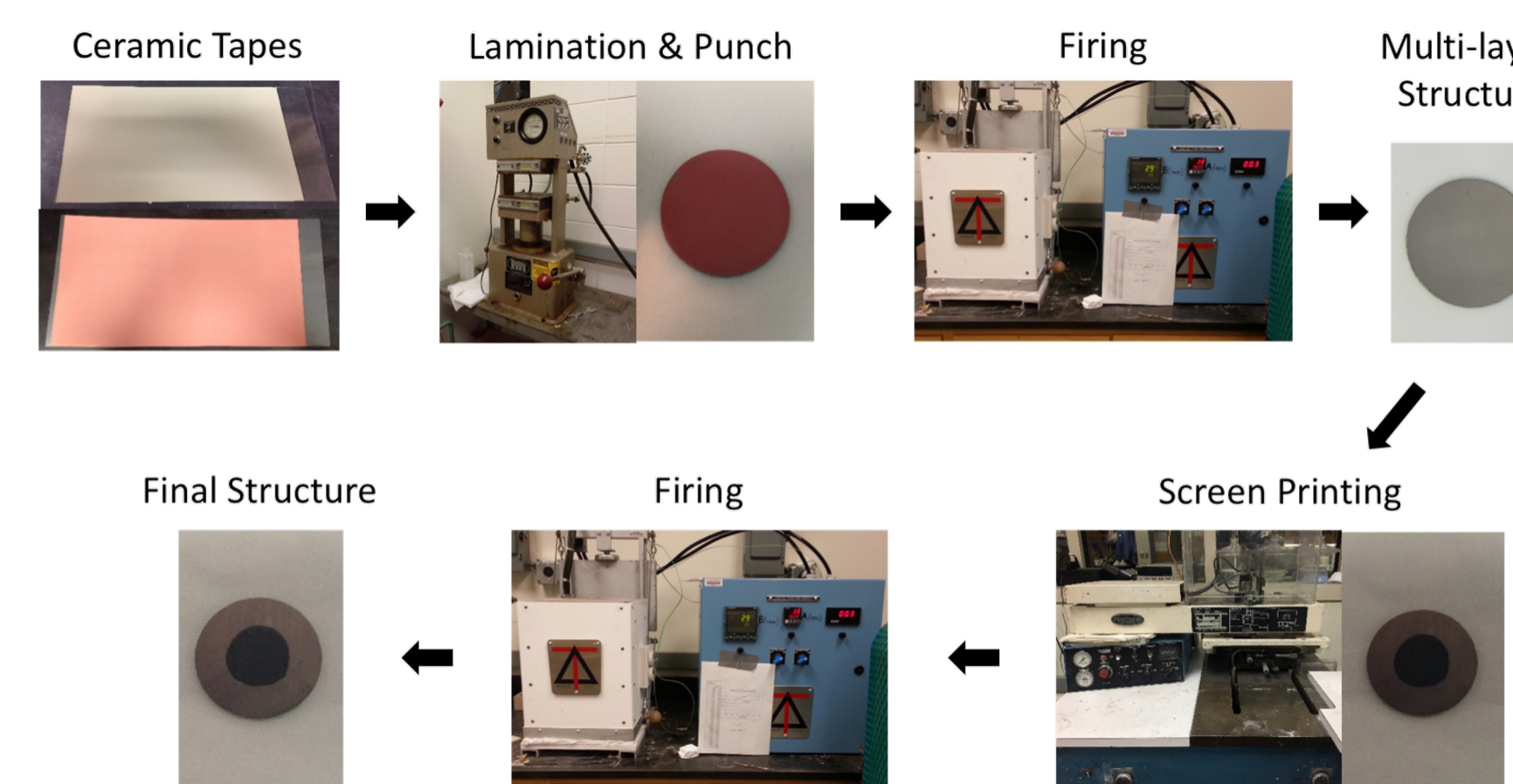
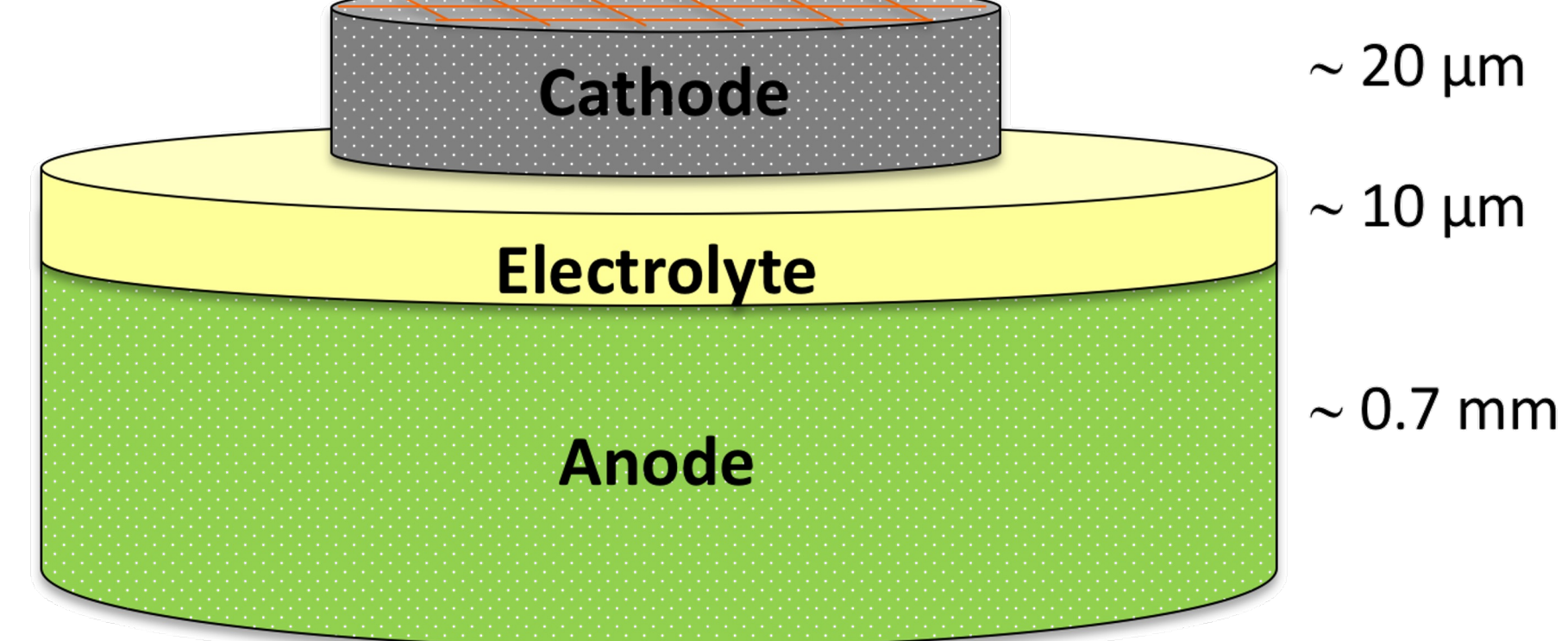
