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Supplemental information

Three-dimensional SEI framework induced by ion regulation in toroidal magnetic field for lithium metal battery

Yan Li, Manjie Xiao, Chunli Shen, Lianmeng Cui, Wei Yang, Chi Zhang, Xinhui Chen, Liqiang Mai, Yan Zhao, and Xu Xu

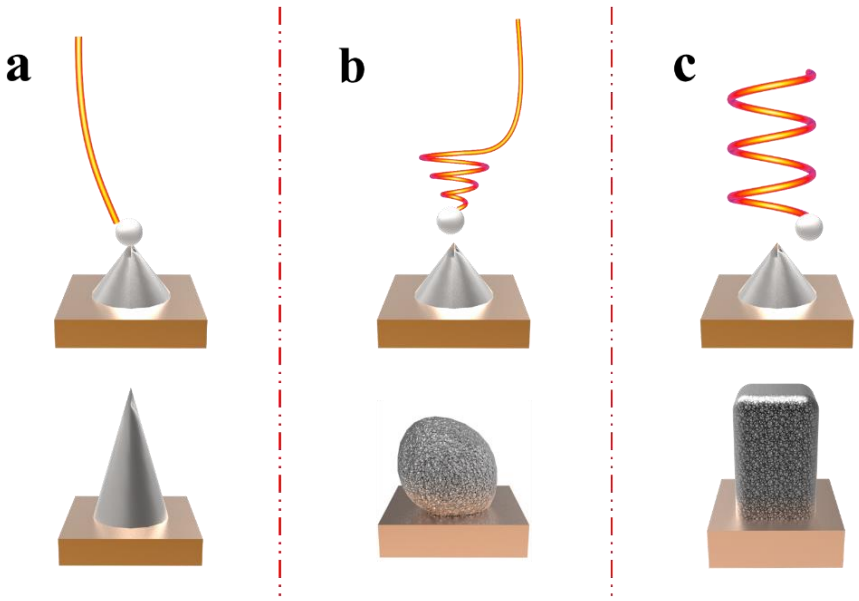

Figure. S1 Explanation of the mechanism of lithium deposition behaviors under (a) no magnetic field, (b) vertical magnetic field, (c) toroidal magnetic field.

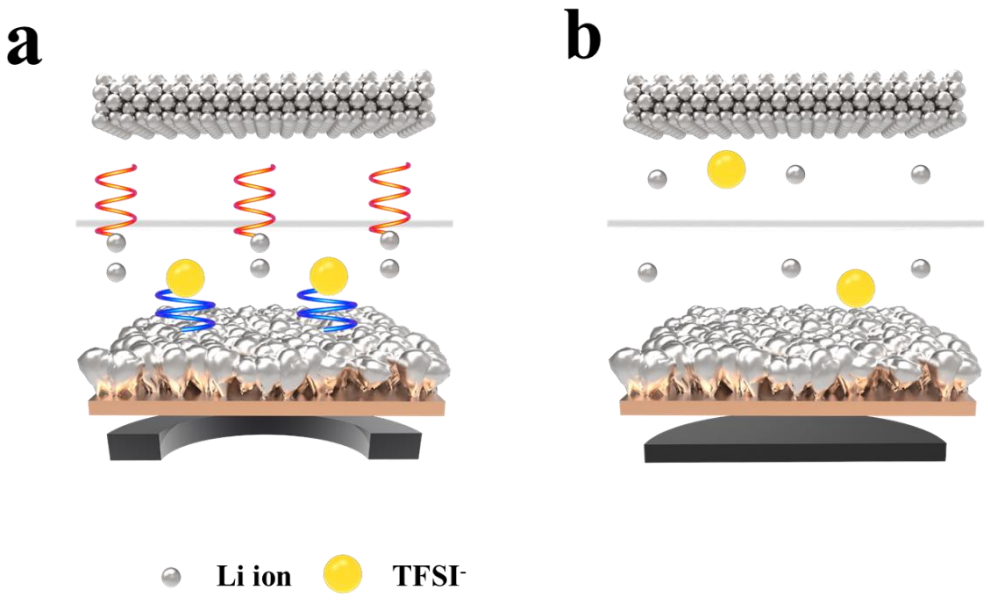

Figure. S2 Explanation of the mechanism of Li^+ and $TFSI^-$ diffusion behaviors under (a) toroidal magnetic field, (b) no or vertical magnetic field.

