Ionic Liquid and Amorphous Metal-Oxide Semiconductor Interactions: Towards a New Programmable Neuromorphic Platform

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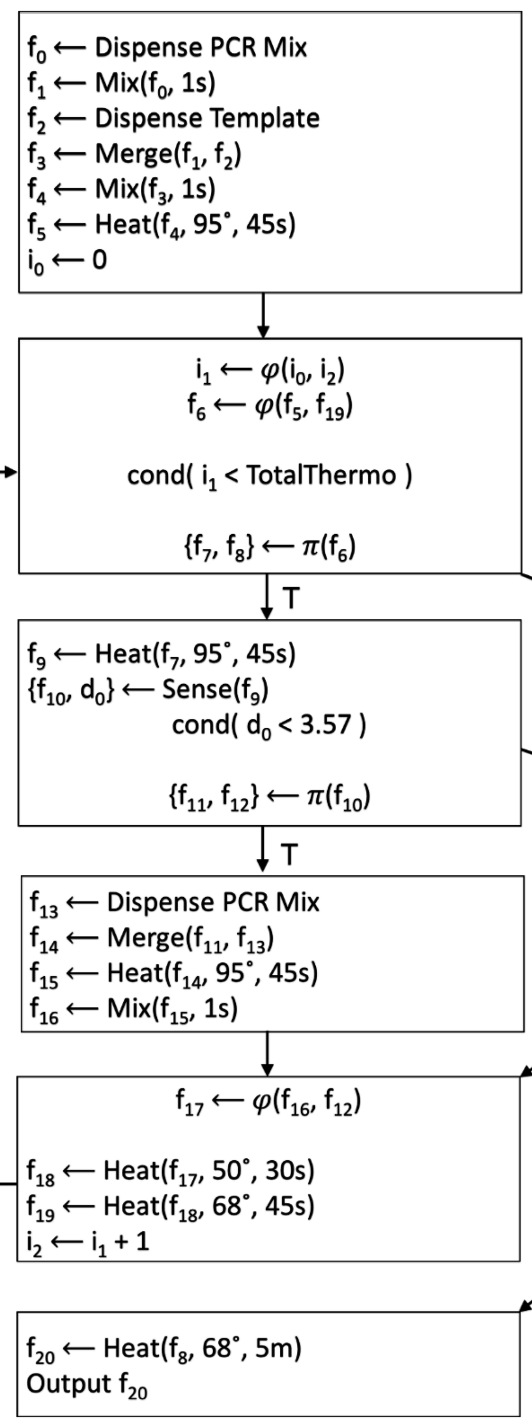
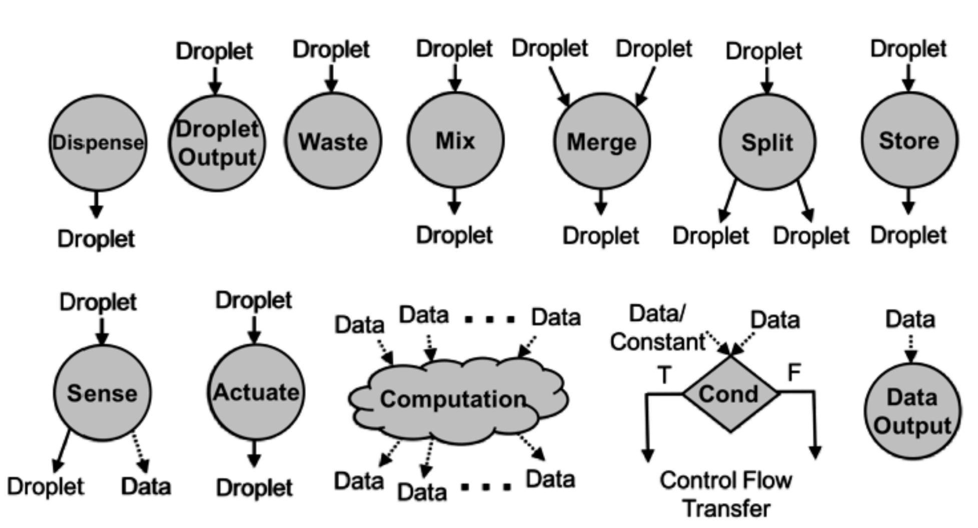
BioScript Programming Language for Digital Microfluidics

