CPS: Synergy: Collaborative Research: Cyber-physical Digital Microfluidics based on Active Matrix Electrowetting Technology: Software-Programmable High-Density Pixel Arrays

THE UNIVERSITY of TENNESSEE KNOXVILLE

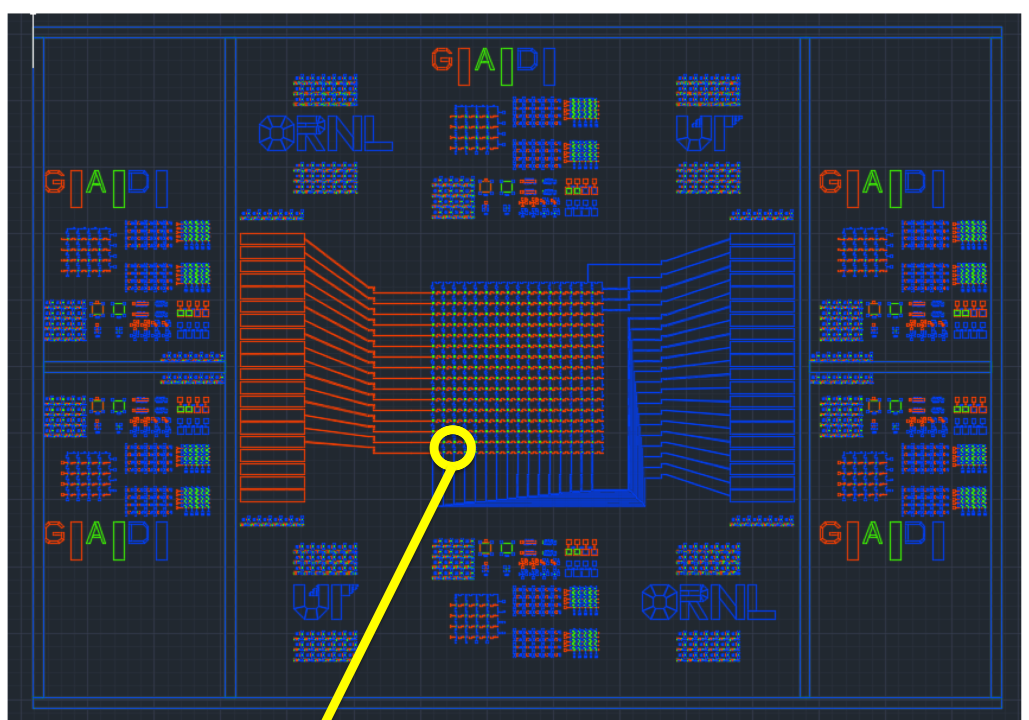
UC RIVERSIDE — UNIVERSITY OF CALIFORNIA

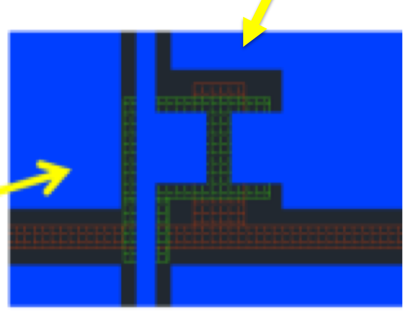
Philip Brisk[1], Walker L Boldman[2], Philip D Rack[2,3]

1) University of California, Riverside 2) University of Tennessee 3) Center for Nanophase Materials Science, Oak Ridge National Laboratory