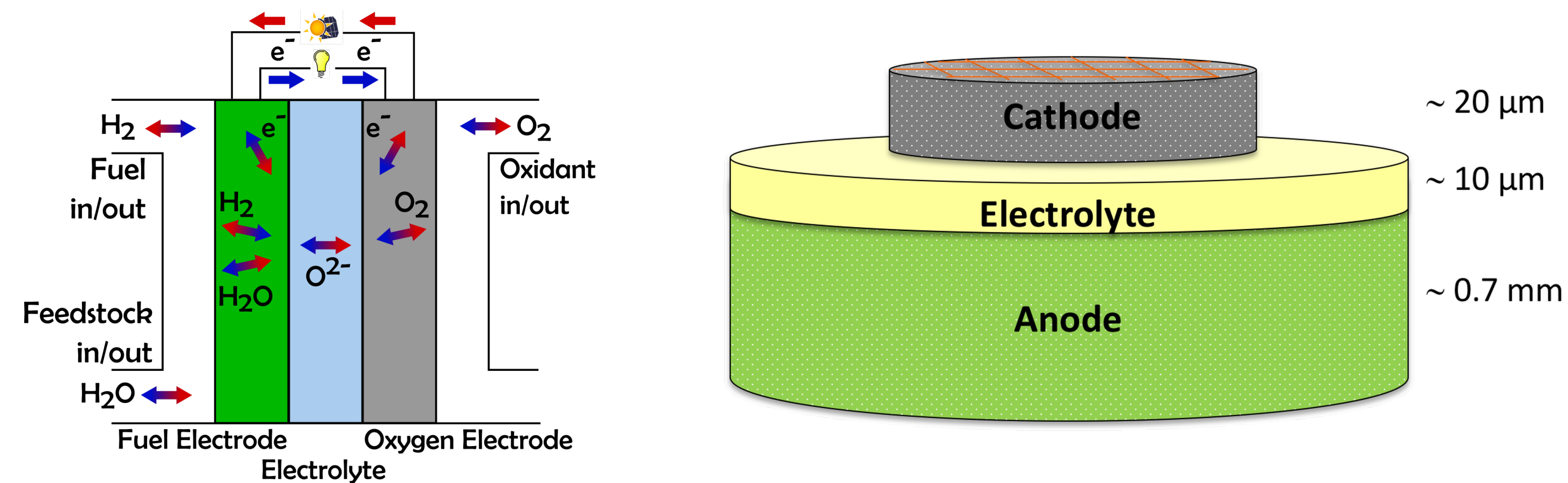