Example Application: PCR with Droplet Replenishment

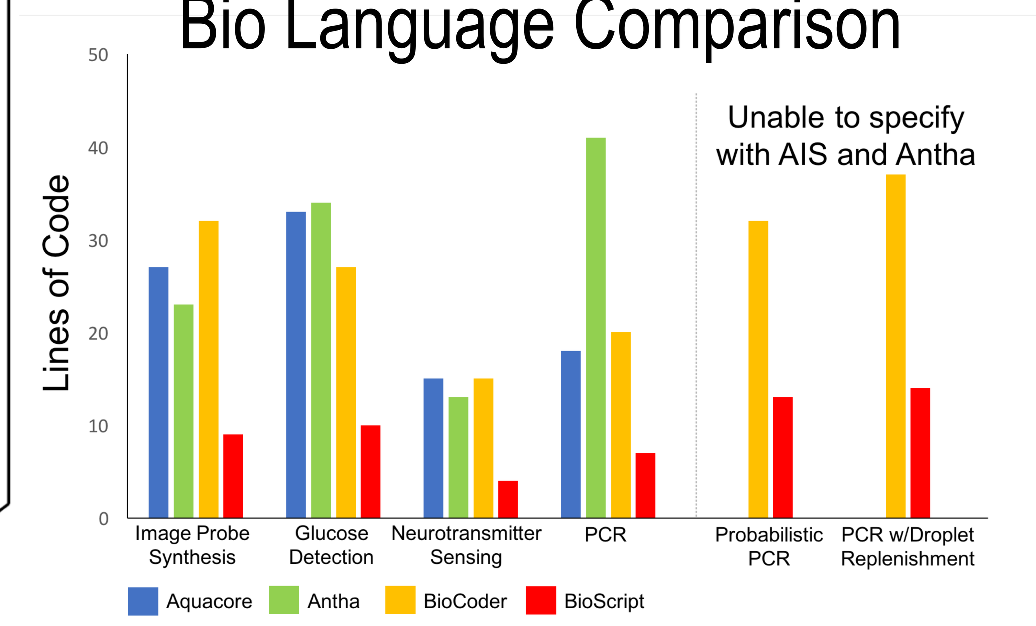
```
PCRMix = Vortex PCR Master Mix with Template for 1s

Repeat 50 times {
  Heat PCRMix at 95C for 20s
  volumeWeight = Weigh PCRMix

  if (volumeWeight <= 50uL) {
    replacement = Vortex 25uL of PCR Master Mix
                  with 25L of Template for 5s
    Heat replacement at 95C for 45s
    PCRMix = Mix PCRMix with replacement for 5s
  }

  Heat PCRMix at 68C for 30s
  Heat PCRMix at 95C for 45s
}

Heat PCRMix at 68C for 5min
Save PCRMix
```