16x16 Active Matrix Platform – Device Schematic

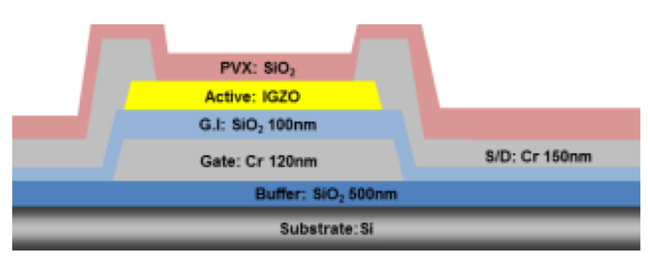
a



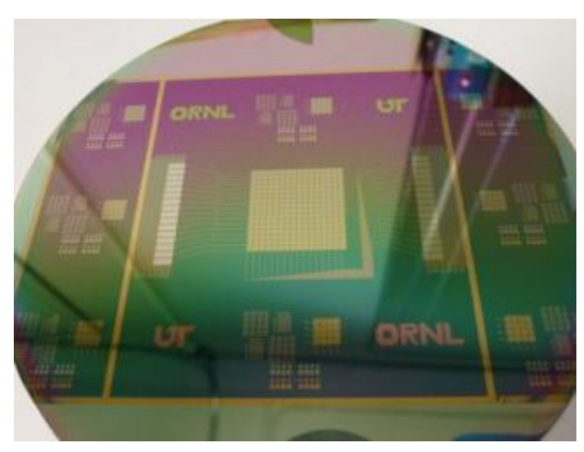


Active matrix electrowetting is achieved by using Indium Gallium Zinc Oxide (IGZO) thin film transistors to independently control each pixel an n*m array using only n+m electrodes. Here, we Snapshot of the CAD file (**a**) With an enlarged capture showing the TFT. A 2D cross section of one pixel is also shown (**b**), as well as a photograph of a fully fabricated device (**c**).