# Scott Barnett Research Group

## Department of Materials Science and Engineering Northwestern University

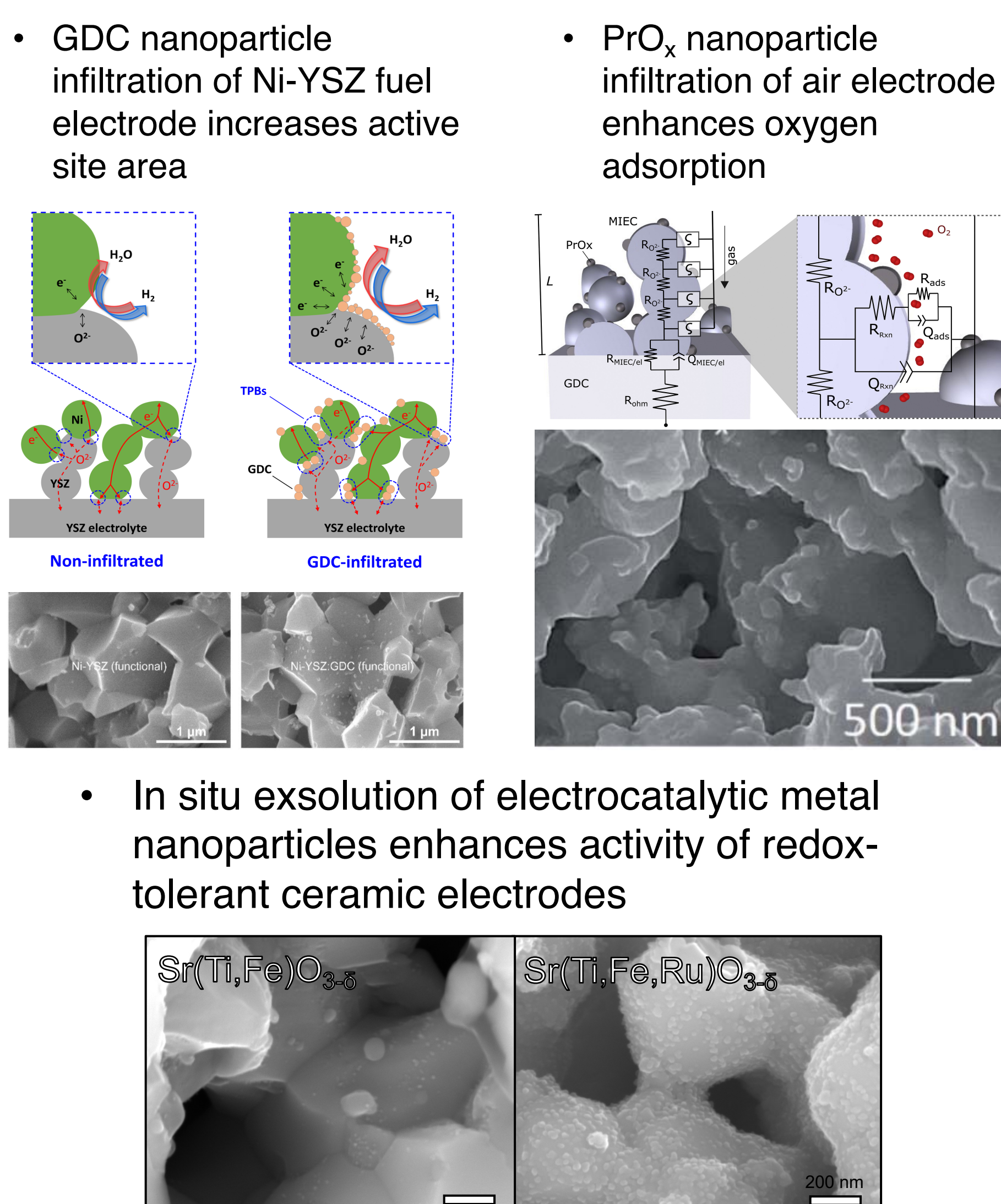


### Solid Oxide Fuel and Electrolysis Cells

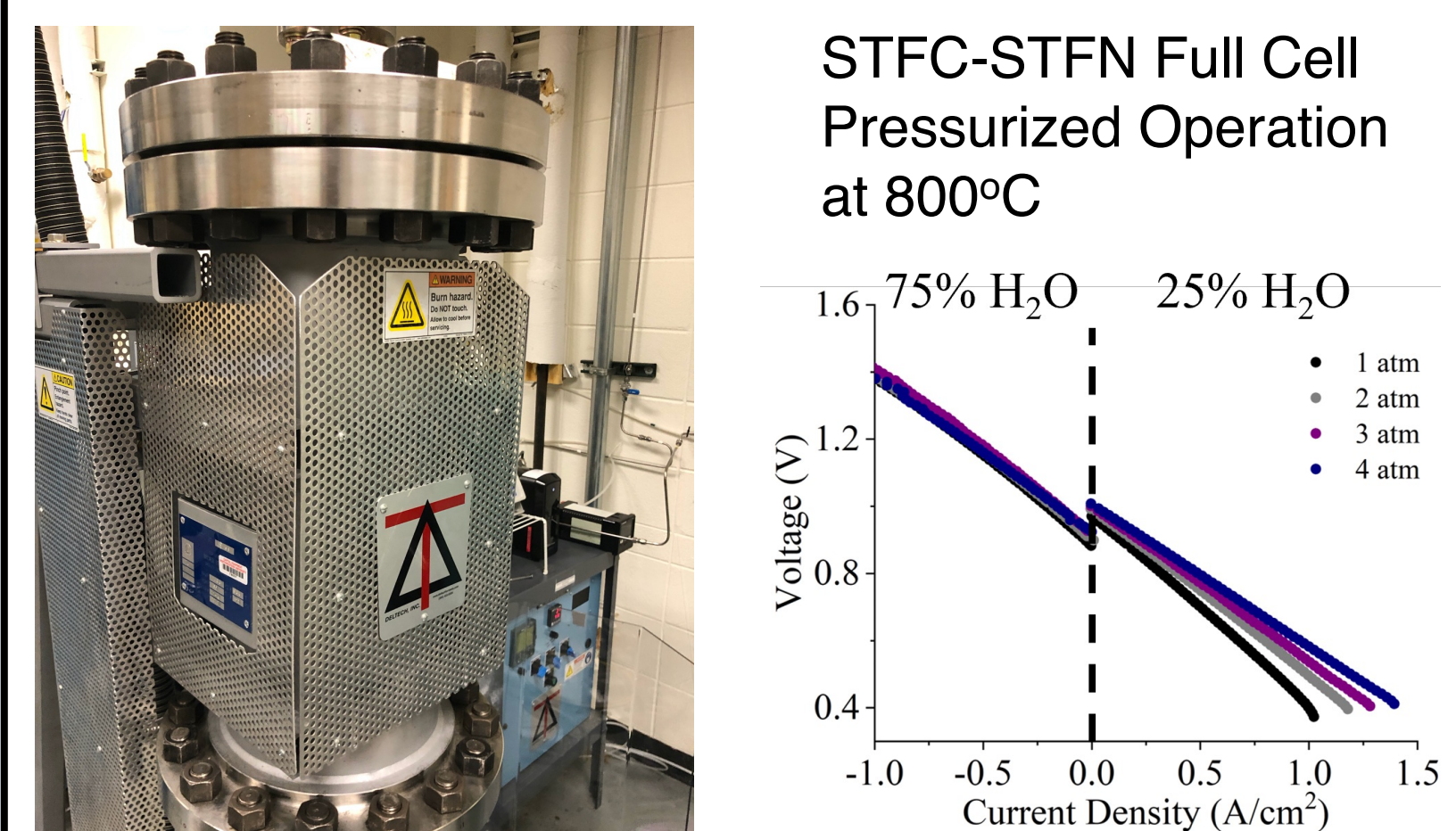


- SOFCs are solid-state electrochemical devices consisting of ceramic/cermet layers typically operating at 600-1000°C
- Constructed independent of fuel ( $H_2$  or  $C_xH_y$ ) reservoir size
- Applications as distributed power generators, energy storage systems, and electrolyzers
- Degradation over long (> 40,000hr) operation is a barrier to commercialization

