Electronic Supplementary Material (ESI) for Journal of Materials Chemistry

Electronic Supplementary Information

Solution-Processable Tin-Doped Indium Oxide with a Versatile Patternability for Transparent Oxide Thin Film Transistors

By Keunkyu Song, Yangho Jung, Youngwoo Kim, Areum Kim, Jae Kwon Hwang, Myung Mo Sung, and Jooho Moon*

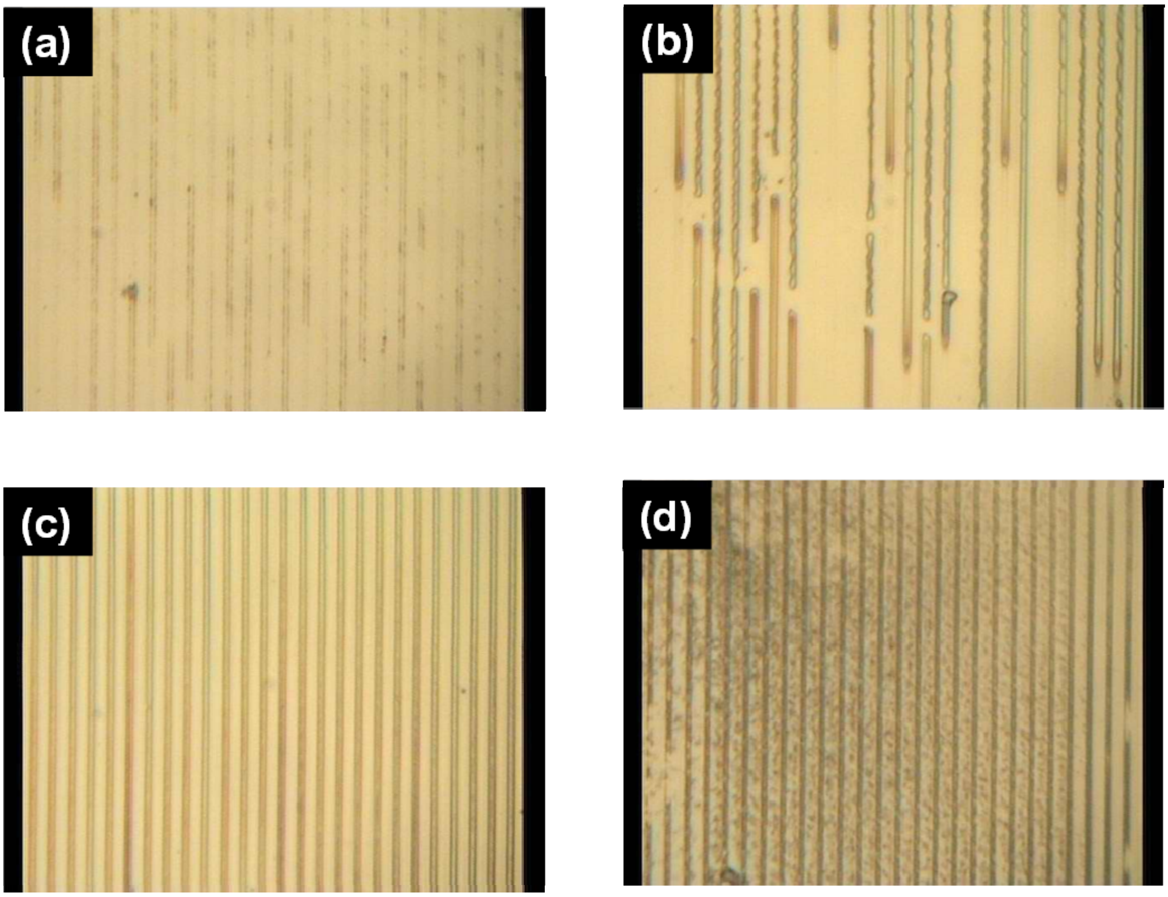

Figure S1. Optical images of microscale ITO patterns fabricated by LB-nTM on SiO_2/Si substrates materials using the ITO inks with varying solution concentrations: (a) 0.05 M, (b) 0.15 M, (c) 0.25 M, and (d) 0.35 M. The width of line pattern is 4 μm and spacing between lines is 5 μm.

