Electronic Supplementary Information (ESI)

Low-temperature, Inkjet Printed p-type Copper (I) Iodide Thin Film Transistors

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Experimental

Materials

Copper(I) iodide (γ-CuI, anhydrous, 99.995%) were purchased from Sigma-Aldrich. A solvent of acetonitrile (HPLC>99.9%) was purchased from Fisher Scientific. SU-8 photoresist (SU-8, 2010) was purchased from Microchem.

Fabrication of printed CuI TFTs

SiO_2/Si substrates were used to fabricate printed CuI TFTs. The back side of the substrate was deposited with gold (Au) layer of 100 nm thickness. Oxide layer of 100nm thickness was thermally grown on the silicon substrate as a dielectric layer. All of the substrates were treated through oxygen plasma process to clean the substrate. 0.05 M CuI solution was dissolved in acetonitrile solvent, followed by ultrasonication for 30 min. The solution then was filtered with a syringe filter (Nonsterile, PTFE 25mm x 0.20um). The filtered precursor solution served as a printing ink without any additives. Piezoelectric inkjet printer (Dimatix DMP-2831, Fujifilm) was used to manufacture the CuI film. The dimension of the printed film was controlled by software installed in the printer. The deposition temperature was tuned from room temperature to 60 °C. As-printed film was placed on a hot plate set to 120 °C for 30 min. to evaporate the solvent. A gold layer of 50nm thickness then was deposited as source and drain by thermal evaporator using a shadow mask for patterning. The active channel layer was defined as 1000 μm and 200 μm for width and length, respectively. After depositing source and drain, the device was placed on a hot plate at 150°C for 30min in order to keep the device from the moisture. Then, SU-8 was applied on the printed CuI channel layer as a passivation layer in order to prevent moisture and impurities from affecting device performances.

Characterization

Optical, electrical, and morphological properties of CuI films were investigated. The cross-sectional morphology of the CuI films was characterized by scanning electron microscopy (SEM, FEI Helios 650). Atomic force microscope (AFM, Veeco Nanoscope digital instruments) was employed to analyze the surface morphology and roughness of the films. The films were characterized by X-ray diffraction (XRD, Bruker D8 discover) to investigate the crystalline structure. The optical properties of the films were studied using UV-vis spectroscopy (Jasco, V-670 Spectrophotometer). Electrical properties of the film were analyzed by using Hall effect measurement (Ecopia, HMS-5000). For analysis of optical properties and electrical properties, CuI film was printed on bare soda lime glass substrate. Device performances of the printed CuI TFTs were measured using an Agilent Technologies E5270B Semiconductor Parameter Analyzer under ambient conditions.