### Nanostructured Electrodes

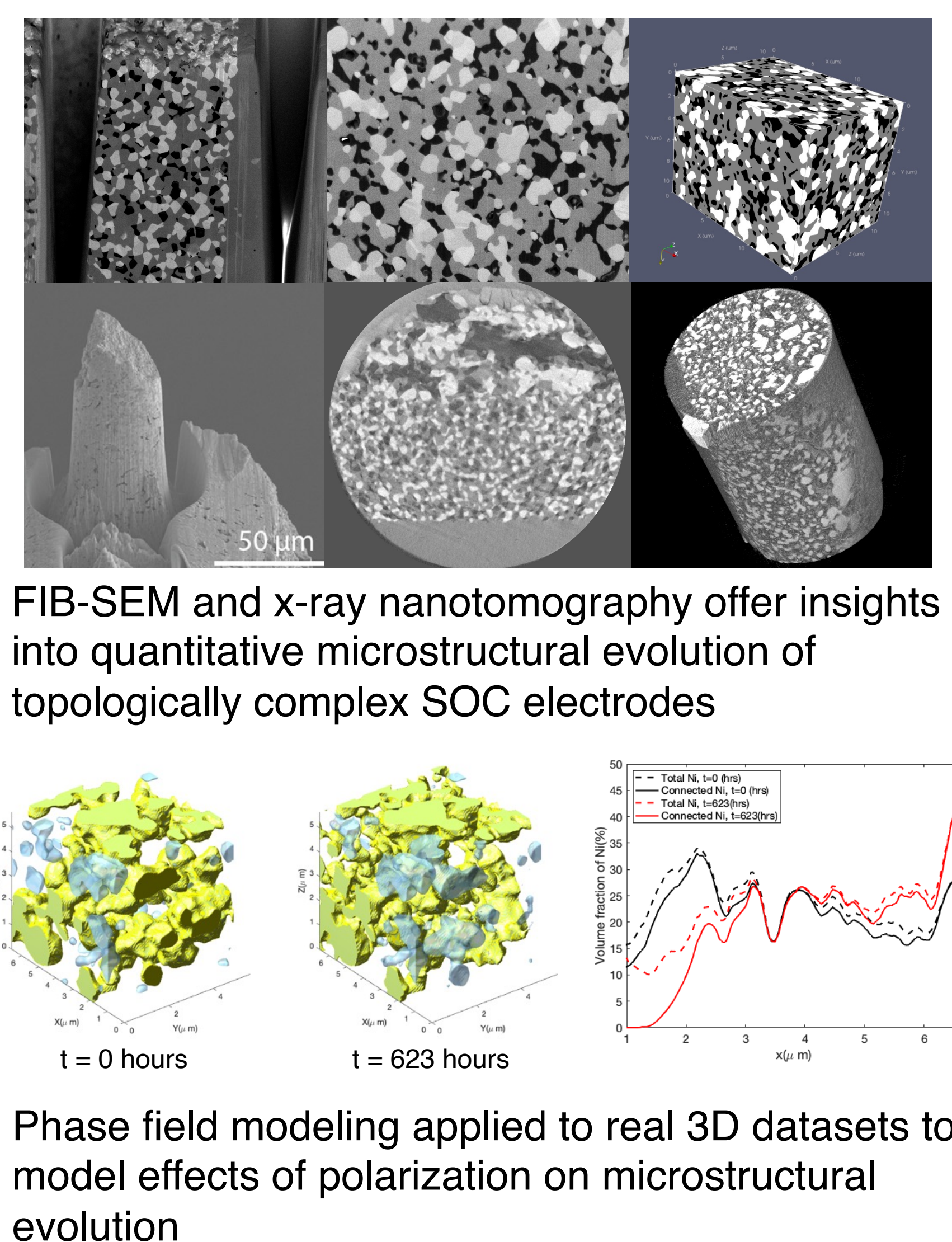


### Pressurization



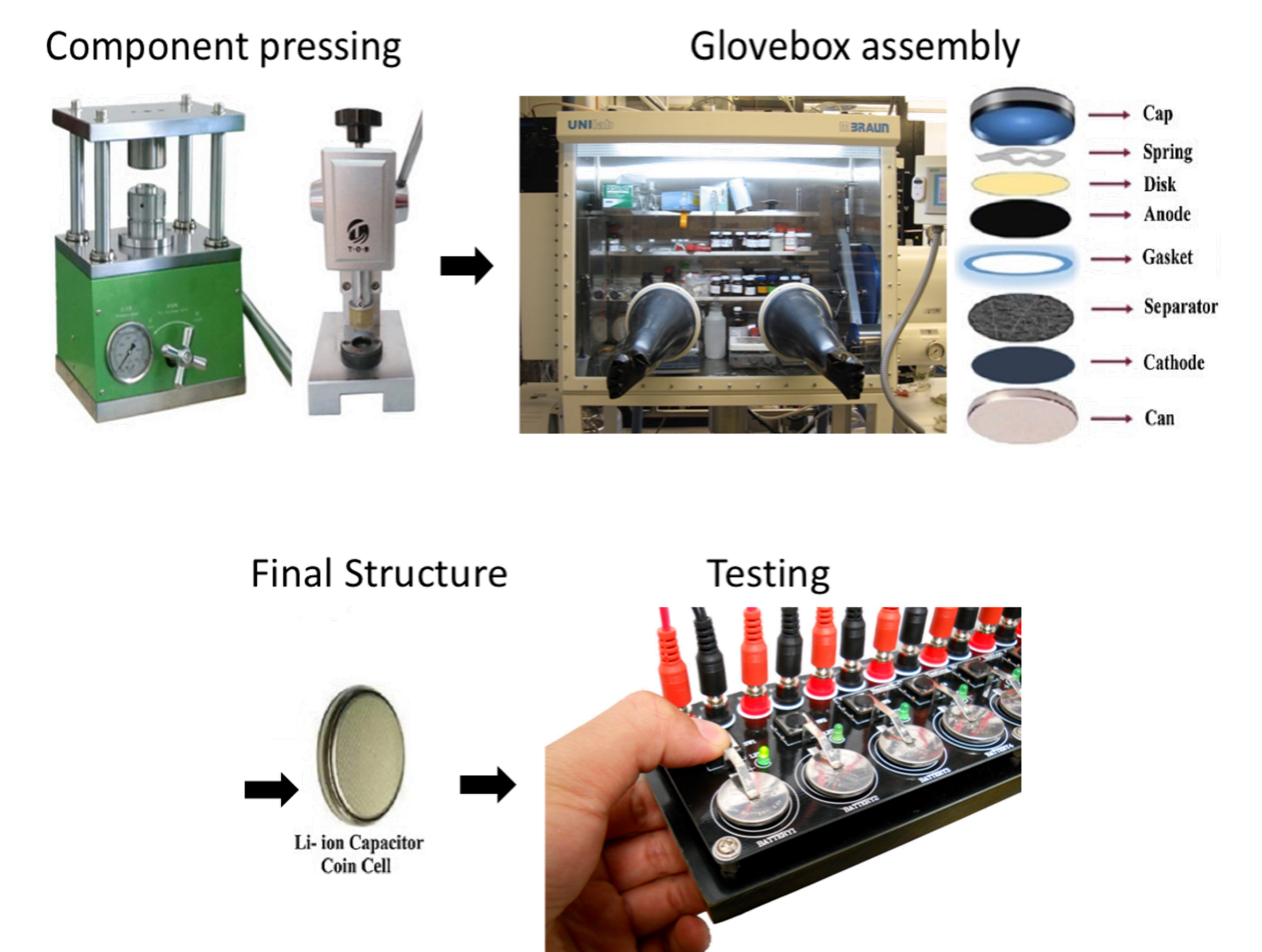
