Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Photopatternable Solid Electrolyte for Integrable Organic Electrochemical Transistors: Operation and Hysteresis

Anton Weissbach[a]†, Lukas M. Bongartz[a]†, Matteo Cucchi[a], Hsin Tseng[a], Karl Leo[a]*, Hans Kleemann[a]

[a] *Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP), Technische Universität Dresden, Nöthnitzer Str. 61, 01187 Dresden, Germany; E-mail: karl.leo@tu-dresden.de*

† These authors contributed equally to this work.

Supplementary Information

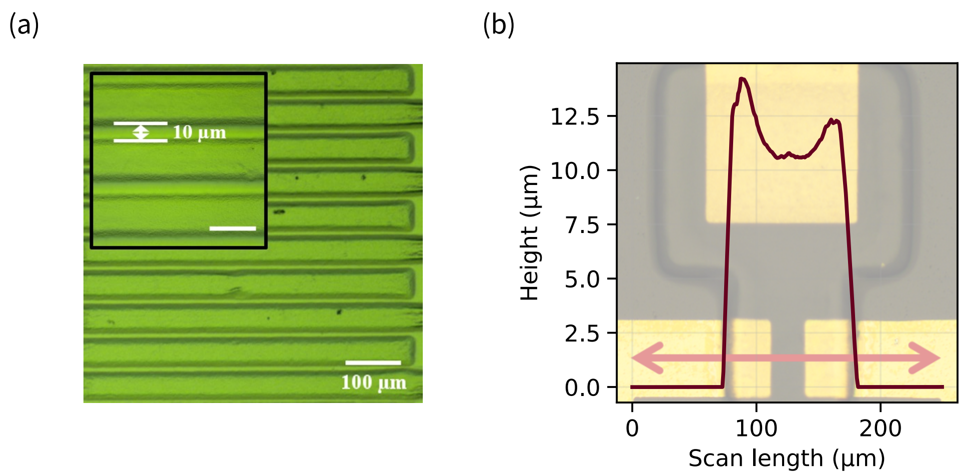

Figure S1 (a) Micrograph demonstrating the achievable resolution of the solid electrolyte. (b) Height profile across the solid electrolyte. An electrolyte thickness of 11 μm was achieved by adjusting the gap between substrate and photomask as well as by the exposure time.