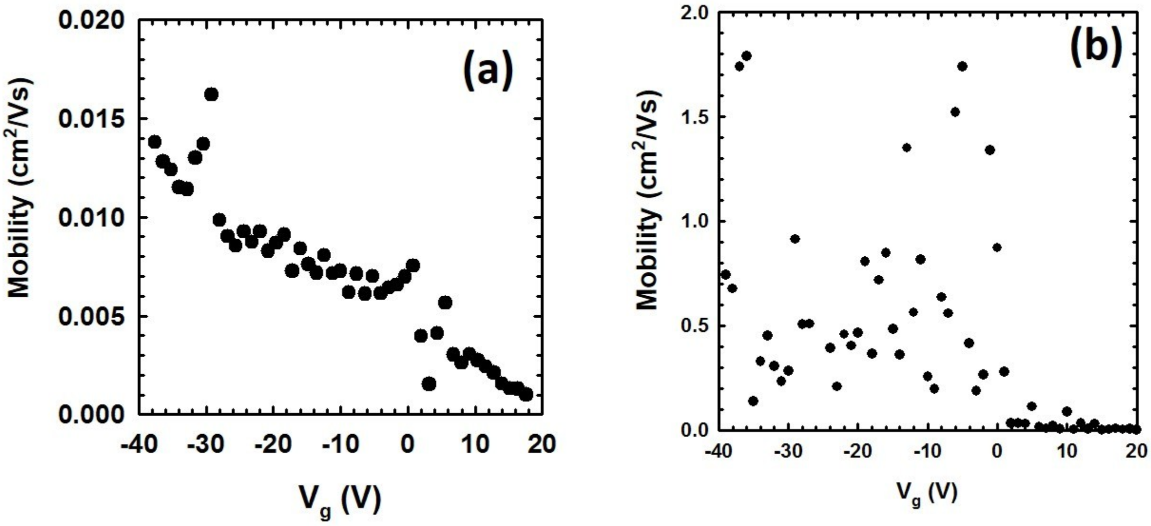
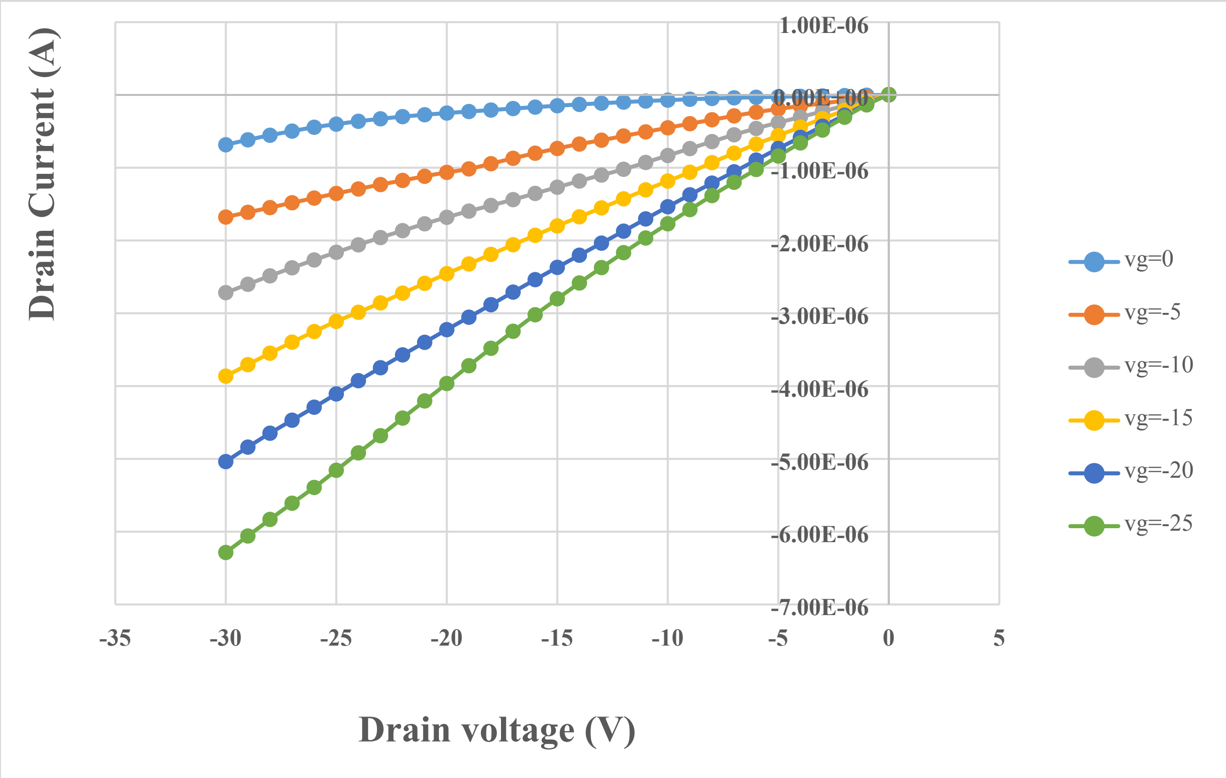


Figure S1. Mobility values of (g) printed CuI TFTs at room temperature and (h) printed CuI TFTs at 60 °C as a function of gate voltage.