Supported Operations



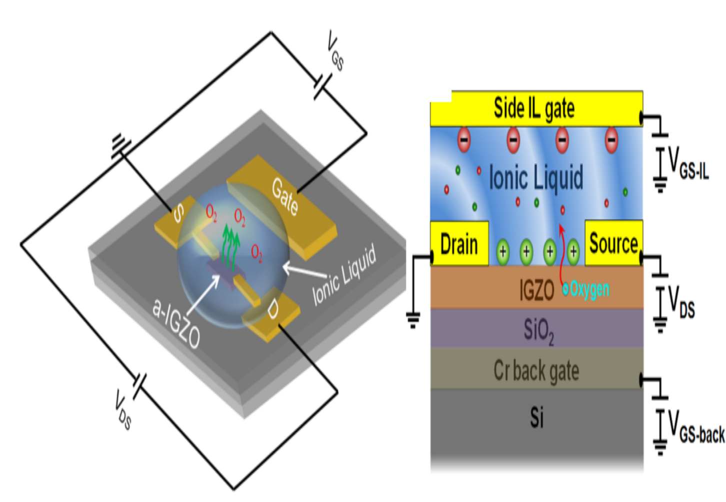
Bio Language Comparison



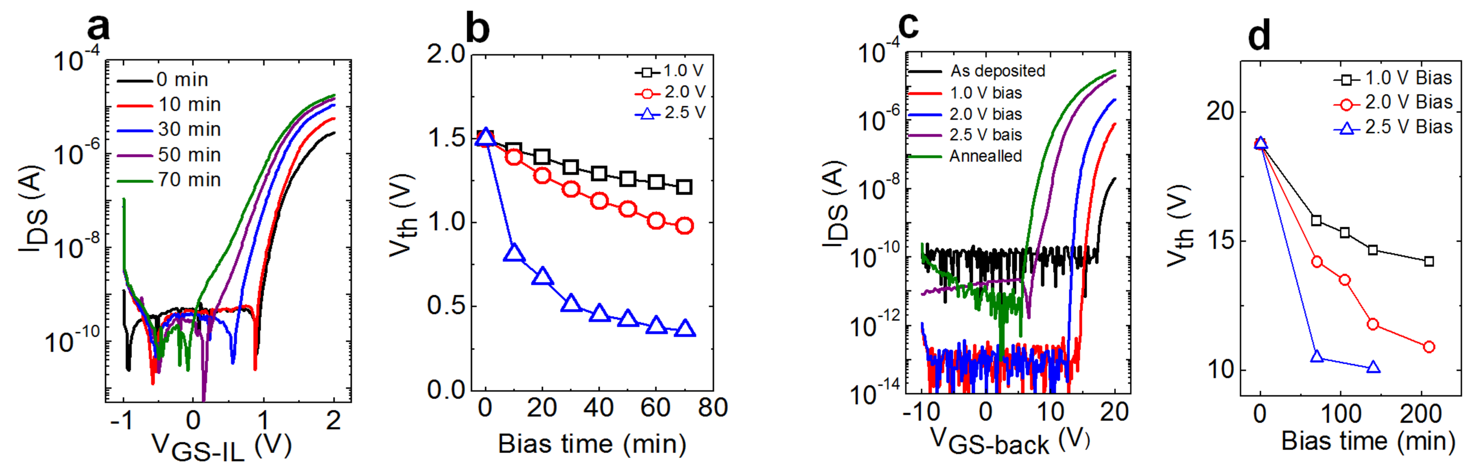
Compiler Representation

Ionic Liquid Athermal Activation of Amorphous Metal-Oxide Semiconductors

Amorphous metal-oxide semiconductors offer the high carrier mobility and excellent large-area uniformity required for high performance, transparent, flexible electronic devices; however, a critical bottleneck to their widespread implementation is the need to activate these materials at high temperatures. We report highly controllable activation of amorphous IGZO semiconductor channels using ionic liquid gating at room temperature. Activation is controlled by electric field-induced oxygen migration across the ionic liquid-semiconductor interface.



Field induced activation of a-IGZO TFTs by IL gating.

