Supplementary Information

Water adsorption effects of nitrate ion coordinated Al₂O₃ dielectric for high performance metal-oxide thin-film transistor

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Figure S1.

(a) $2(\text{Al(NO}_3\text{)}_3\cdot9\text{H}_2\text{O}) + \text{C}_3\text{H}_8\text{O}_2$

(b) $\rightarrow 2\text{Al}^{3+} + 6\text{NO}_3^- + 18\text{H}_2\text{O} + \text{C}_3\text{H}_8\text{O}_2$

(c) $\rightarrow 2\text{Al}^{3+} + \text{H}_2\text{O}_2 + 6\text{NO}_3^- + \text{C}_3\text{H}_8\text{O}_2 + 18\text{H}_2\text{O}$

(d) $\xrightarrow{350\,^\circ\text{C}} \text{Al}_2\text{O}_3 + 4\text{NO}_3^- + 21\text{H}_2\text{O}(\text{g}) + 3\text{CO}_2(\text{g}) + \text{N}_2(\text{g}) + \text{H}_2(\text{g})$

(e) $\xrightarrow{500\,^\circ\text{C}} \text{Al}_2\text{O}_3 + 2\text{N}_2(\text{g}) + 6\text{O}_2(\text{g})$

Figure S1. Schematic descriptions and the analyses of the formation of ionic Al$_2$O$_3$ dielectric.

(a) The aluminum nitrate hexahydrate (Al(NO$_3$)$_3$·9H$_2$O) was resolved in methoxyethanol (C$_3$H$_8$O$_2$). (b) The hydrogen peroxide (H$_2$O$_2$) was added to Al$_2$O$_3$ precursor solution for suppression of oxygen vacancy. (c) When the Al$_2$O$_3$ precursor solution was annealed at 350 °C, the Al$_2$O$_3$ was formed with a small amount of nitrate ions (NO$_3^-$). (d) When the ion embedded Al$_2$O$_3$ was annealed over 500 °C, the embedded ions were completely decomposed.
Figure S2. The XPS depth profile of 500 °C annealed Al₂O₃ film. The insets indicate N 1s and C 1s peaks.
**Figure S3.**

(a) The 10 times coated ionic amorphous Al$_2$O$_3$ layer was fabricated on the heavily boron doped Si wafer and (b) the thickness of amorphous ionic Al$_2$O$_3$ layer was 242.57 nm.
Figure S4. Leakage current density of (a) 350 °C and (b) 500 °C annealed amorphous Al$_2$O$_3$ dielectric with thickness of 242nm and 200nm, respectively. Their values are $4.1 \times 10^{-6}$A/cm$^2$ and $4.6 \times 10^{-9}$A/cm$^2$ at 1MV/cm, respectively.
Figure S5. The transmittance of ionic amorphous Al$_2$O$_3$ dielectric layers on quartz glass under UV-visible range photons (200 nm ~ 700 nm).
Figure S6. (a) Output curve of TFTs consisted of 350 °C annealed Li-ZnO semiconductor film on 500 °C annealed Al₂O₃ dielectric layer with the sweep of 10 V steps on gate voltage from 0 V to 50 V. (b) Transfer curve of Li-ZnO/Al₂O₃ TFT with drain current of 30V. (c) Clockwise hysteresis of Li-ZnO/Al₂O₃ TFT. (d) Output curve of 350 °C annealed In-ZnO on 500 °C annealed Al₂O₃ dielectric layer with sweep of 10 V steps on gate voltage from 0 V to 50 V. (e) Transfer curve of In-ZnO/Al₂O₃ TFT with drain current of 30 V. (f) Clockwise hysteresis of In-ZnO/Al₂O₃ TFT.
Figure S7. Frequency vs capacitance of 500 °C annealed Al₂O₃ dielectric layer with thickness of 215 nm.