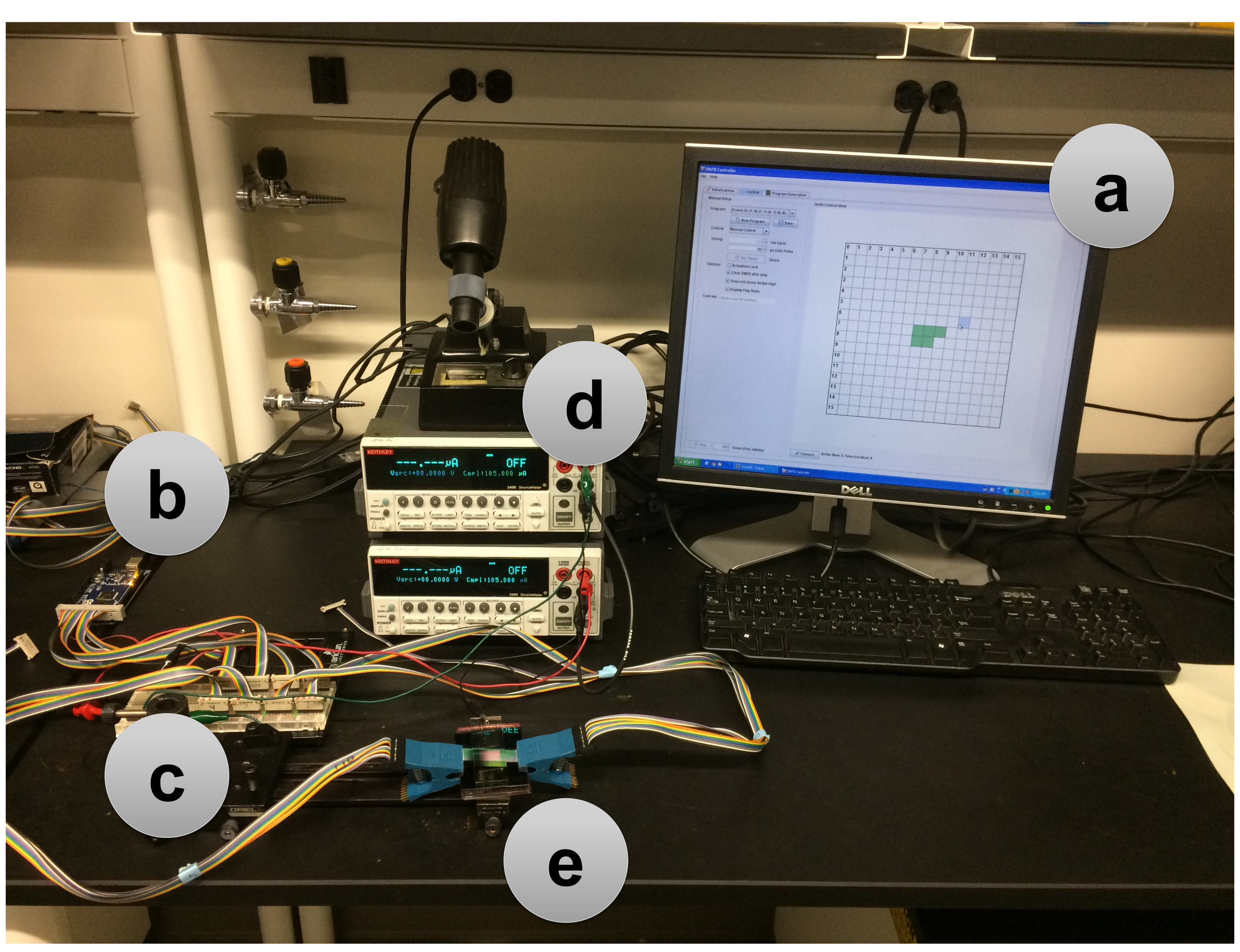
b



c



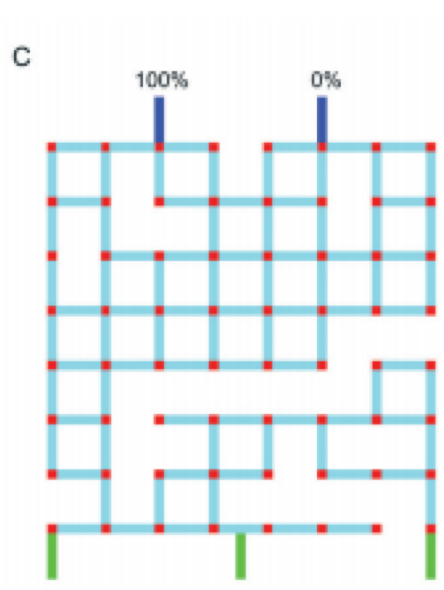
16x16 Active Matrix Platform – Electrowetting Setup

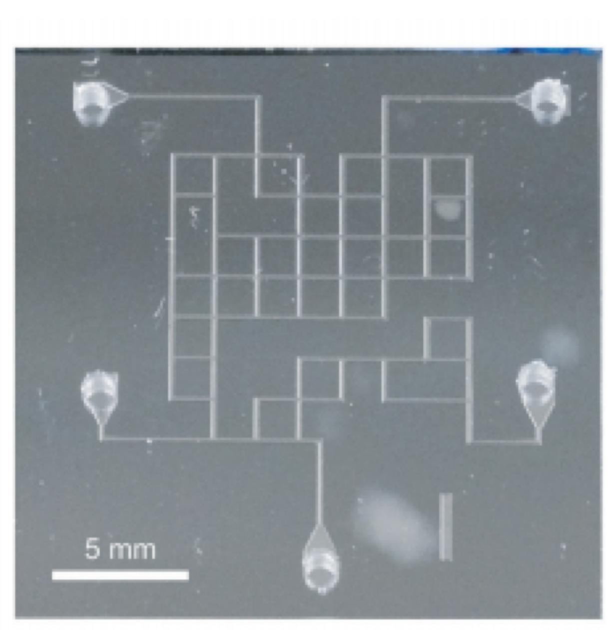


Electrowetting is controlled by software developed by UC Riverside (**a**), which sends a signal to an Arduino board (**b**). The board then sends 5 V signals to a breadboard (**c**), where it is then amplified via Keithley power supplies (**d**). These amplified signals are subsequently sent to the active matrix electrowetting device (**e**).

Future Work in Active Matrix Electrowetting

Further collaboration with UC Riverside would result in exploration of an active matrix electrowetting mimic of their Random Design of Electrofluidics. This device creates functional microfluidic devices By arranging an array of microfluidic channels chosen by simulation (chosen schematic and photograph of device shown on the right), and yields desired concentrations of solutes at the outlets.