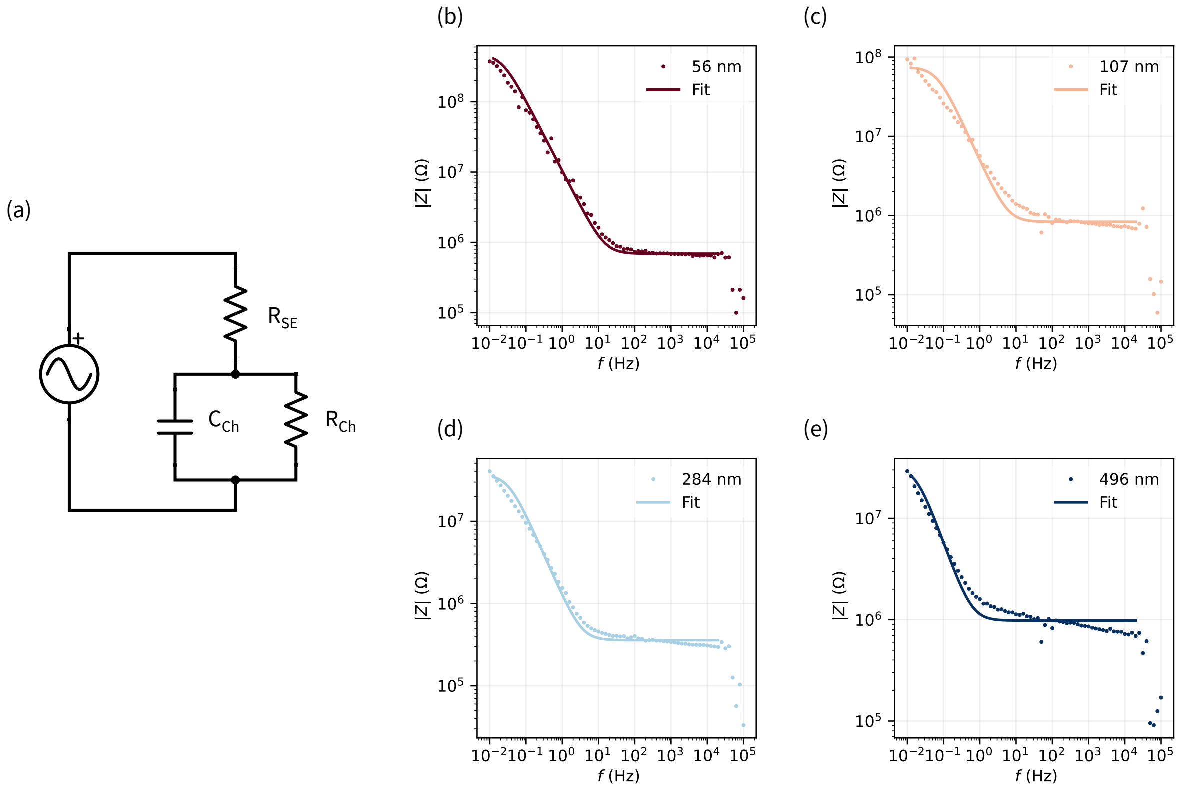

Figure S2 (a) Circuit used for impedance fitting. R_{SE} and C_{Ch} served for estimating τ_{RC}. Experimental impedance data with corresponding fits of OECTs with d(PEDOT:PSS) of (b) 56 nm, (c) 107 nm, (d) 284 nm, and (e) 496 nm.

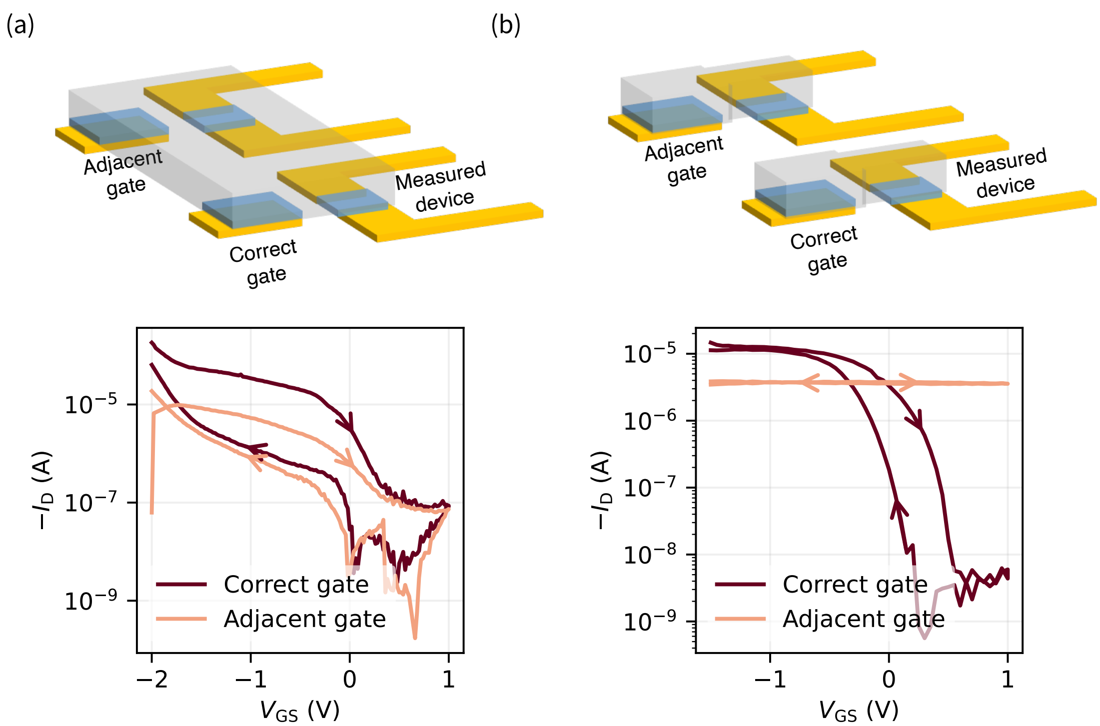

Figure S3 While OECTs with (a) non-patterned solid electrolyte crosstalk, a (b) patterned solid electrolyte allows individual transistor operation that is not influenced by adjacent gates ($V_{DS} = -0.1\,\mathrm{V}$).