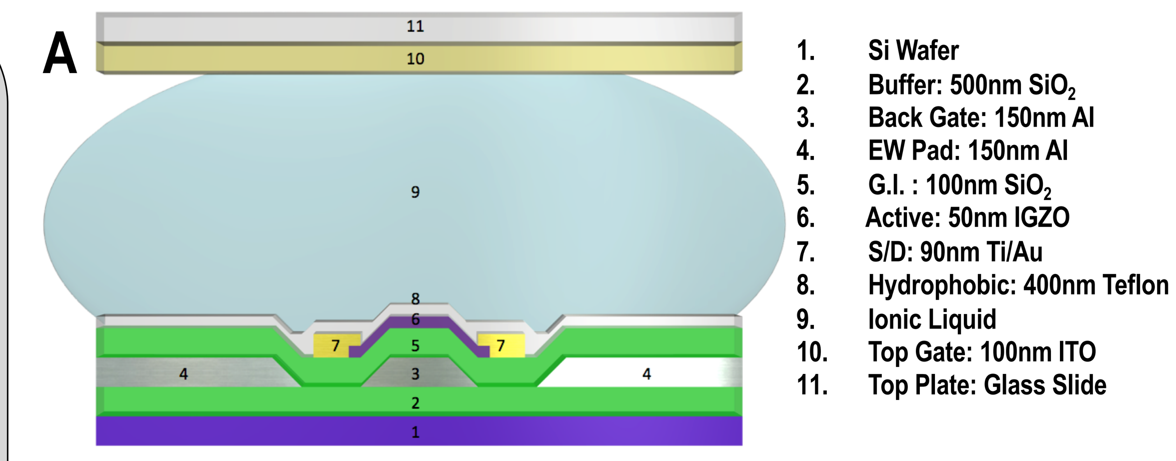


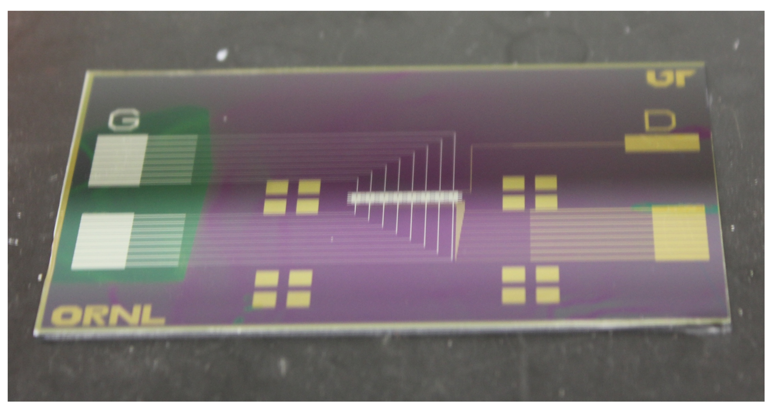
a) Transfer characteristics of IL-gated TFT at 300K. +2.0 V IL gate bias. b) V_{th} as measured for the IL gate structure. c) Back gate measurements after IL bias time of 70 min. d) The back gate V_{th} as a function of IL bias time.

P.R. Pudasaini, J.H. Noh, A.T. Wong, O.S. Ovchinnikova, A.V. Haglund, S. Dai, T.Z. Ward, D. Mandrus, P.D. Rack, *Advanced Functional Materials*, **17**, 2820 (2016)

