Supporting Information

All-sputtered, flexible, bottom-gate IGZO/Al_2O_3 bi-layer thin film transistors on PEN fabricated by fully room temperature process

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BF-STEM image and EDS mapping scan of channel region.

From the BF-STEM and EDS results in Figure S1, an ultrathin Al_2O_3 layer upon IGZO can be significantly observed and proved by the distribution of Al element. Meanwhile, uniform distribution of In, Ga, Zn elements were also obtained in the IGZO layer without obvious aggregation.

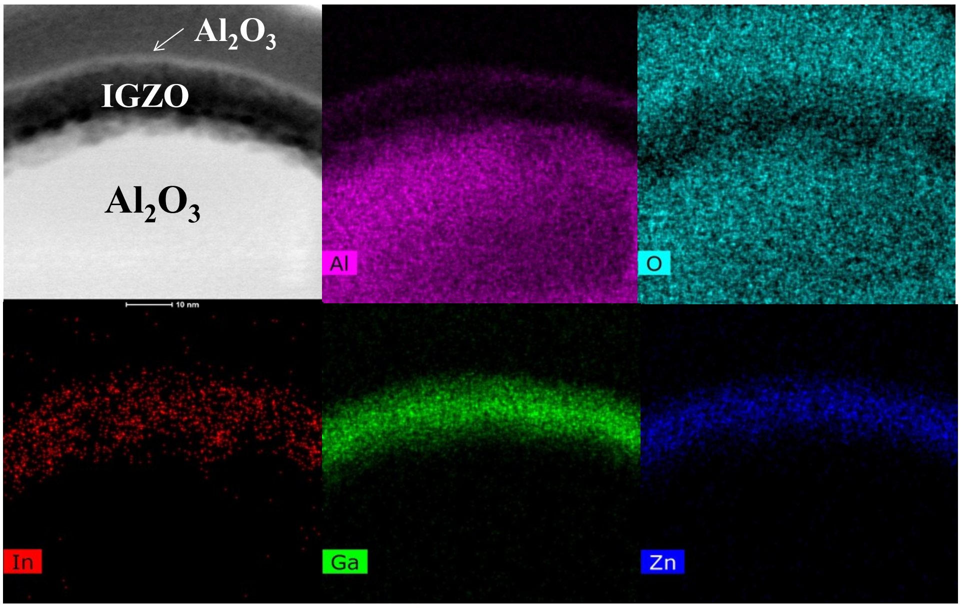

Fig. S1 EDS mapping scan for the channel region of IGZO/Al_2O_3 bi-layer TFT.

Atomic ratio of In, Ga, Zn obtained by XPS measurements.

The atomic ratio of In, Ga, Zn in 50-nm-thick IGZO films on glass sputtered by different modes on the same IGZO target (In: Ga: Zn=1:1:1 at%) was obtained by XPS measurements. As shown in Table S1, the three IGZO films had showed a similar atomic ratio of In, Ga, Zn elements closed to 1:1:1 at%, which indicated that there is no significant composition segregation caused by the different sputtering modes under the same depositing condition.

Table S1. Atomic ratio of In, Ga, Zn in 50-nm-thick IGZO on glass sputtered by different modes.

Element	In	Ga	Zn
PDC-IGZO	35.03%	36.72%	28.25%
DC-IGZO	32.71%	37.57%	29.71%
RF-IGZO	30.58%	35.69%	33.73%

Atomic force microscope (AFM) images of Al_2O_3 gate insulator on $Al/SiO_2/PEN$ and PDC-IGZO, DC-IGZO, RF-IGZO on $Al_2O_3/Al/SiO_2/PEN$.

The AFM images of (a) Al_2O_3 gate insulator on $Al/SiO_2/PEN$; (b) PDC-IGZO, (c) DC-IGZO and (d) RF-IGZO on $Al_2O_3/Al/SiO_2/PEN$ are given in Fig. S2a-d. The surface of Al_2O_3 gate insulator on plastic substrate is a bit rough with a Rq of 4.02nm, which is consistent to the TEM images in Fig.1c. However, the relative density of sputtered Al_2O_3 can reach 92% measured by X-ray reflectivity (XRR), as shown in Fig. S3, which help avoid the high leakage current. Moreover, the Rq of PDC, DC, RF IGZO layers on $Al_2O_3/Al/SiO_2/PEN$ range from 3.05 to 4.66 nm. The smoothest surface of PDC-IGZO can also contribute to the best performance of PDC-IGZO/Al_2O_3 TFT among all these devices.

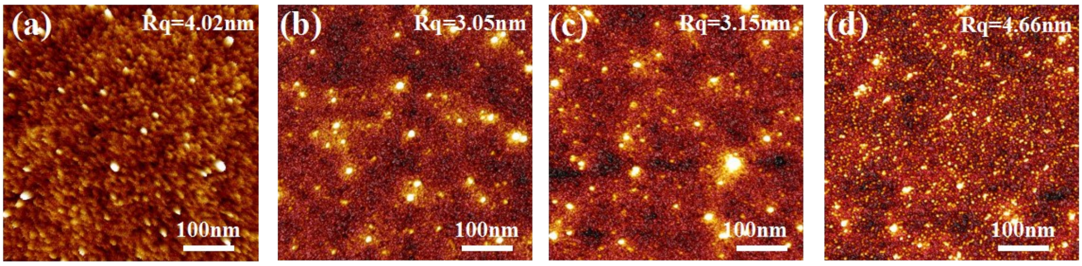

Fig. S2 The AFM images of (a) Al_2O_3 gate insulator on $Al/SiO_2/PEN$; (b) PDC-IGZO, (c) DC-IGZO and (d) RF-IGZO on $Al_2O_3/Al/SiO_2/PEN$

X-ray reflectivity (XRR) measurement of Al_2O_3 gate insulator.

