₄) at 25 °C in 10 wt% Pt–In₂O₃ sensor. The measurements are carried out in dry ambience.