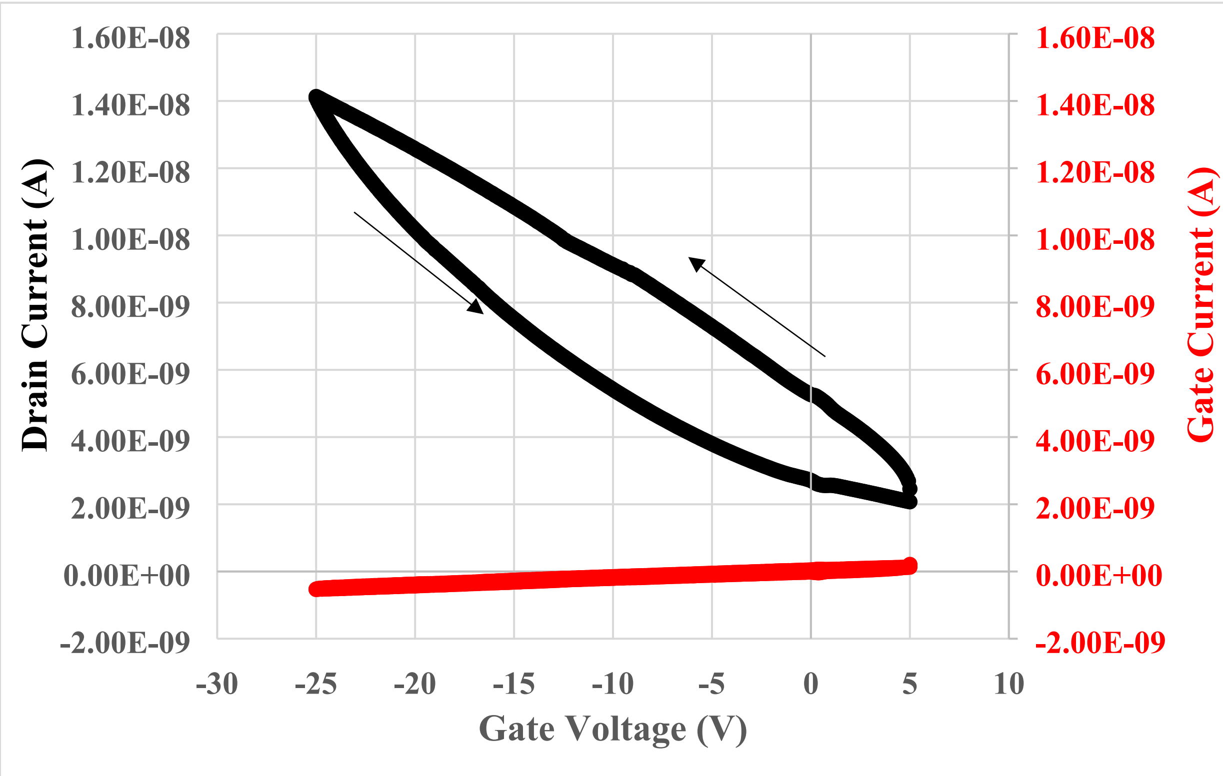


Figure S2. Characterization of CuI TFTs printed at 60 °C: (a) output characteristic curves, (b) hysteresis and gate leakage current measurement.

