Supporting Information for

Synergistic Combination of Amorphous Indium Oxide with Tantalum Pentoxide for Efficient Electron Transport in Low-Power Electronics

Song Yi Park\textsuperscript{a}, Jungwoo Heo\textsuperscript{b}, Yung Jin Yoon\textsuperscript{a}, Jae Won Kim\textsuperscript{a}, Hyungsu Jang\textsuperscript{a}, Bright Walker\textsuperscript{c} and Jin Young Kim\textsuperscript{a,b}

\textsuperscript{a}Department of Energy Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan 44919, South Korea.

\textsuperscript{b}Department of Physics, Ulsan National Institute of Science and Technology (UNIST), Ulsan 44919, South Korea. E-mail: jykim@unist.ac.kr

\textsuperscript{c}Department of Chemistry, Kyung Hee University, Seoul 02447, South Korea. E-mail: walker@khu.ac.kr
**Fig. S1.** O1s depth profile of (a) Ta$_2$O$_5$/In$_2$O$_3$ thin film stack and (b) SiO$_2$/In$_2$O$_3$ thin film stack in which the In$_2$O$_3$ layer was annealed at 300 °C for 5 minutes and 1 hour, respectively.
**Fig. S2.** Ultraviolet photoelectron spectra (UPS) of In$_2$O$_3$ and Ta$_2$O$_5$ thin films prepared on ITO substrates ($E_{WF} = 4.7$ eV).

**Fig. S3.** XRD patterns corresponding to the sample stage and an Si/SiO$_2$ substrate.
Fig. S4. Contact angles of 2-methoxyethanol droplets on dielectric (SiO₂ and Ta₂O₅) surfaces.

Fig. S5. Contact angles of water droplets on dielectric (SiO₂ and Ta₂O₅) surfaces.
Fig. S6. High-magnification, cross-sectional TEM images of (a) SiO$_2$/In$_2$O$_3$ and (b) Ta$_2$O$_5$/In$_2$O$_3$ samples annealed for 60 minutes at 300 °C.

Fig. S7. Energy-dispersive X-ray spectroscopy (EDS) line profiles of (a) SiO$_2$/In$_2$O$_3$ and (b) Ta$_2$O$_5$/In$_2$O$_3$ samples. Background images are corresponding scanning TEM (STEM) images.
Fig. S8. Capacitance density – frequency (C-f) curve of Ta$_2$O$_5$ dielectric layer
**Fig. S9.** XPS spectra for In$_2$O$_3$ films for In 3d and O 1s with various annealing time.

**Fig. 10.** AFM topographical images for Ta$_2$O$_5$/In$_2$O$_3$ films with different annealing time.
Fig. S11. (a) Transfer curves of In$_2$O$_3$ TFTs with different dielectric; SiO$_2$ and SiO$_2$/Ta$_2$O$_5$. Both devices were fabricated with annealing at 300 °C for 5 minutes, to avoid damage of Ta$_2$O$_5$ layer during annealing process. (b) Capacitance – frequency curves for SiO$_2$ and SiO$_2$/Ta$_2$O$_5$. (c, d) Hysteresis curves for SiO$_2$ and SiO$_2$/Ta$_2$O$_5$ devices, respectively.
Fig. S12. Transconductance, $g_m$ versus $V_{GS}$ of two devices. The values were acquired from the curves shown in Fig. 4a and 4c. Shaded area indicates the region where field effect mobilities of the devices are constant.
Fig. S13. (a) Transfer, (b) output and (c) gate leakage current characteristics of Ta$_2$O$_5$/In$_2$O$_3$ TFTs annealed for various lengths of time.
Fig. S14. Hysteresis characteristics for (a) SiO$_2$/In$_2$O$_3$ and (b) Ta$_2$O$_5$/In$_2$O$_3$ TFTs.