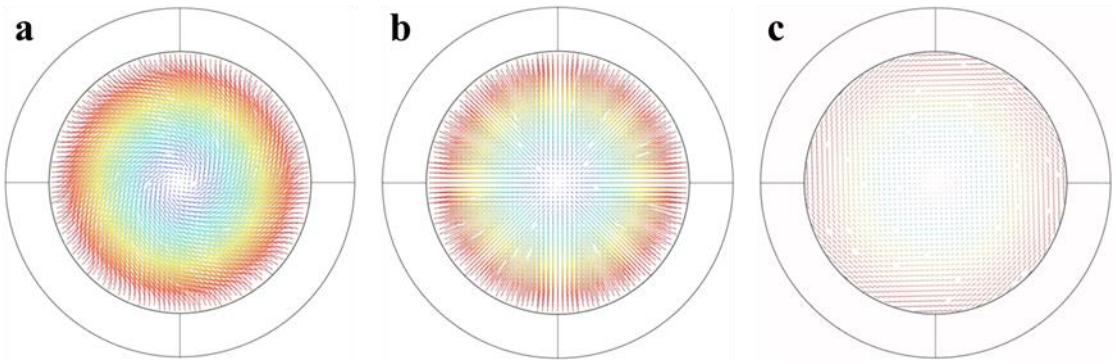

Figure. S3 The top view trajectories of ions in COMSOL simulation with (a) toroidal magnetic field, (b) no magnetic field, (c) vertical magnetic field.

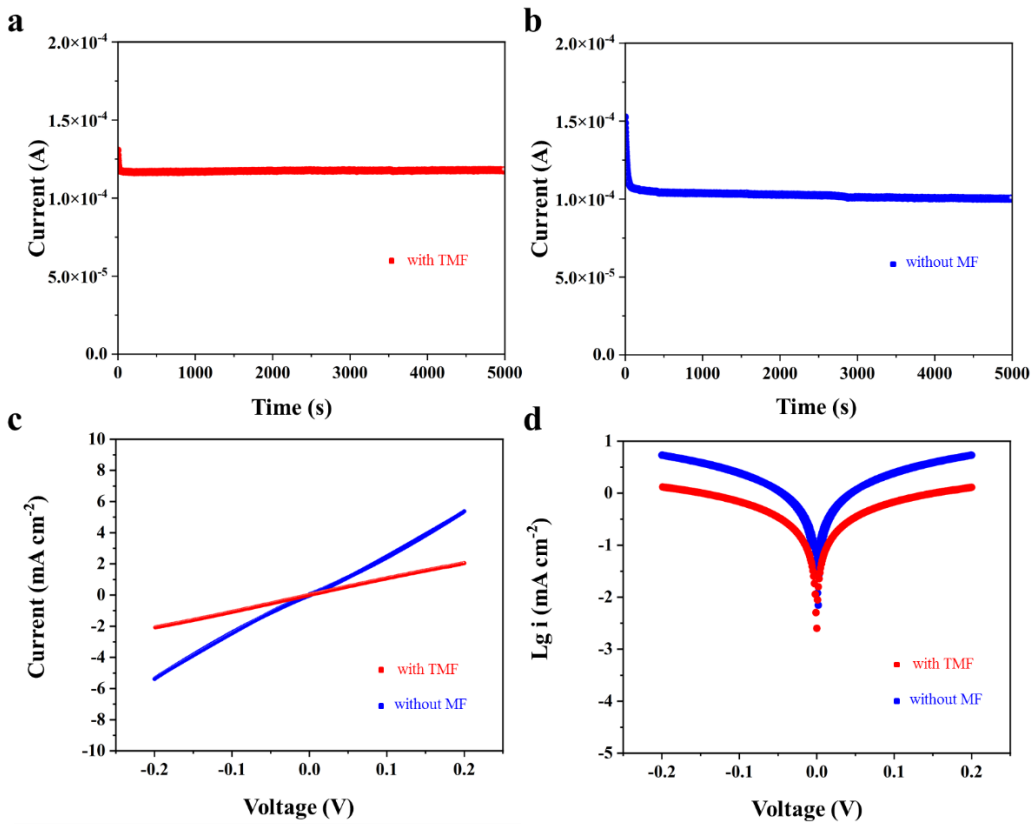

Figure. S4 Lithium ion migration number of the Li||Li symmetric battery with (a) toroidal magnetic field, (b) no magnetic field. Exchange current density of the Li||Li symmetric battery with (c) toroidal magnetic field, (d) no magnetic field.