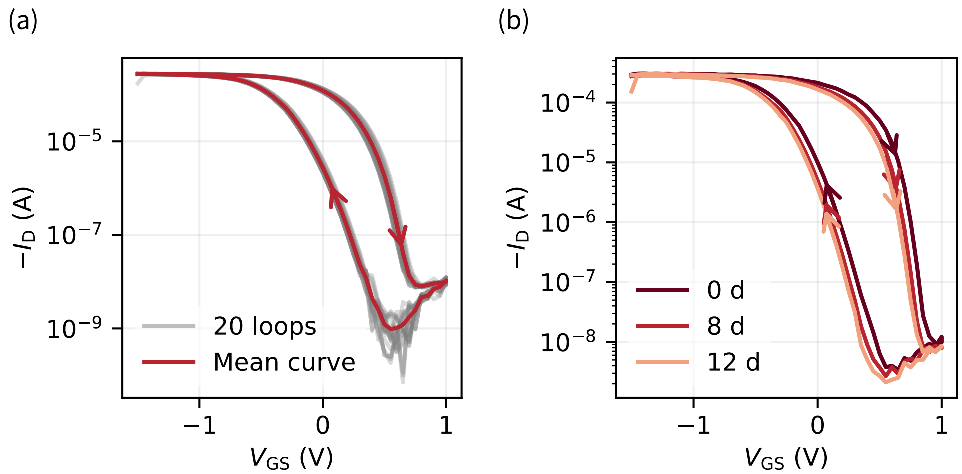

Figure S4 Transfer recordings demonstrating stable transistor operation (a) iteratively and (b) over several days ($V_{DS} = -0.1\,V$).

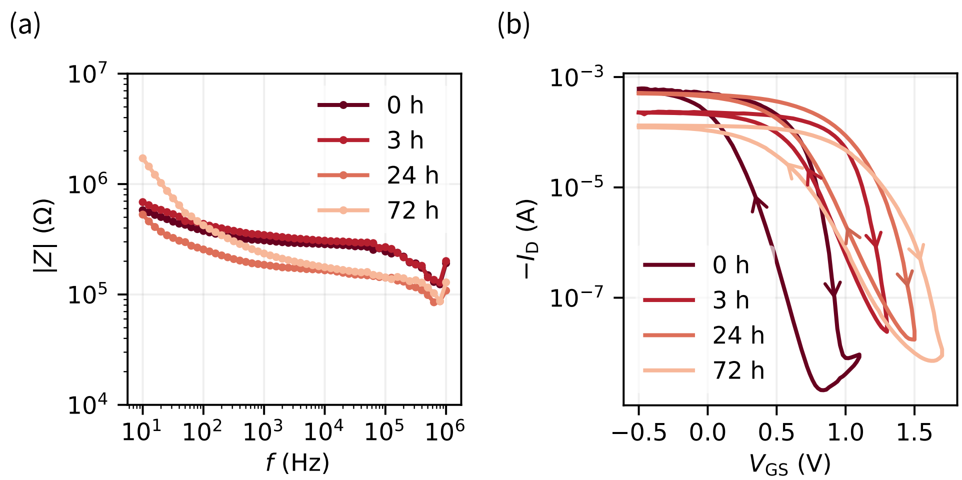

Figure S5 (a) Impedance measurements revealed the solid electrolyte as stable in ambient atmosphere. (b) Meanwhile, the threshold voltage was found to shift from $V_{Th} = 0.76\,V$ (0 h) to $1.14\,V$ (3 h), $1.16\,V$ (24 h), and $1.28\,V$ after $72\,h$ ($V_{DS} = -0.1\,V$).