According to the result of X-ray reflectivity (XRR) measurement, the density of sputtered Al_2O_3 was simulated to 3.21 g/cm^3, the relative density reach up to 92%, which help avoid the high leakage current.

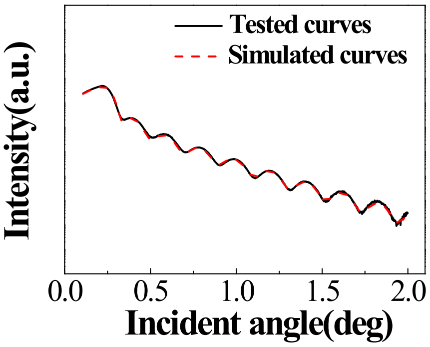

Fig. S3 The X-ray reflectivity measurement of the 100 nm sputtered Al_2O_3 insulator on glass.

The I-V curves with Leakage current of TFTs.

The leakage current of the four devices is showed in Fig. S4a-d. All kinds of IGZO/Al_2O_3 TFTs (Fig. S4a-c) exhibited lower leakage current than the single IGZO TFT (Fig.S3d), implying that the IGZO/Al_2O_3 structure can decrease the leakage current as explained in Fig. 7a.

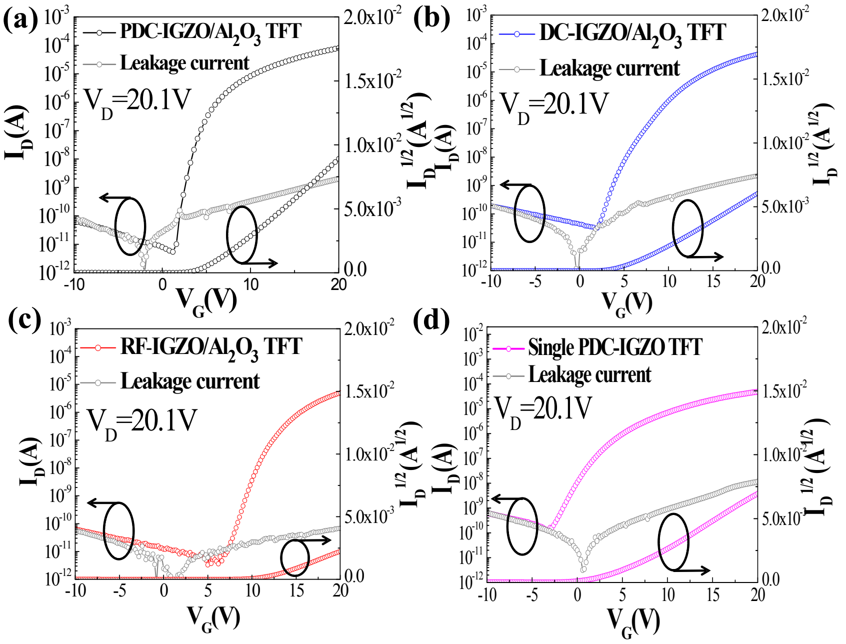

Fig. S4 The I-V curves with Leakage current of (a) PDC-IGZO/Al_2O_3 TFT; (b) DC-IGZO/Al_2O_3 TFT; (c) RF-IGZO/Al_2O_3 TFT and (d) single PDC-IGZO TFT.

The mobility distribution of PDC-IGZO/Al_2O_3 bi-layer TFTs.

As shown in Fig. S5, the PDC-IGZO/Al_2O_3 bi-layer TFTs exhibited an average saturation mobility of 18.5 cm^2/Vs and a maximum mobility of 22.6 cm^2/Vs. The V_{th} and SS distribution also suggested that the PDC-IGZO/Al_2O_3 bi-layer channel has present a promising and uniform performance for driving the oxide TFTs on plastic substrates.

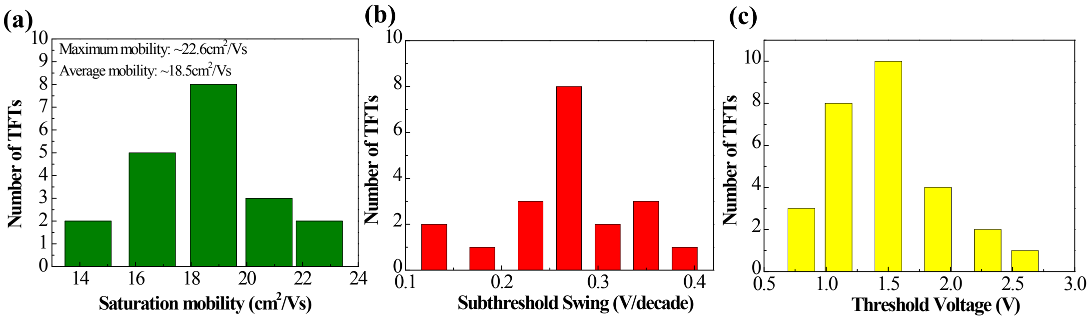

Fig. S5 The distribution of saturation mobility, subthreshold swing and threshold voltage of twenty PDC-IGZO/Al_2O_3 bi-layer TFTs in our research.