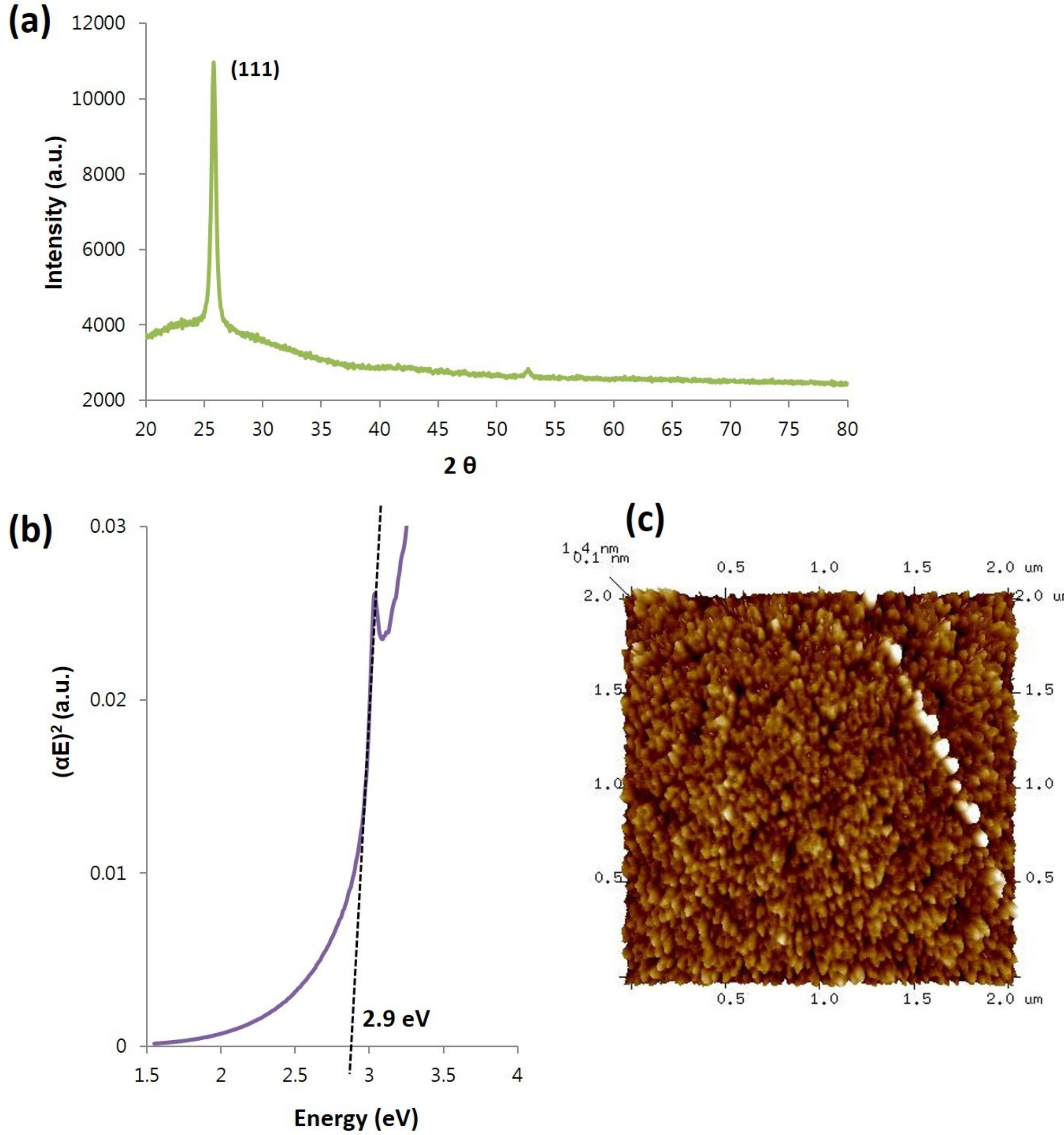


Figure S3. Characterization of printed CuI TFTs baked at 150 °C: (a) XRD pattern, (b) band gap measurement, and (c) AFM image.

Table S1. Summary of reported p-type metal oxide TFTs

	Material	Process	Mobility (cm^2/ Vs)	On/Off ratio	Reference
Vacuum-based process	SnO_x	Rf magnetron sputtering	1.1-1.2	10^3	[1]
	SnO	Sputtering	3.24	10^3	[2]
	Cu_2O/SnO	Sputtering	0.66	1.5×10^2	[3]
	Cu_2O	Magnetron sputtering	2.40	3.96×10^4	[4]
	CuO	Thermal oxidation	1.9	10^2	[5]
Solution-based process	Cu_2O	spin coating	0.16	10^2	[6]
	Cu_2O	Spray pyrolysis	0.01	4×10^3	[7]
	Cu_2O	Spin coating	0.29	1.6×10^4	[8]
	CuO	Spin coating	0.01	10^3	[9]
	SnO	Spin coating	0.13	$10^{1.9}$	[10]
	CuI	Inkjet printing	1.86	10^2	This work
	CuO	Spin coating	0.8	10^5	[11]
	NiOx	Spin coating	0.97	9.8×10^5	[12]
	NiOx	Spin coating	4.4	10^5	[13]
	CuO	Inkjet print	0.22	10^3	[14]

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