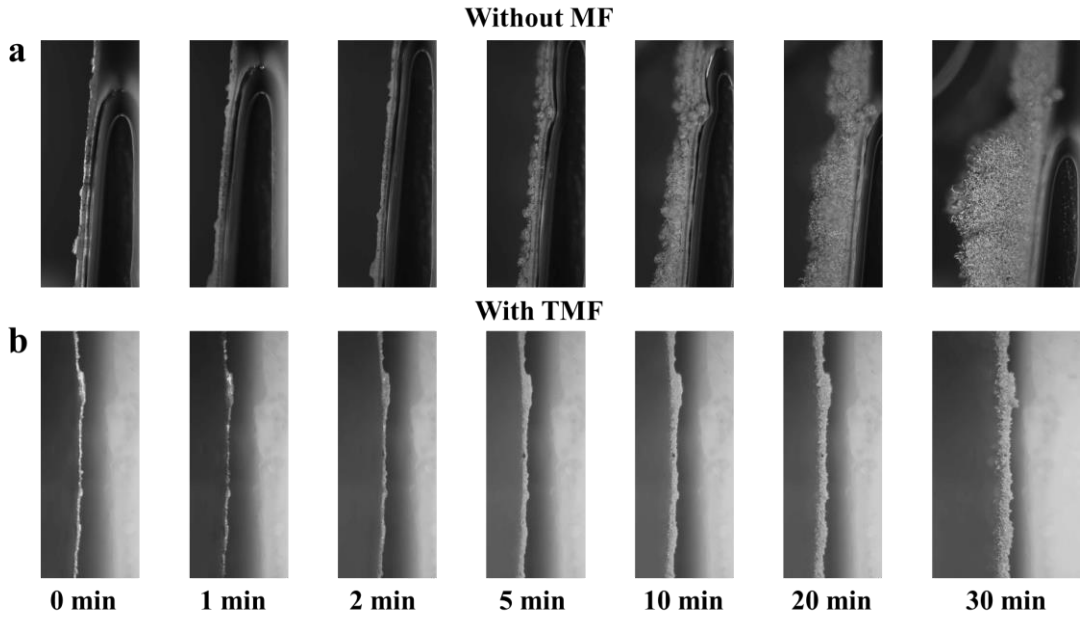

Figure. S5 In situ optical microscopy of Li||Cu battery at 20 mA/cm^2 for 0-30 minutes with (a) no magnetic field, (b) toroidal magnetic field.

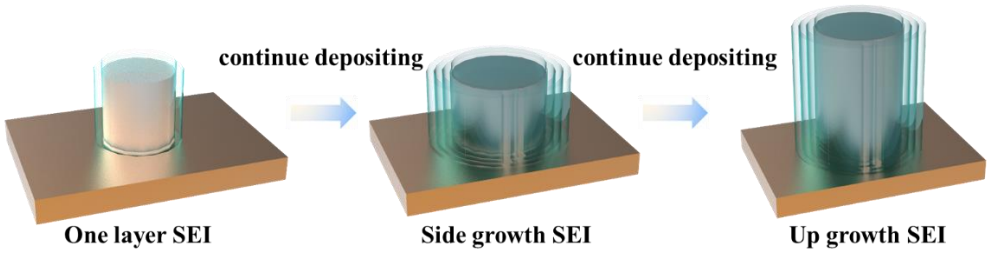

Figure. S6 Explanation of the growth mechanism of three-dimensional SEI framework.