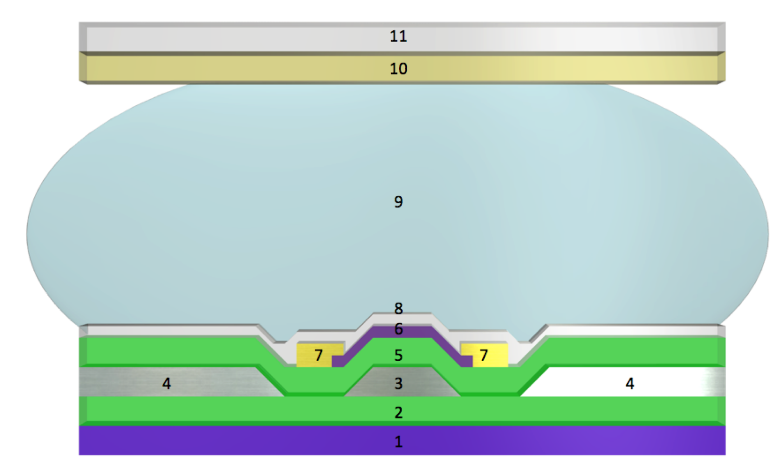




J. Wang, P. Brisk, and W. H. Grover, "Random design of microfluidics," *Lab Chip*, pp. 4212–4219, 2016

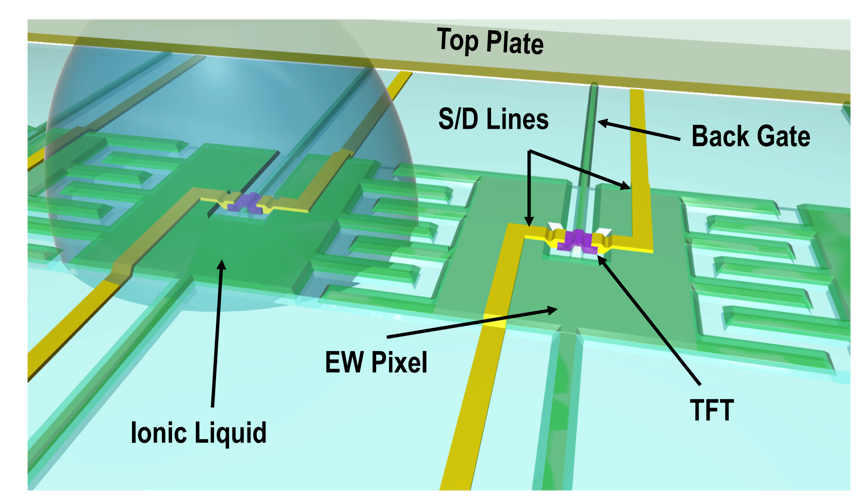
Programmable Neuromorphic Device Schematic and Short Term Potentiation