Programmable Neuromorphic Device Schematic

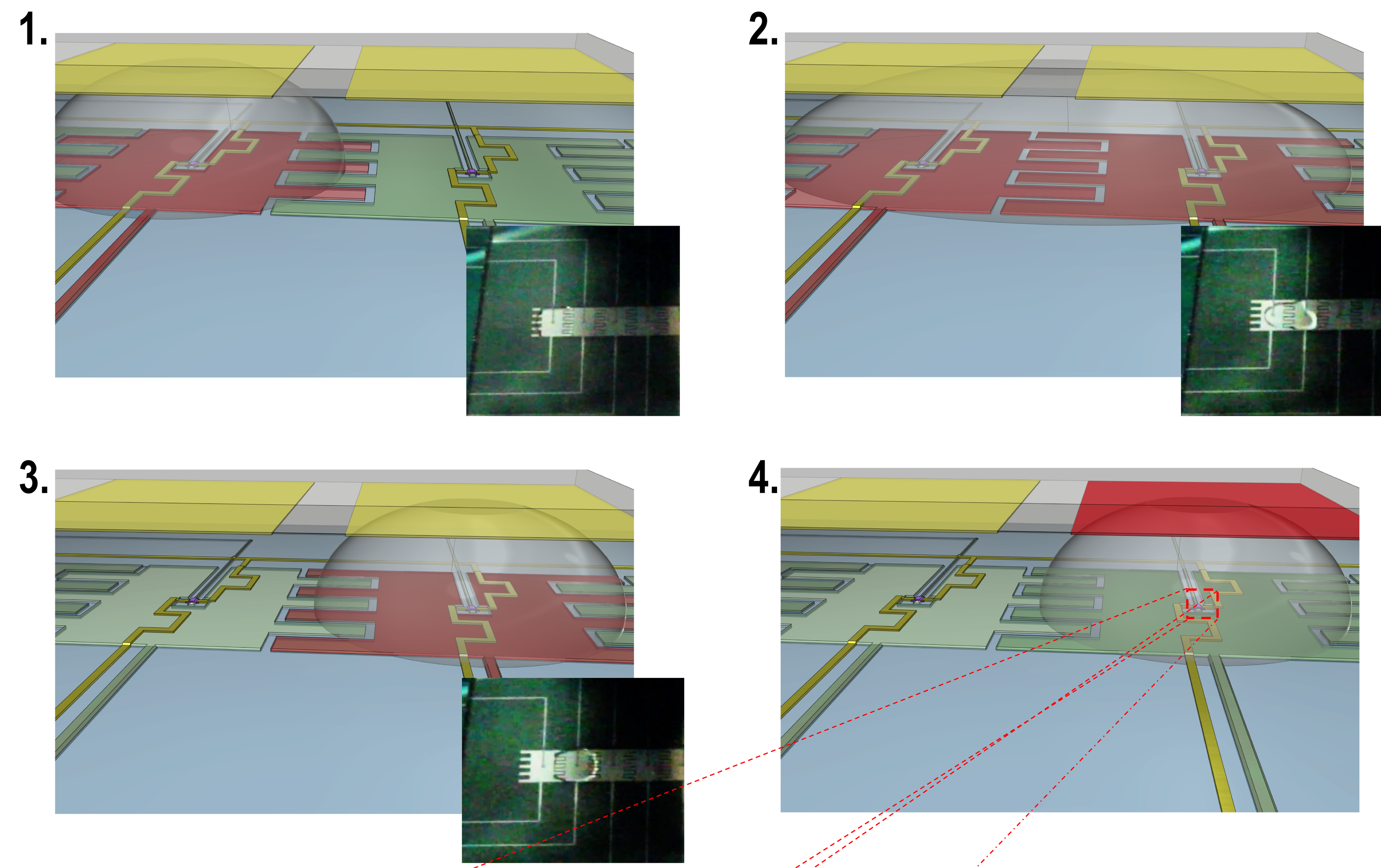
Neuromorphic computing attempts to model neuro -biological architectures using analog electronic signals. Using a hydrated Ionic liquid (BMIM-TFSI), we demonstrate control over an amorphous metal oxide transistor threshold voltage and on-current via H+ injection. Combining this with a pixelated electrowetting array results in a programmable neuromorphic platform which can be scaled to high pixel counts.