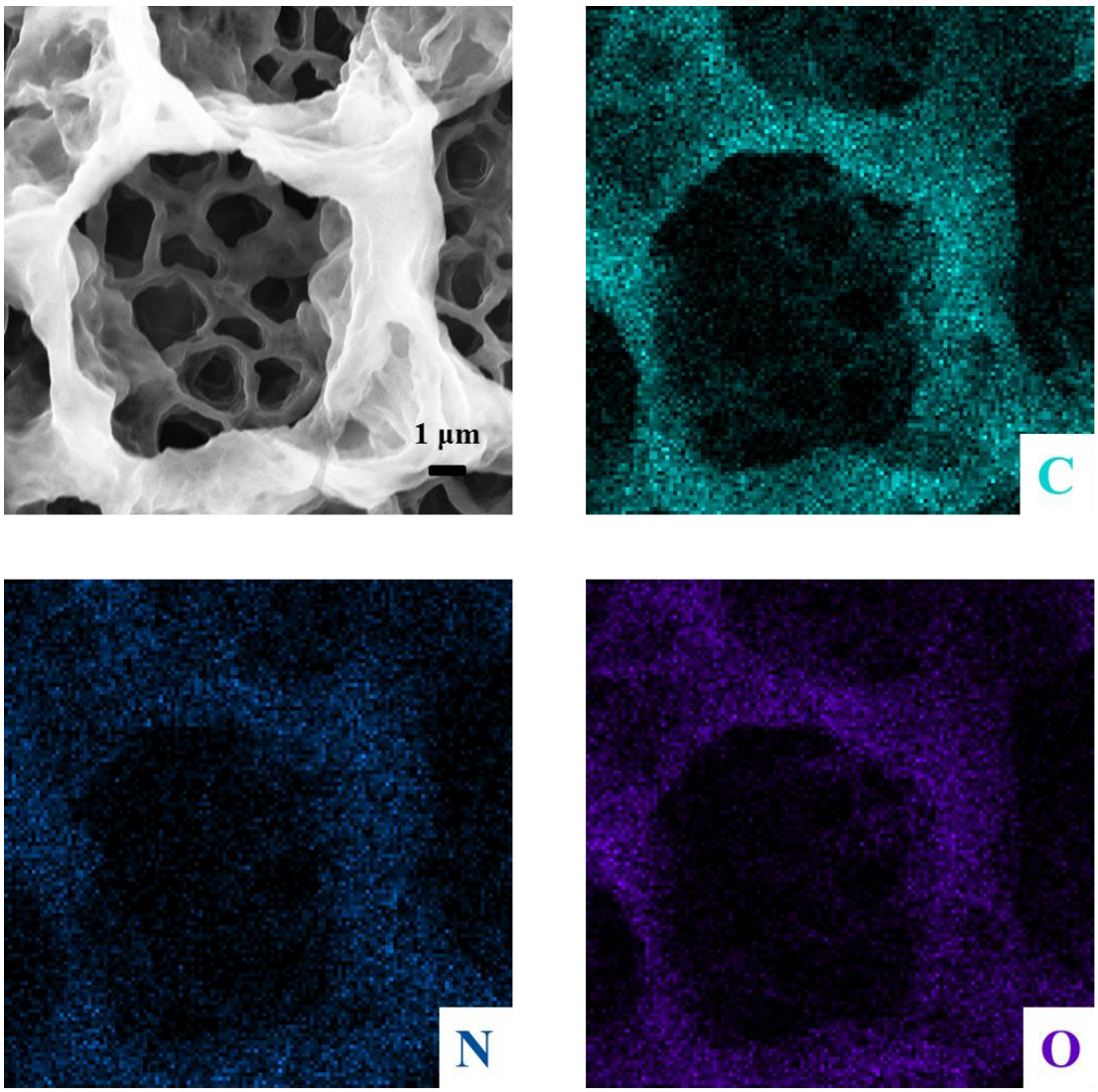

Figure. S7 The mapping element of the C, N and O elements.