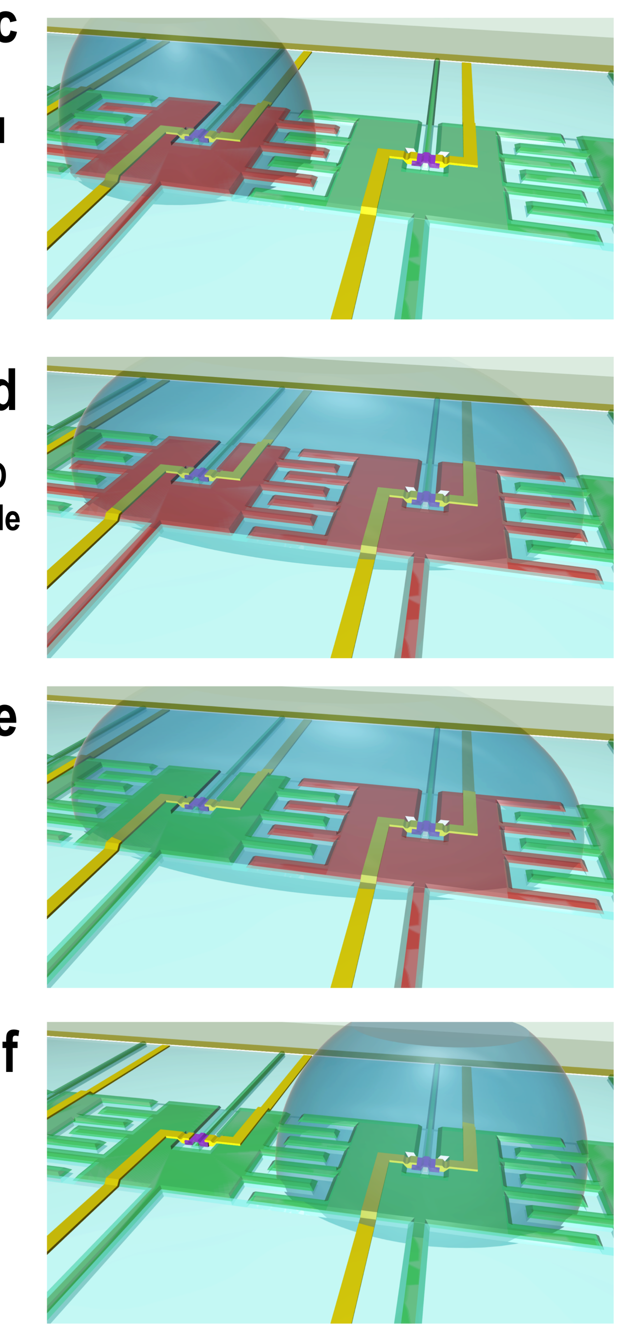
a



1. Si Wafer
2. Buffer: 500nm SiO_2
3. Back Gate: 150nm Al
4. EW Pad: 150nm Al
5. G.I. : 100nm SiO_2
6. Active: 50nm IGZO
7. S/D: 90nm Ti/Au
8. Hydrophobic: 400nm Teflon
7. Ionic Liquid
8. Top Gate: 100nm ITO
9. Top Plate: Glass Slide