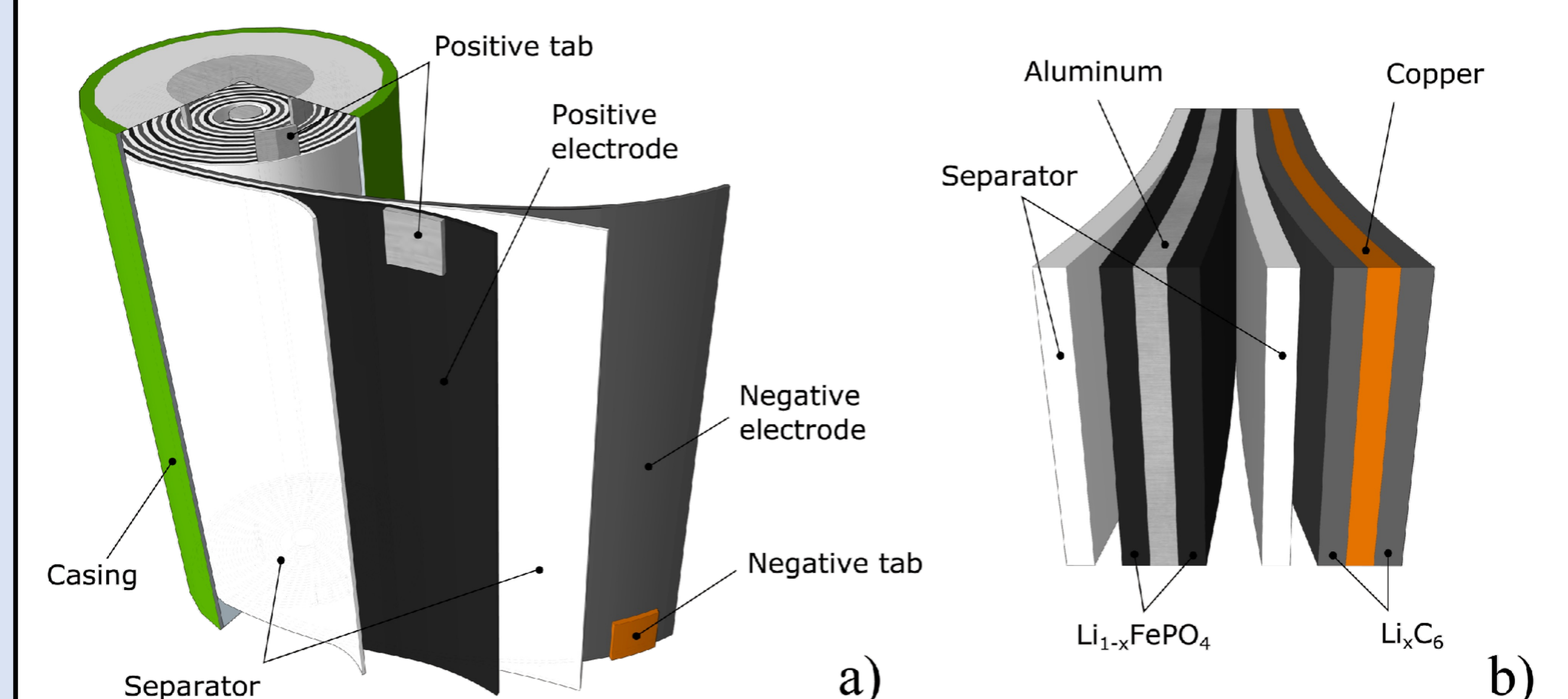
- Polarization resistance reduces with increasing pressure
- Nanoparticle catalytic activity increases with increasing pressure