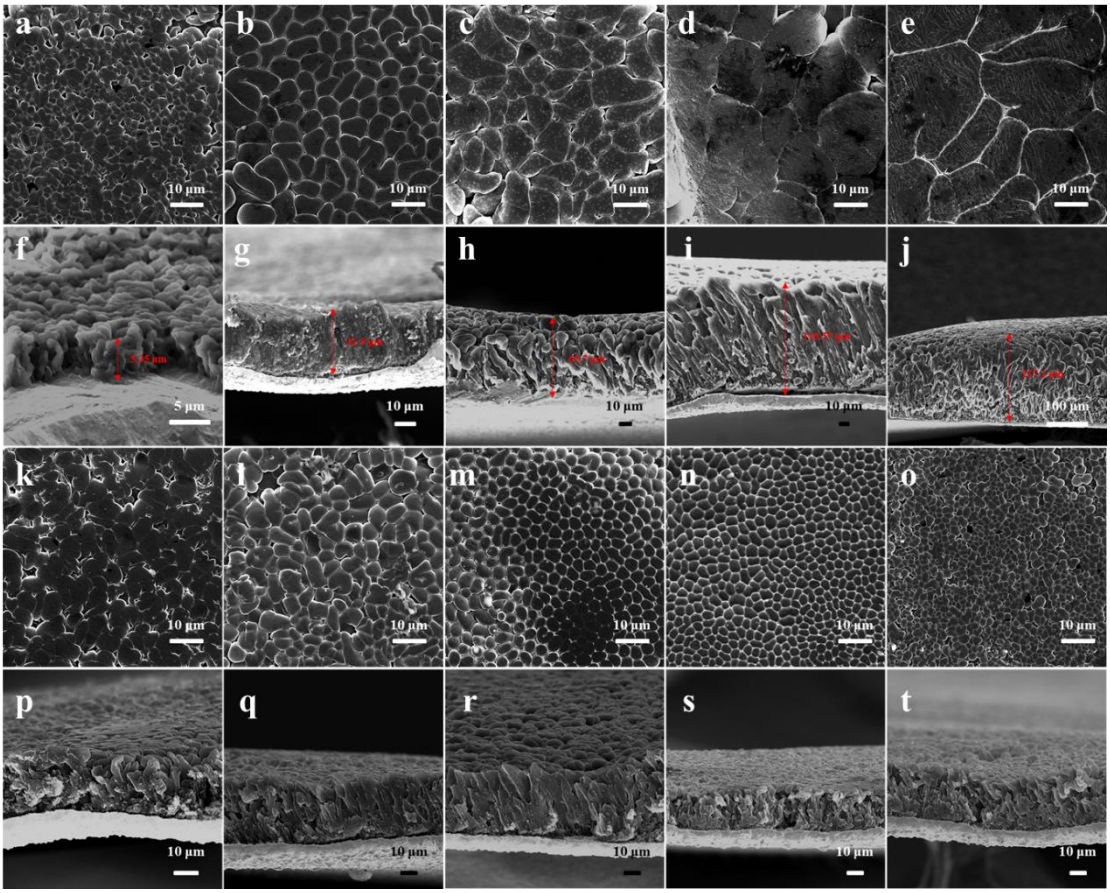

Figure. S8 The top surface SEM images of electrodepositing with toroidal magnetic field at the current density of 1 mA/cm^2 for (a) 1 mAh/cm^2, (b) 5 mAh/cm^2, (c) 10 mAh/cm^2, (d) 20 mAh/cm^2. (e) 50 mAh/cm^2. And cross-section topography at the current density of 1 mA/cm^2 for (f) 1 mAh/cm^2, (g) 5 mAh/cm^2, (h) 10 mAh/cm^2, (i) 20 mAh/cm^2. (j) 50 mAh/cm^2. The top surface SEM images of electrodepositing with toroidal magnetic field for 5 mAh/cm^2 at the current density of (k) 2 mA/cm^2, (l) 5 mAh/cm^2, (m) 10 mAh/cm^2, (n) 20 mAh/cm^2. (o) 50 mAh/cm^2. And cross-section topography with toroidal magnetic field for 5 mAh/cm^2 at the current density of (p) 2 mA/cm^2, (q) 5 mAh/cm^2, (r) 10 mAh/cm^2, (s) 20 mAh/cm^2. (t) 50 mAh/cm^2.