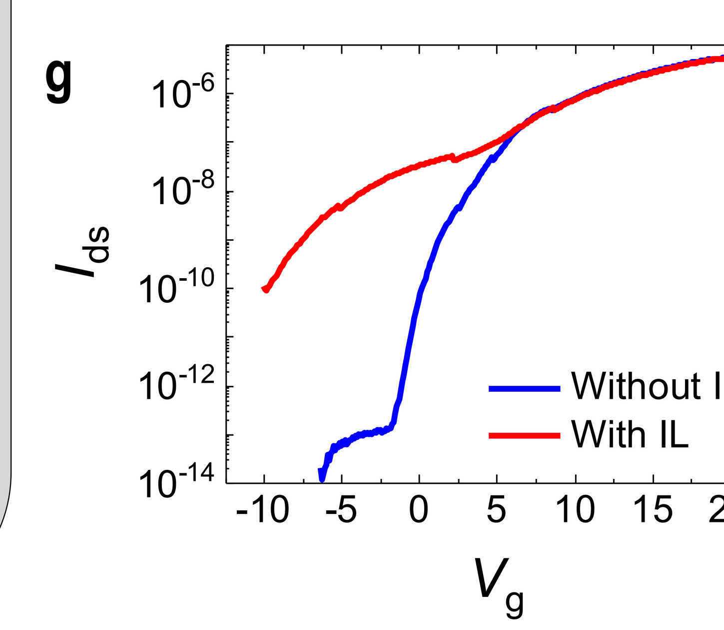
b





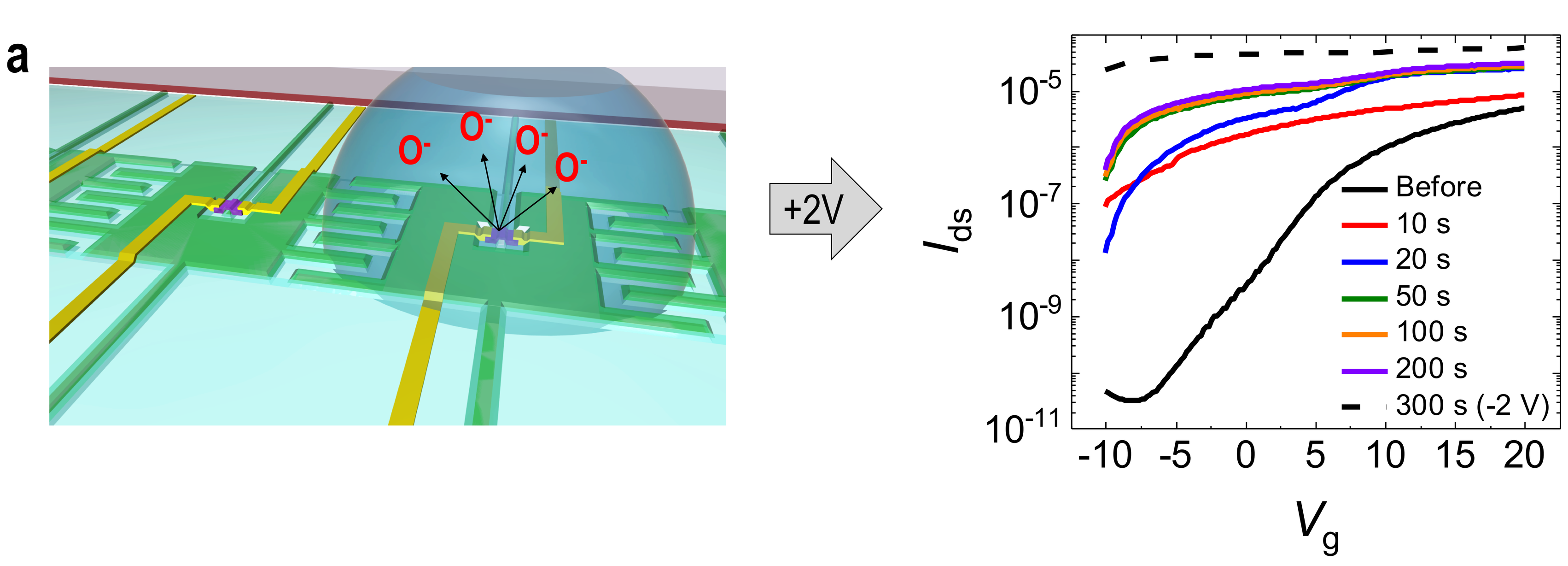
Using Ionic liquids (DEME and LiClO - PEO), we demonstrate control over an amorphous metal oxide transistor threshold voltage and on-current. Combining this with a pixelated electrowetting array (2D cross-section shown in (**a**) and a model schematic in (**b**)) results in a programmable neuromorphic platform, which can be scaled to high pixel counts. Short term potentiation is realized via the electrowetting of the ionic liquid over the desired aIGZO TFT pixel (**c-f**). The TFT transfer characteristics change dramatically, as noted by a ~580x increase in the Ids when Vg is equal to zero (**g**). This electrostatic effect is only present while the ionic liquid/solid interface is formed, and can thus be combined with electrowetting of the ionic liquid to create a programmable STP device.