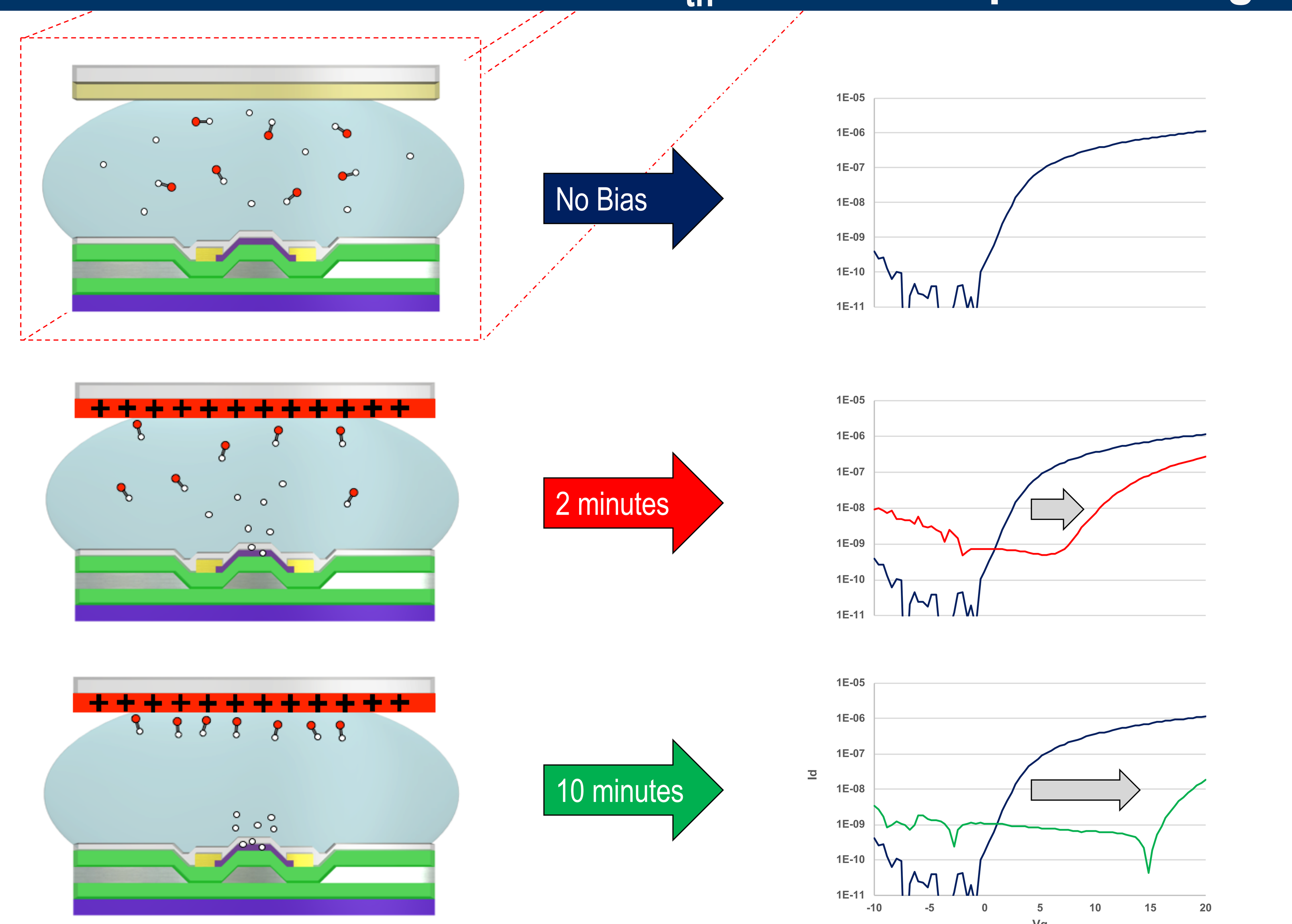


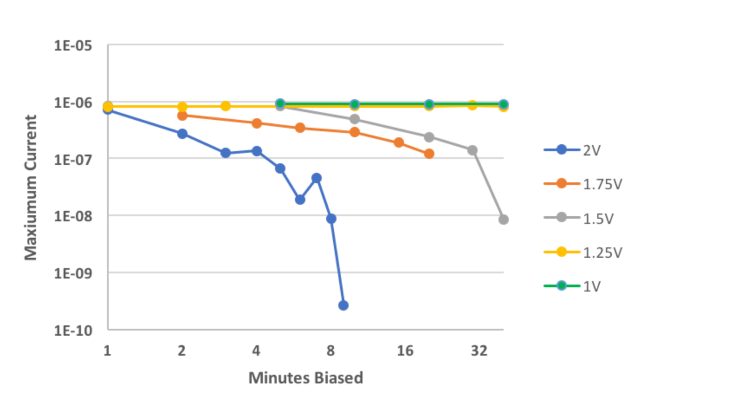
a) 2D Cross section of neuromorphic platform and b) photograph of fabricated device.

Electrowetting of Ionic Liquid

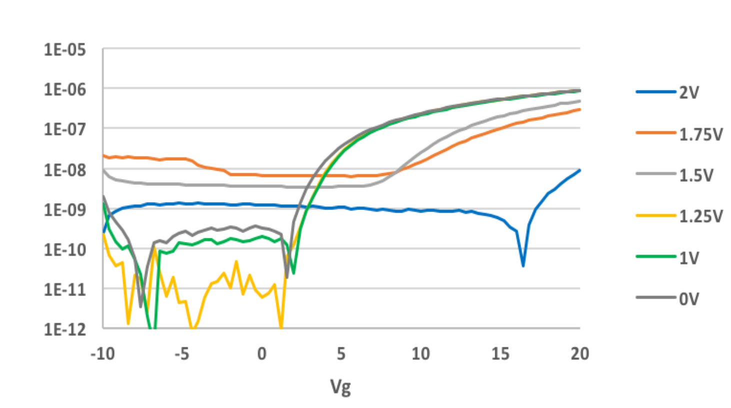


Modulation of Current and V_{th} via Ionic Liquid Biasing





Maximum current of transfer curve at incremented applied voltage bias.



Back gate measurements after 10 minute bias time at incremented applied bias voltages.