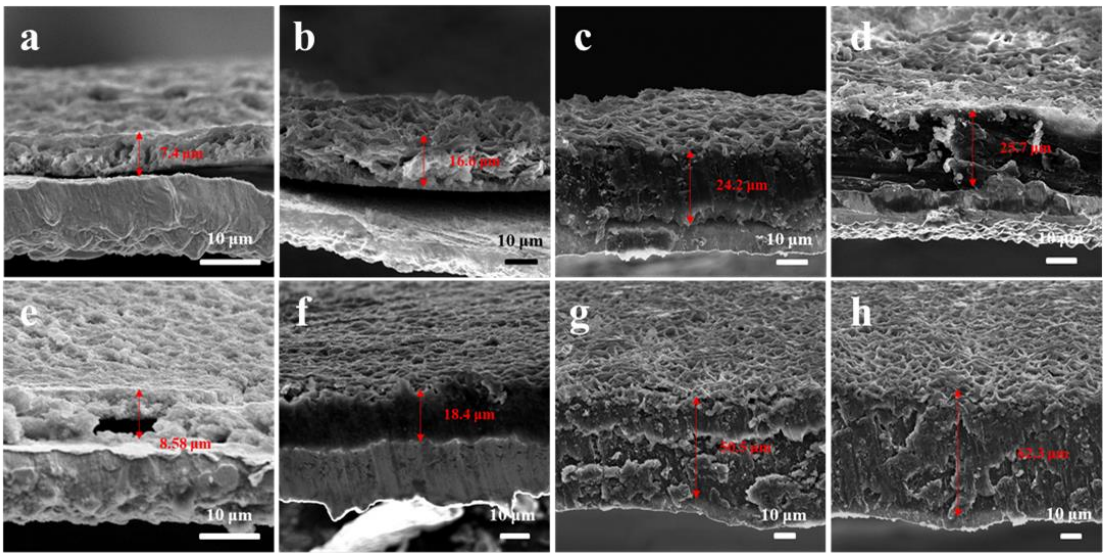

Figure. S9 The cross section SEM images for three-dimensional SEI framework deposition/stripping after different times. (a-d) Deposition/stripping after 1, 5, 10 and 20 times at the current density of 5 mA/cm^2. (e-h) Deposition/stripping after 1, 5, 10 and 20 times at the current density of 10 mA/cm^2.