g

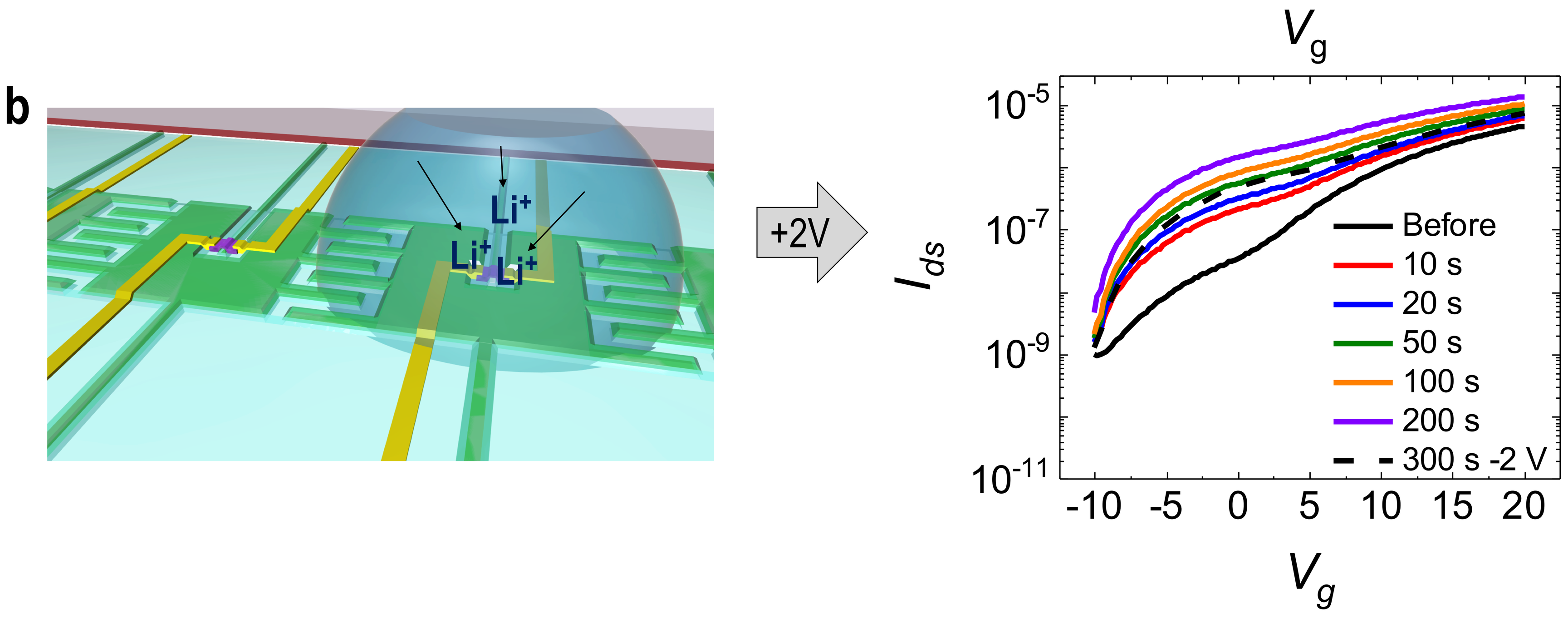


Long Term Potentiation – Electrochemical Gating

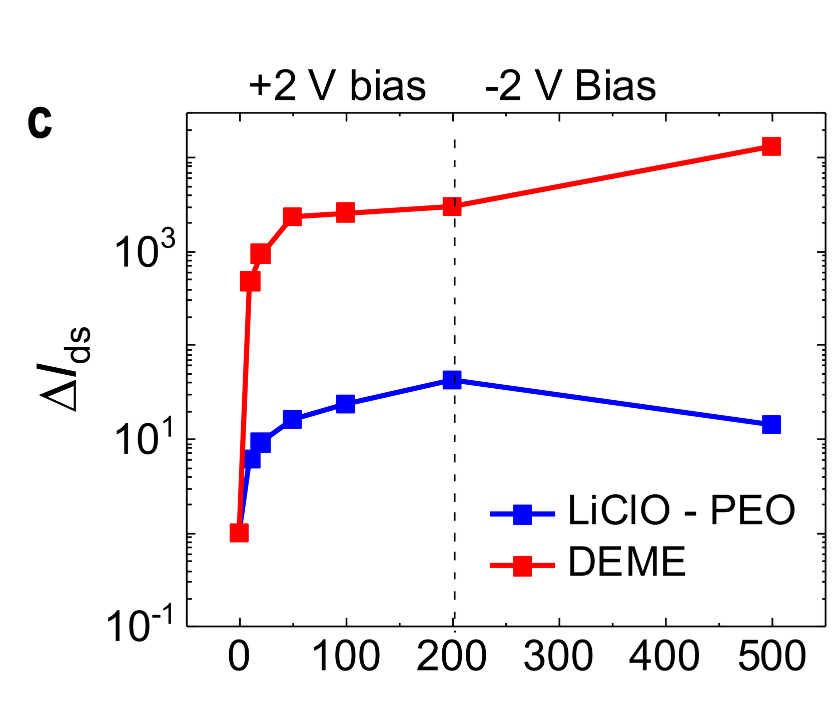
a



b



c



Long term potentiation is induced by electrochemically altering the chemical composition in the active layer via a top gate bias. Here, both DEME (**a**) and LiClO – PEO (**b**) were used. DEME electrochemically dopes the aIGZO via oxygen extraction, which is a permanent, but non-reversible effect. For this reason, LiClO – PEO, which dopes the aIGZO via lithium intercalation, was also used. While the electrochemical effect of LiClO – PEO is not as pronounced, it is reversible under a negative top gate Bias (**c**).

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