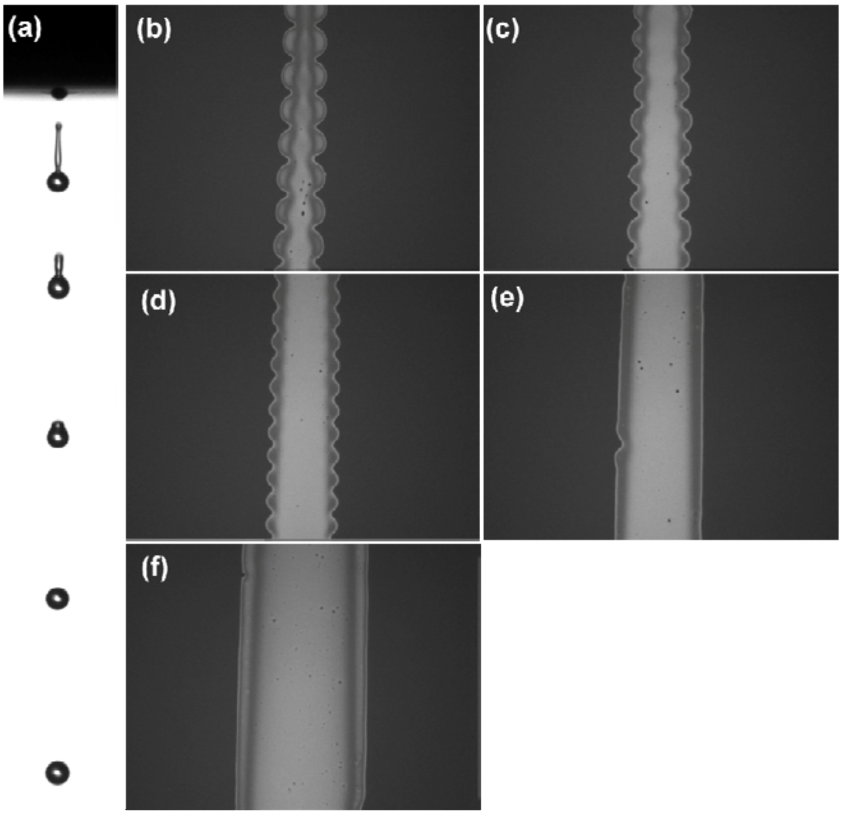

Figure S2. (a) The dynamics of ITO ink droplet formation under the optimized driving conditions. Microscope images of inkjet-printed line patterns as a function of droplet interspacing: (b) 160, (c) 130, (d) 100, (e) 70, and (f) 40 μm.

Figure S2a shows the dynamics of ITO ink droplet formation under the optimized driving conditions. The diameter, volume, and velocity of droplet are 39.61μm, 32 pL, and 1.59 m/sec, respectively. The CCD camera with a strobe LED light took snapshots of the drop formation dynamics with an interframe time of 1 μs to view individual droplets and to measure their sizes and travel velocities. The drop dynamics were captured by increasing the delay time of the camera in a step of 1 μs. Droplet images were taken at various delay intervals and showed the flight distance from the nozzle tip. The printing was carried out at a relative humidity of 40% at 25 °C. The substrate was the spin-coated zinc tin oxide (ZTO) semiconductor pre-annealed at 500 °C for 1 h. The inkjet printing was performed onto the ZTO substrate pre-heated to 75 °C.