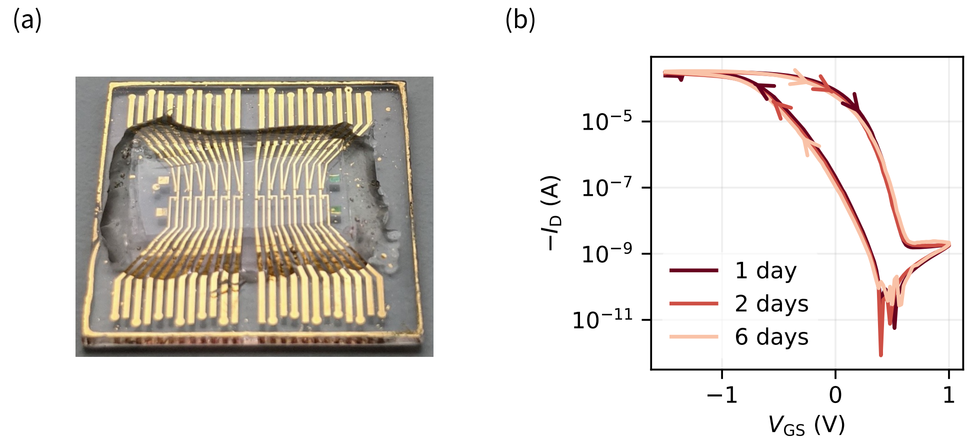

Figure S6 (a) Photography of an encapsulated sample. A two-component-glue based on epoxy resin was employed. (b) Stability of an encapsulated sample shown over several days ($V_{DS} = -0.1\,V$).

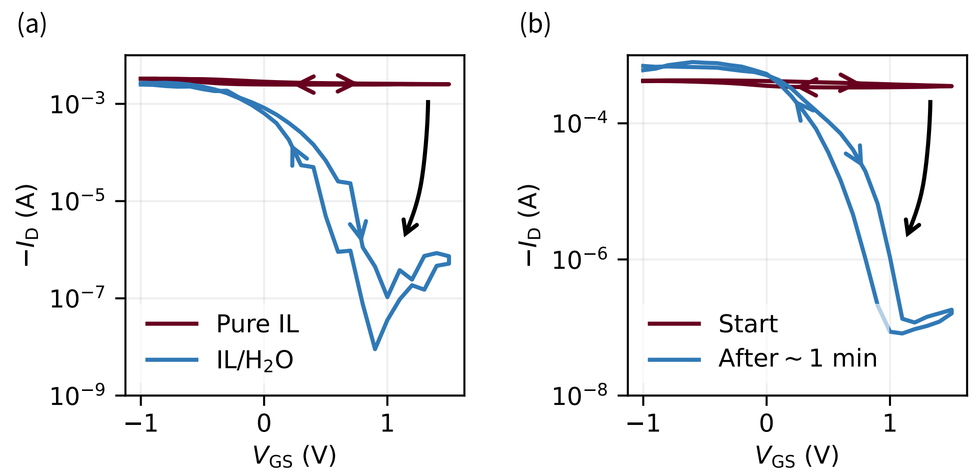

Figure S7 (a) An OECT with pure ionic liquid as electrolyte shows no operation in N_2-atmosphere. Upon adding a drop of water, gating is enabled ($V_{DS} = -0.1\,V$). (b) The same effect is achieved by humidity when a sample with pure ionic liquid is brought from the glovebox into ambient (red curve: $V_{DS} = -0.1\,V$, blue curve: $V_{DS} = -0.7\,V$).

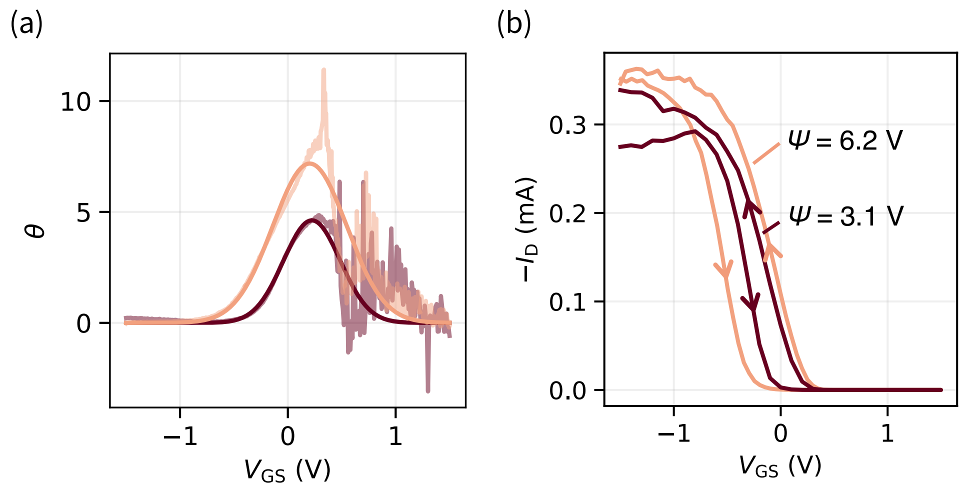

Figure S8 Supplementary figures to Fig. 3c. (a) are the experimental data ($\theta_{ex.}$) and fits ($\theta(V_{GS})$). Fitting parameter red: $V_{GS}^* = 0.22\,\mathrm{V}$, $\theta^* = 4.62$, $\sigma_\theta = 0.26\,\mathrm{V}$. Fitting parameter orange: $V_{GS}^* = 0.20\,\mathrm{V}$, $\theta^* = 7.18$, $\sigma_\theta = 0.34\,\mathrm{V}$. (b) shows the transfer curves in a linear plot for demonstrating scaling of the ψ parameter ($V_{DS} = -0.1\,\mathrm{V}$).