### 3D Nanotomography



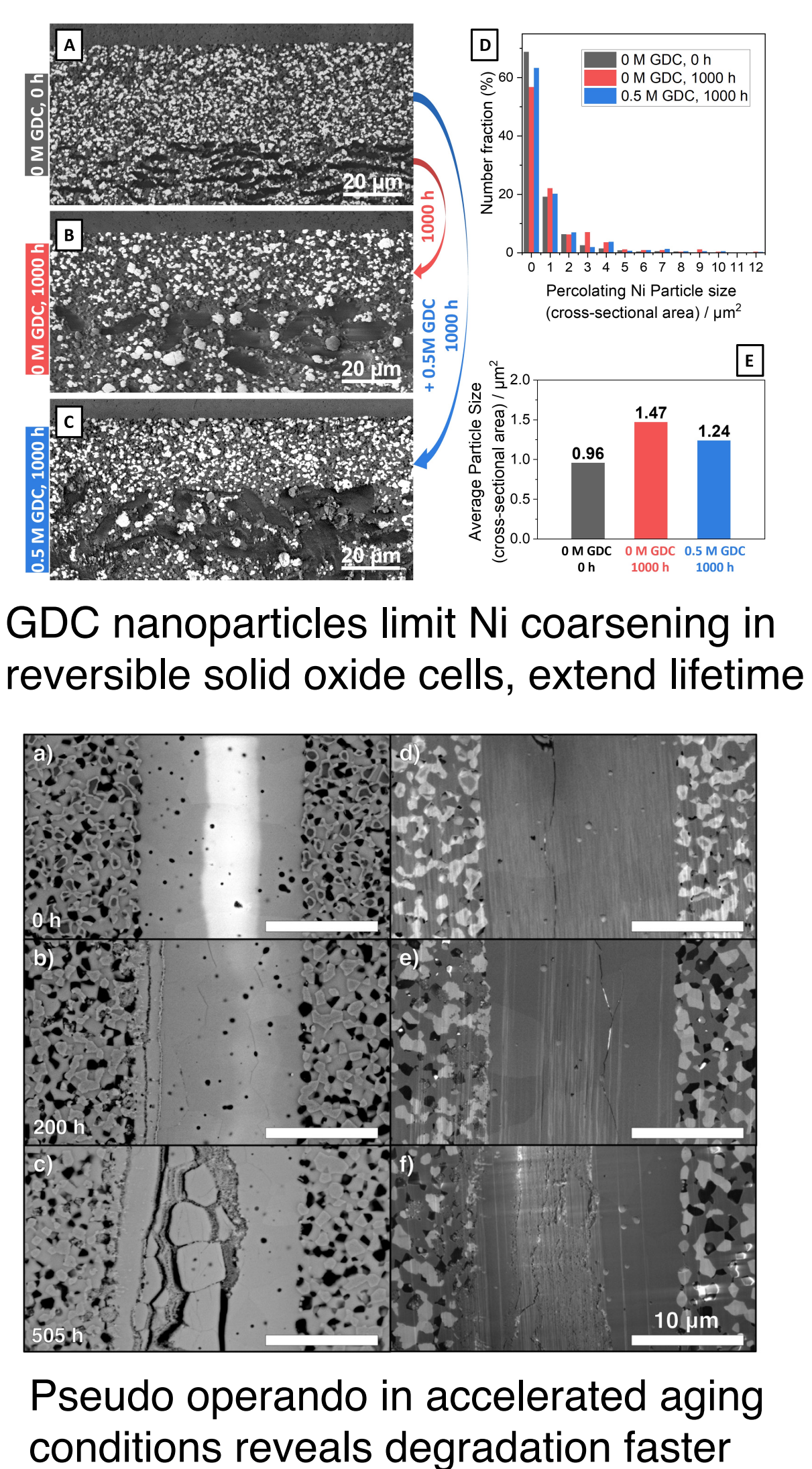
Phase field modeling applied to real 3D datasets to model effects of polarization on microstructural evolution

### Li-ion Batteries

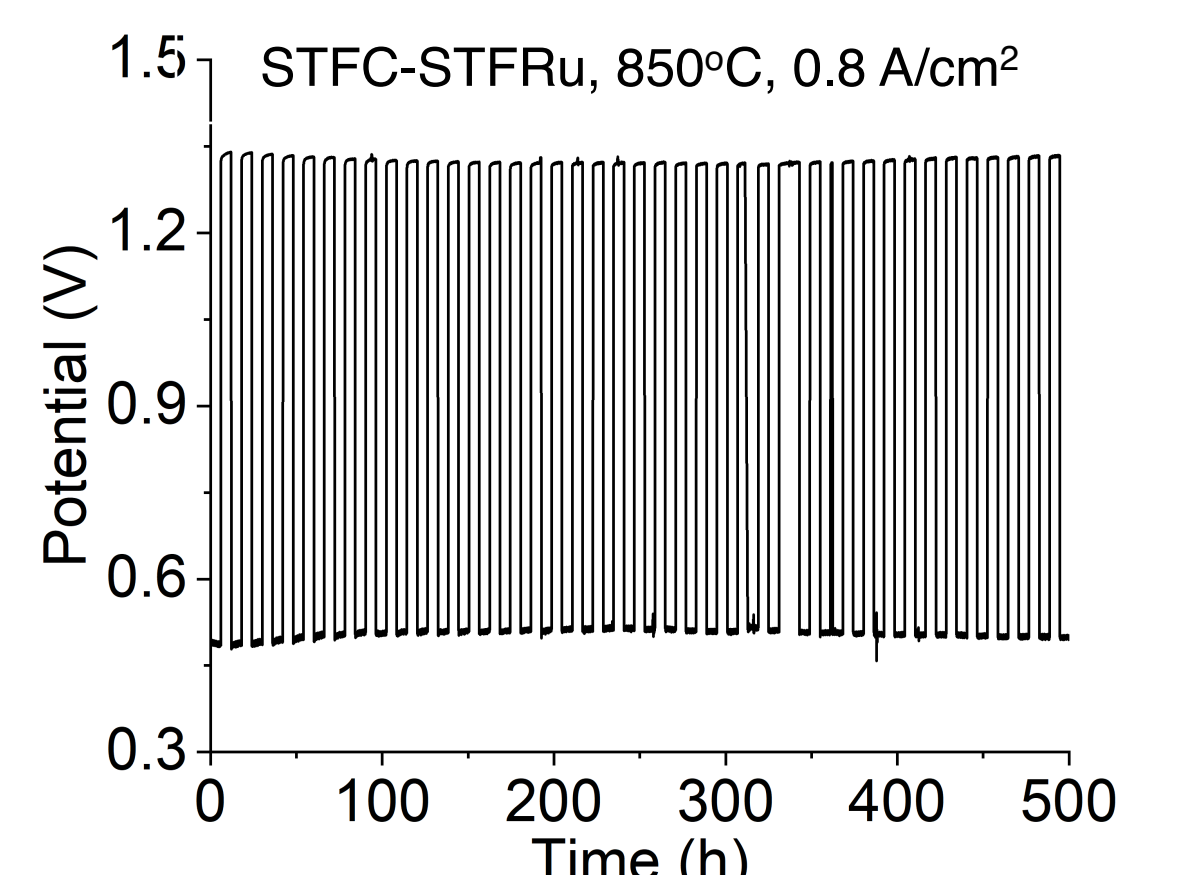


- LIBs made up of transition metal oxide electrodes with a solid-state or liquid electrolyte
- Stored capacity dependent on amount of cathode and anode active material
- Investigated materials: LFP and LMO (cathode), LTO and graphite (anode)
- Research focused on energy density, cyclability, safety, and calendar life