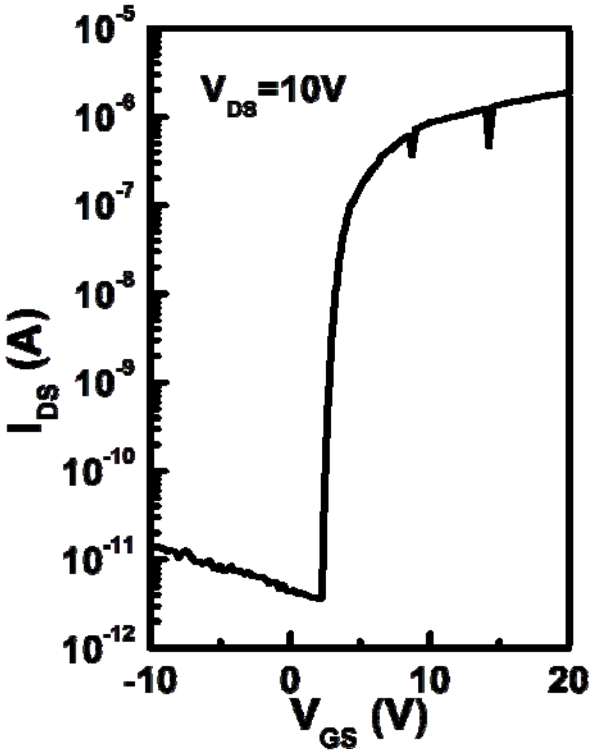

Figure S3. The characteristic of fully transparent TFT (TTFT) in which solution ITO materials are used gate (*G*), source (*S*) and drain (*D*) electrodes on the glass substrate at the same time exhibits in here. The fully transparent TFTs with spin-coated gate and inkjet-printed ITO S/D electrodes show an on/off-current ratio of ~10^6, a field-effect mobility of 0.24 $cm^2\ V^{-1}\ s^{-1}$, and a threshold voltage of 2.43 V. The subsequently deposited layers of TTFT are ITO (inkjet-printed S/D)/ZTO(spin-coated semiconductor, *t*=30nm)/SiO_x(PECVD, *t*=200nm)/ITO(spin-coated Gate, *t*=10nm)/glass.

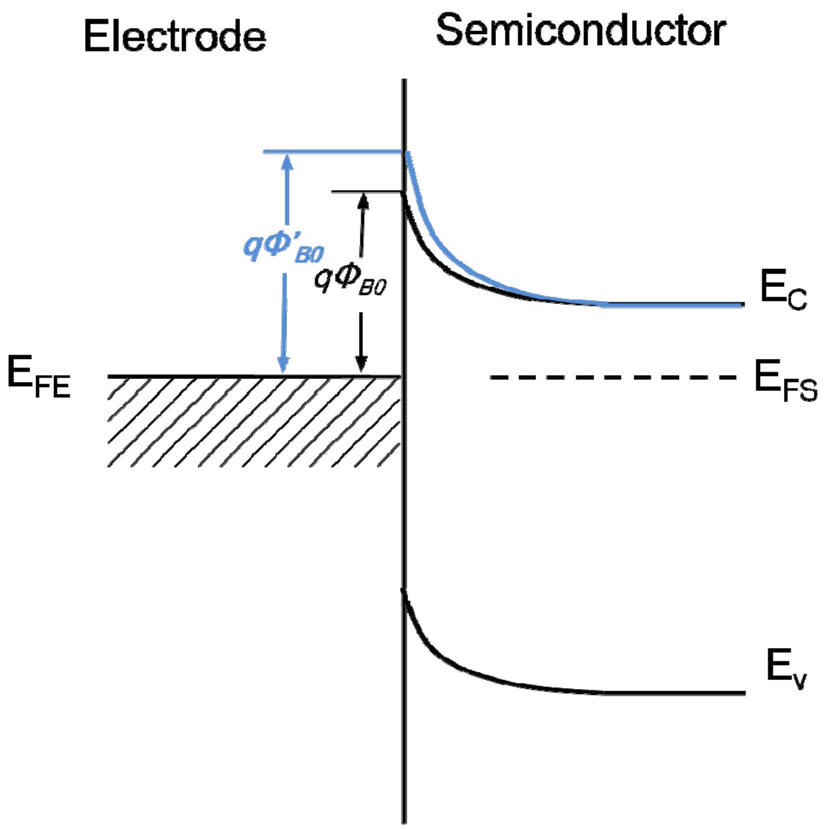

Figure S4. Energy diagram before (black) and after (blue) interdiffusion between the semiconductor and the electrode interface. An undesirable interdiffusion at the interface is likely to alter energy levels. The charge energy barrier ($q\Phi_{B0}$) aroses so that the contact resistance between two layeres is increased (E_{FE}: Fermi level of electrode, E_{FS}: Fermi level of semiconductor, E_C: conduction band of semiconductor, E_V: valence band of semiconductor, $q\Phi_{B0}$: charge energy barrier, $q\Phi'_{B0}$: charge energy barrier after interdiffusion).

Table S1. The electrical characteristics of solution-processed oxide TFTs fabricated with soluble ITO electrodes.

Semi-conductor	Gate electrode	S/D electrode	Mobility ($cm^2 V^{-1}s^{-1}$)	Threshold voltage (V)	On/off current ratio
ZnO-TFT	s-ITO	Al	0.29	6.2	$\sim 10^6$
	v-ITO	Al	0.33	4.0	$\sim 10^6$
ZTO-TFT	n^+-Si	s-ITO	0.16	2.3	$\sim 10^6$
	n^+-Si	Al	0.72	8.0	$\sim 10^7$