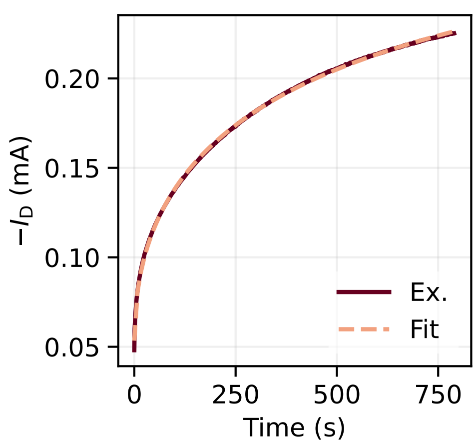

Figure S9 Retention time measured at constant $V_{DS} = -0.1\,\mathrm{V}$ and $V_{GS} = 0\,\mathrm{V}$ (off→on curve). The fit function is a stretched exponential function $\Delta I(t) = [I(t=\infty) - I(t=0)][1 - \exp\left(-\left(\frac{t}{\tau}\right)^\beta\right)]$, which is typically used to describe bias stress-induced hysteresis in organic field-effect transistors[1–3].

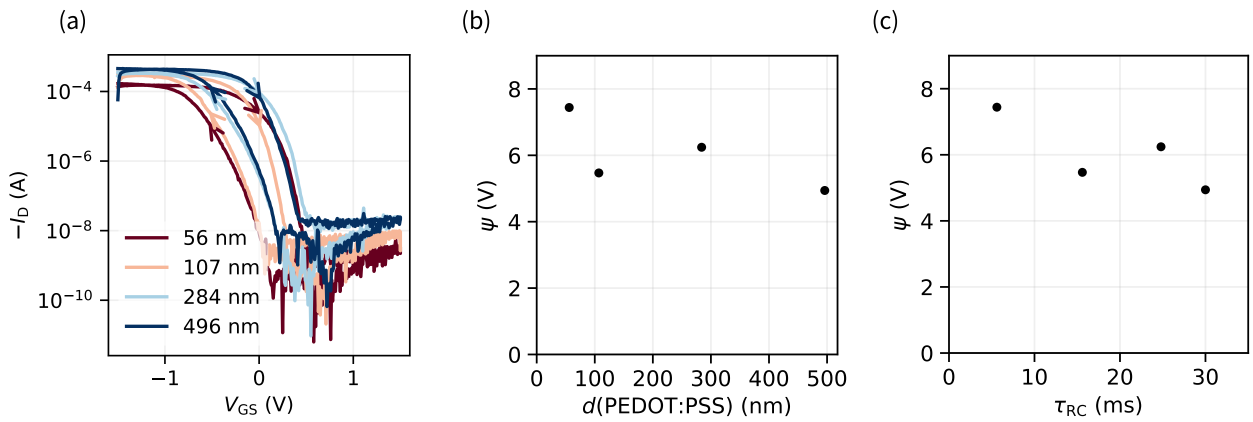

Figure S10 (a) Transfer curves ($V_{DS} = -0.1\,\mathrm{V}$) with (b) corresponding ψ parameters of OCETs with varied d(PEDOT:PSS). A scan rate of $18\,\mathrm{mV\,s^{-1}}$ was applied. The decrease in hysteresis is the result of increased channel capacities, which lead to higher RC times, as shown in (c).

References

[1] W. Jackson, J. Marshall and M. Moyer, *Physical Review B*, 1989, **39**, 1164.

[2] G. Gu, M. G. Kane and S.-C. Mau, *Journal of applied physics*, 2007, **101**, 014504.

[3] U. Zschieschang, R. T. Weitz, K. Kern and H. Klauk, *Applied Physics A*, 2009, **95**, 139–145.