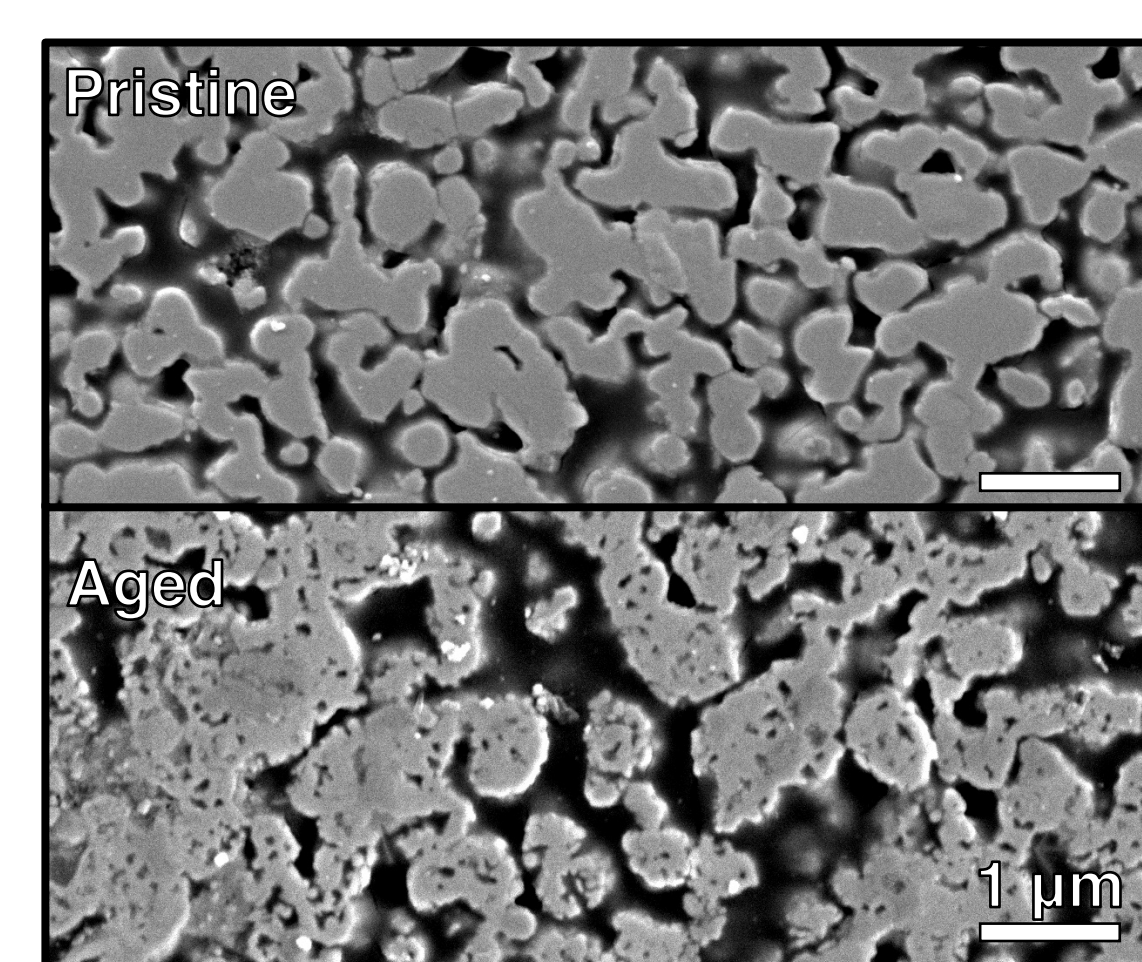
### Degradation



Pseudo operando in accelerated aging conditions reveals degradation faster

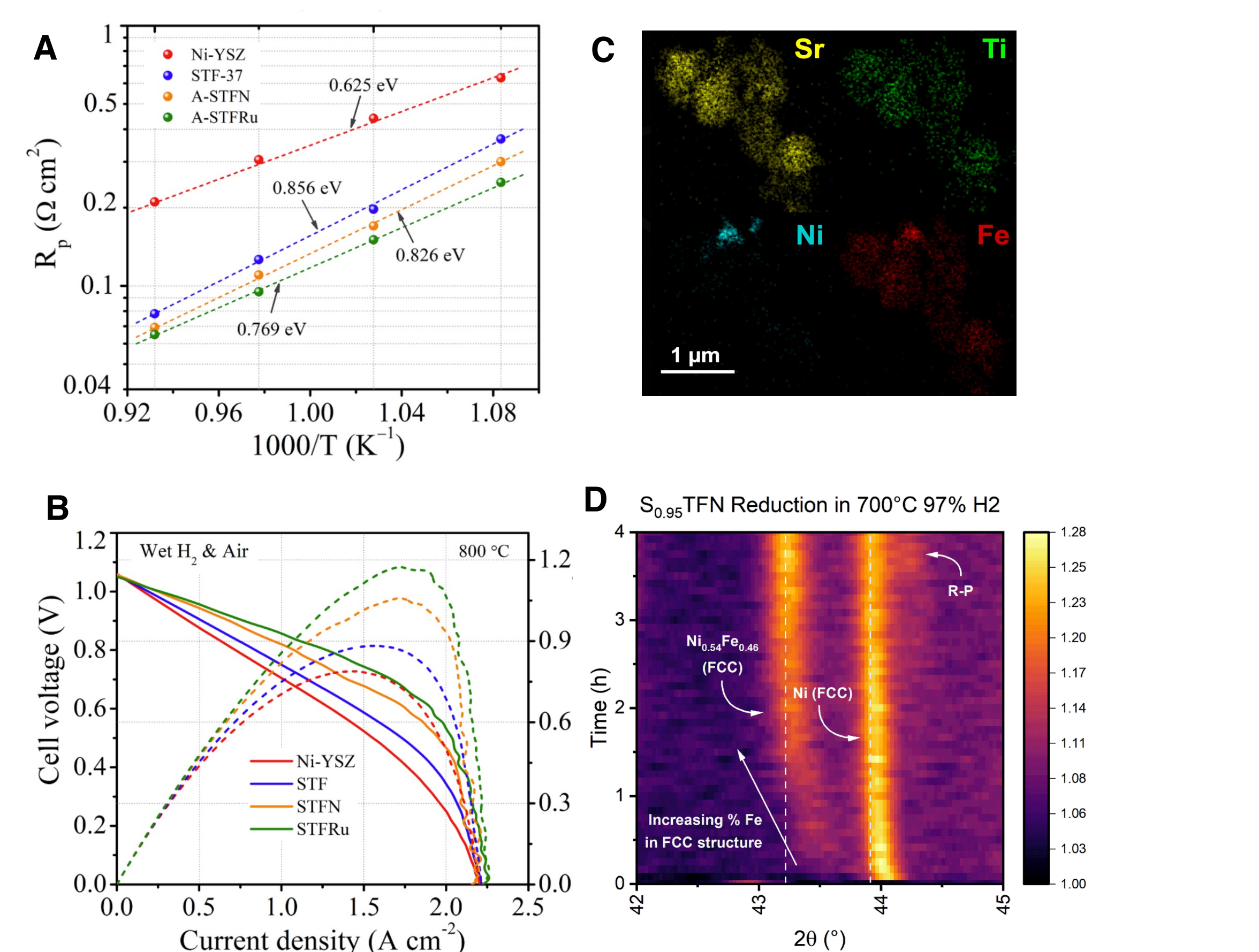


Stable operation for SOCs with ceramic electrodes under reversible operation



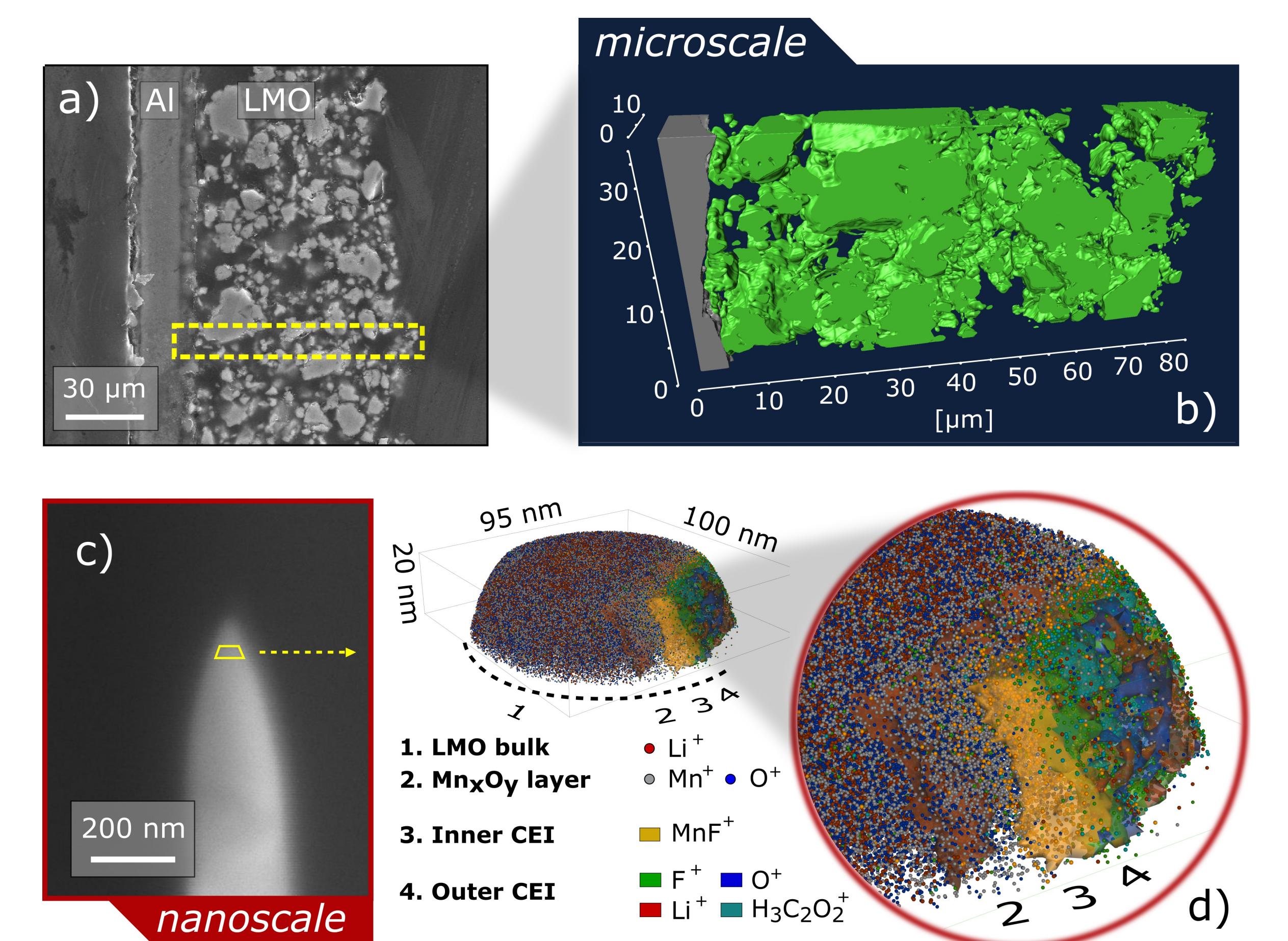
Operation of large-area cells reveals degradation from  $Cr_2O_3$  vapors

### Materials Development



- New high- $\sigma$  perovskites like  $SrTi_{1-x}Fe_xZ_{y-1}O_{3-\delta}$  ( $Z = Ni, Ru, Co$ , etc.) show lower polarization resistances (A) and Peak power densities (B) than the industry standard
- Changes in local composition and structure can be tracked through energy-dispersive x-ray spectroscopy (C) and in-situ x-ray diffraction (D) to map out the phase space of the new materials

### Multiscale Li-ion Characterization



Multi-scale characterization of a  $LiMn_2O_4$  (LMO) electrode and its cathode electrolyte interphase (CEI) layer. (a) Cross-sectional SEM image of the LMO electrode and (b) FIB-SEM 3D reconstruction of an electrode; (c) sharpened tip for atom probe tomography (APT) nanoscale analysis; (d) 3D ion map of the LMO electrode