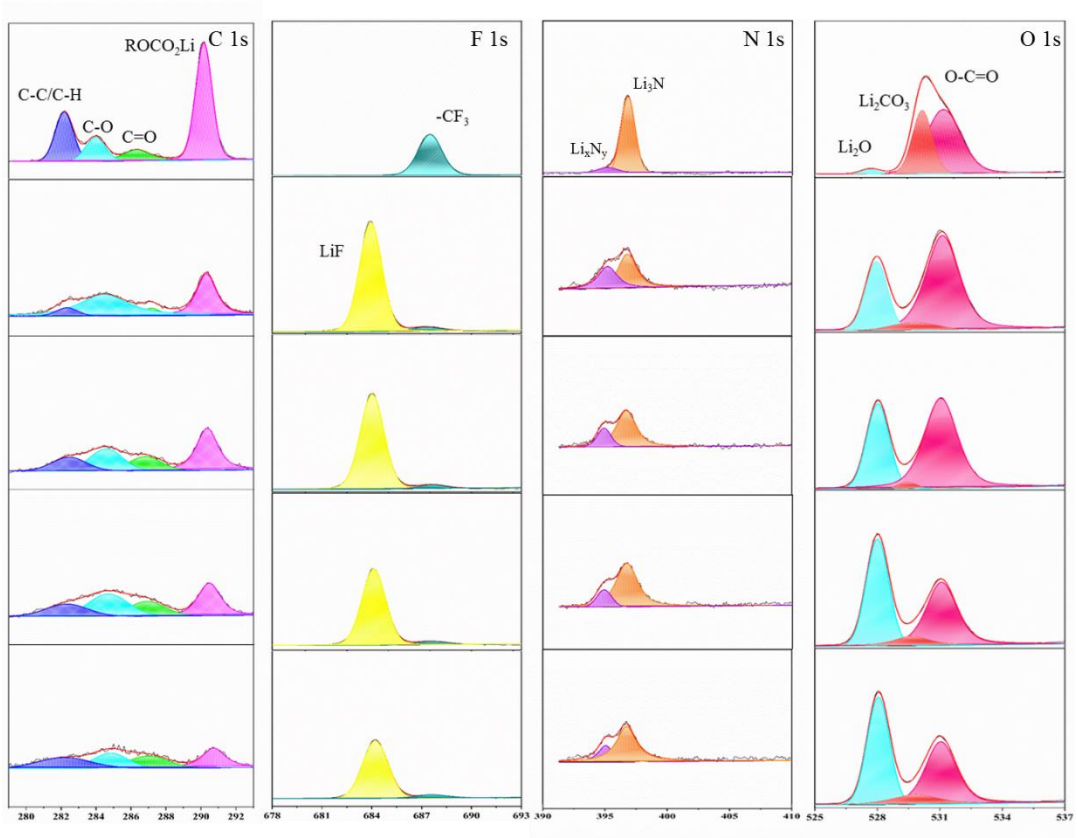

Figure. S10 In-situ XPS etching tests for C, F, N and O elements at 0, 50, 100, 150 and 200 sec on common SEI structure

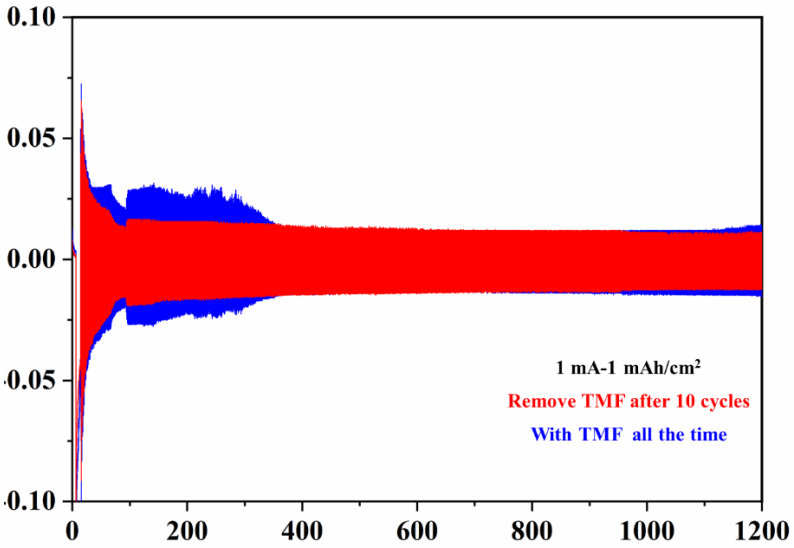

Figure. S11 Cycling performances of the Li||Li symmetric battery at 1 mA/cm^2-1 mAh/cm^2, for removing TMF after 10 cycles and cycled with TMF all the time.

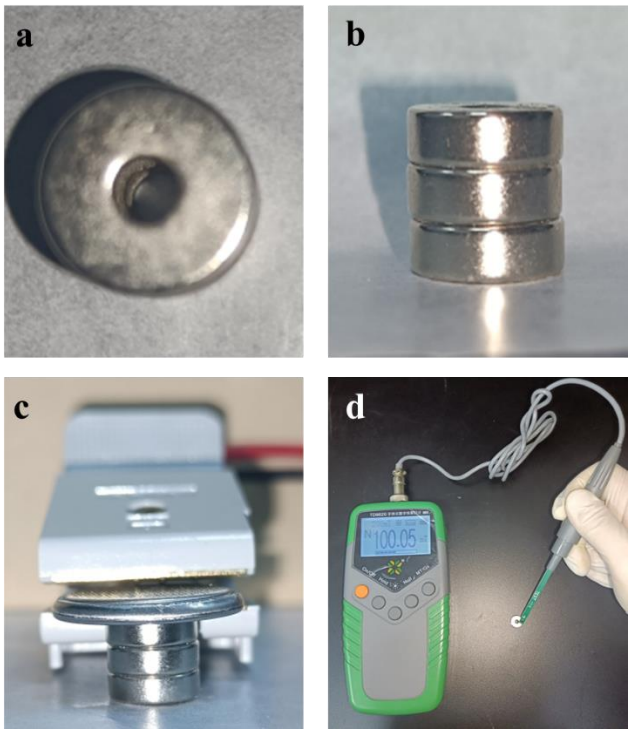

Figure. S12 The photo of toroidal magnet at (a) vertical view, (b) Side view. (c) The magnet is placed under the battery. (d) The magnetic flux at the top of the magnet is about 100 mT.

