Supporting Information

Synergistic Improvement of Sensing Performance in Ferroelectric-Based Gas Sensors Using Remnant Polarization

Wonjun Shin, Jiyong Yim, Jong-Ho Bae, Jung-Kyu Lee, Jaehyeon Kim, Seongbin Hong, Yujeong Jeong, Dongseok Kwon, Gyuweon Jung, Changhyeon Han, Jeonghan Kim, Byung-Gook Park, Daewoong Kwon*, and Jong-Ho Lee*

Department of Electrical and Computer Engineering and Inter-University Semiconductor Research Center (ISRC), Seoul National University, Seoul 08826, Korea
E-mail: jhl@snu.ac.kr

J. Yim, C. Han, J. Kim, D. Kwon
Department of Electrical Engineering, Inha University, Incheon, Korea.
E-mail: dw79kwon@inha.ac.kr

J. H. Bae
School of Electrical Engineering, Kookmin University, Seoul 02707, Korea
Figure S1. Fabrication process flow of the IGZO FeTFT gas sensors. (a) Wafer cleaning. (b) TiO$_2$ deposition. (c) HZO deposition. (d) Post-deposition annealing (PDA). (e) IGZO deposition. (f) IGZO annealing. (g) IGZO patterning. (h) Source/drain metal formation.

Figure S2. (a) X-ray diffractograms and (b) EDS line scan of the IGZO film.
Figure S3. Devic-to-device variation of the fabricated FeTFT gas sensors. Transfer characteristics ($I_D-V_{BG}$) are measured at 10 independent samples of the FeTFT gas sensors. The $V_{GS}$ is double-swept from -4.0 V to 9.0 V with a drain voltage of 1.0 V.

Figure S4. Schematic diagrams of gas sensing measurement system. Gas sensing characteristics of the sensors are analyzed by using a semiconductor parameter analyzer (B1500A) and the probe station that contains a test chamber, chuck, gas inlet, and outlet. NO$_2$ gas is used as a target gas and gas flow is controlled by a mass flow controller (MFC). The operating temperature of the sensing material in the sensor is set to 150 °C by an external heater. The target gas is mixed with dry air with a relative humidity of 4% for controlling the gas concentration and then the gas is injected into the test chamber.
Figure S5. Drain, source, and gate currents versus $V_{BG}$ of the reference TFT gas sensor measured at 20 °C.

Figure S6. Response of the FeTFT gas sensor to NO$_2$, SO$_2$, H$_2$S, NH$_3$, EtOH, and CO gases (NO$_2$ 500 ppb, H$_2$S 100 ppm, H$_2$S 100 ppm, NH$_3$ 125 ppm, EtOH 500 ppm, and CO 1000 ppm).
Figure S7. Response of the FeTFT gas sensor to 50 ppb of NO$_2$ gas over time as a parameter of $V_{\text{PGM}}$. The response is measured under different $V_{\text{PGM}}$s at 150 °C for 30 days. The sensor shows a slight decrease in the response after 30 days. Further research is required to determine the exact mechanism of such degradation.
Table S1. Comparison of this work with previous NO\textsubscript{2} gas sensors.

<table>
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<tr>
<th>Sensing material</th>
<th>Sensor platform</th>
<th>Response to NO\textsubscript{2} 500 ppb</th>
<th>Operating temperature</th>
<th>Tunability</th>
<th>Ref.</th>
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References