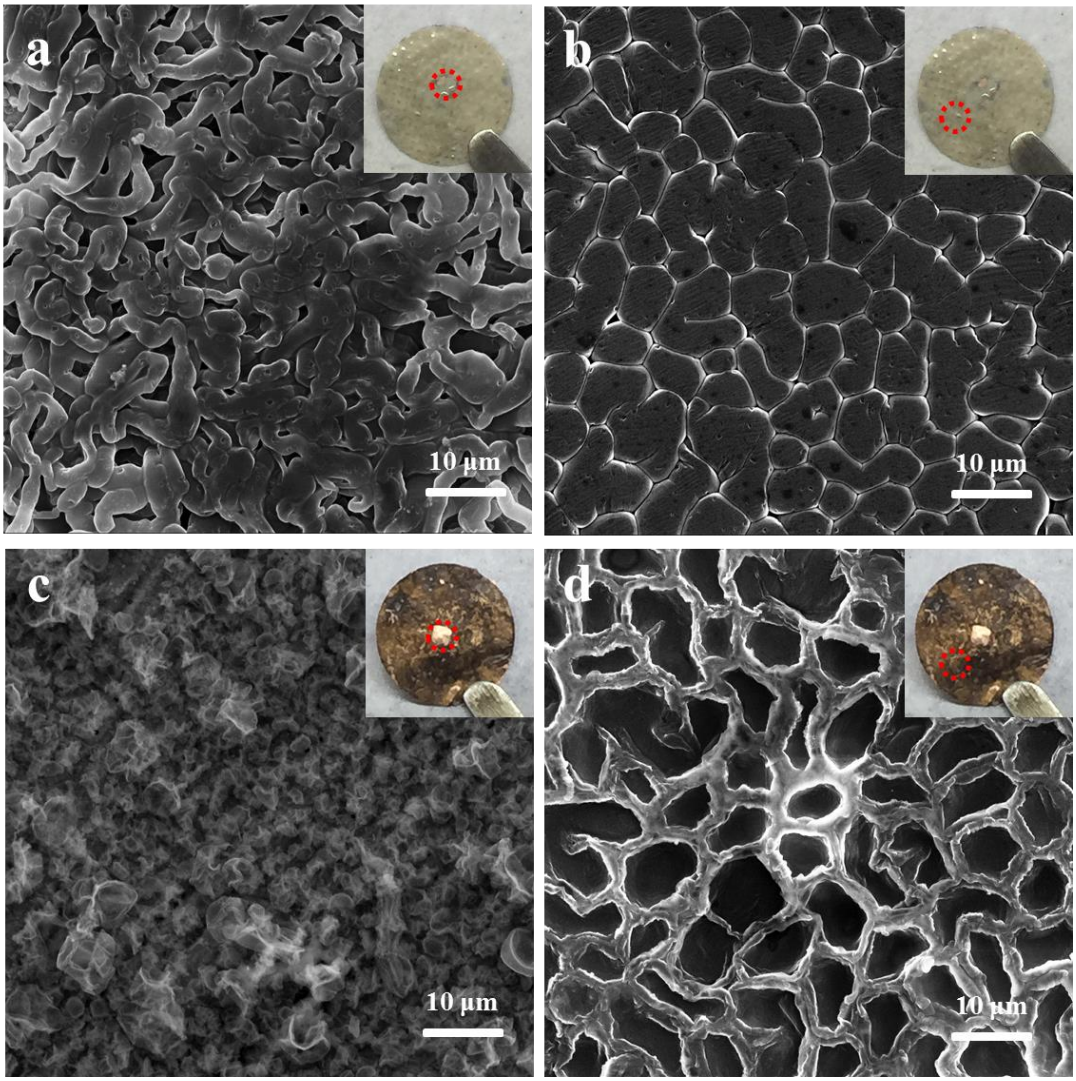

Figure. S13 The SEM images of the deposited Li metal anode of 5 mAh/cm2, (a) center of the Li metal anode, (b) near-edge of the Li metal anode. The SEM images of the 3DSF (c) center of the Li metal anode, (d) near-edge of the Li metal anode.