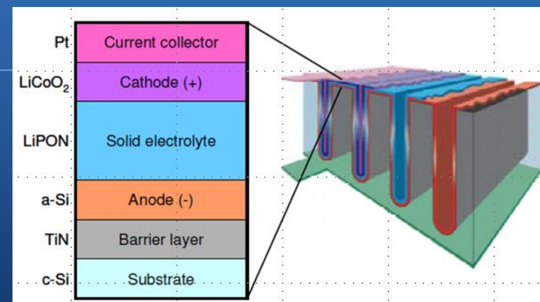
Multicomponent Lithium Oxide ALD for Solid State Batteries



Ultratech Cambridge Nanotech provides optimal ALD solutions toward all solid-state 3D Li-ion batteries: fully optimized Lithium oxide thin films with low contamination, tunability of the composition for ternary and quaternary Lithiated films, in-situ diagnostic for rapid process optimization and film characterization.

Electrode materials, solid state electrolytes & passivation layers

Due its inherent self-limited nature, Atomic Layer Deposition is an ideal candidate to achieve dense, uniform and conformal thin films with unprecedent tunability of the thickness and composition.

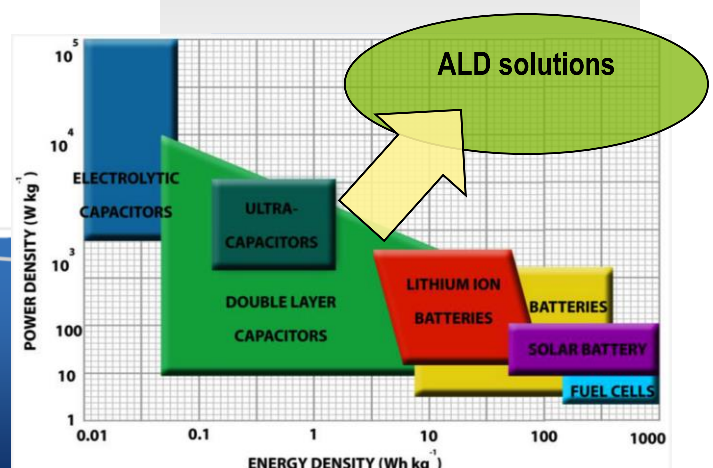
By implementing Lithium-based ALD films in nanostructured 3D Li-ion batteries, significant gains in power density, cycling performances during charge/discharge, and safety have been recently reported.

Using Ultratech Cambridge Nanotech ALD platforms, electrochemically active materials with high specific capacity such as $LiCoO_2$, $LiMn_2O_4$ ternaries or lithium transition metal phosphate quarternaries (e.g., $LiFePO_4$) have been successfully deposited on high aspect ratio 3D nanostructures, leading to fast ion transport and increased power density.

Safer solid state electrolyte exhibiting high Lithium ion conductivity combined with low electron conductivity have also been demonstrated, and novel solutions to implement all-solid state with enhanced structural stability, low volume change during charge discharge, greater safety are now achievable.

ALD Benefits for 3D Li-ion batteries

Higher Power	Shorter diffusion path in 3D nanostructure lead to higher power density
Discharge Rate	Improved charge / discharge rate from high surface to volume ratio
Cycle Life	Improved cycle life using ALD passivation layers and low-stress films
Safety	Non-flammable solid-state electrolyte



Lithium-based active layers

With the Savannah thermal and Fiji Plasma Enhanced ALD reactors, Ultratech Cambridge Nanotech provides excellent solutions to deposit lithium oxide and Lithium based multicomponent films.

- Controlled and reproducible delivery of the Lithium precursor at a safe temperature (130˚C for LiOtBu) using Low Vapor Pressure Delivery (LVPD) kit, with low carbon contamination (<at.0.1%) of Li_2O films [1]

- Wide range of Li-based multicomponent oxide chemistries demonstrated for ternary and quaternary materials including Li, Mn, Co, P, Fe, Ta oxides for cathode, anode and solid electrolyte materials [2-4]

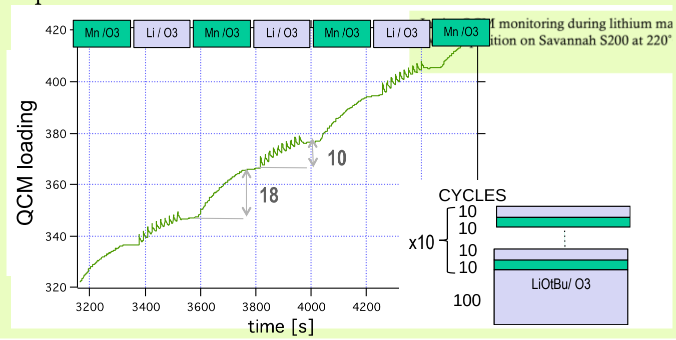
- Fully integrated in-situ capabilities (Quartz Crystal Microbalance, Spectroscopic Ellipsometry) enable real-time diagnostic and metrology, to characterize complex reaction mechanisms in multicomponent systems and control the film composition.[5]

- Most published peer-reviewed articles for active ion storage materials, solid state electrolyte and passivation layers on a commercial ALD platform

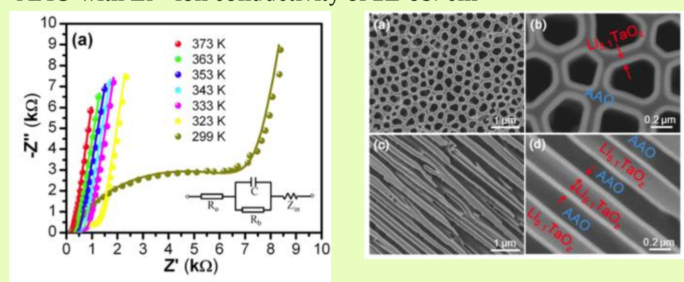
ALD Passivation layers for enhanced battery performances

ALD has been demonstrated has an excellent pathway to deposit very thin passivation layers (<1nm) that significantly improve capacity retention of LIBs during electrochemical cycling by inhibiting the dissolution of the transition metal while enabling the diffusion of the Lithium through the passivation layers.[6]

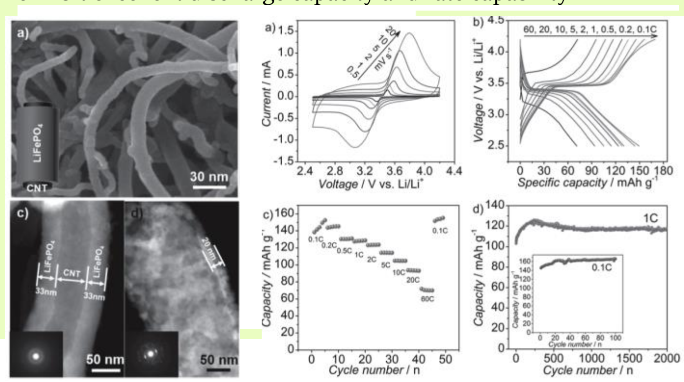
In-situ QCM monitoring during lithium manganese oxide deposition on Savannah S200 at 220˚C [4]

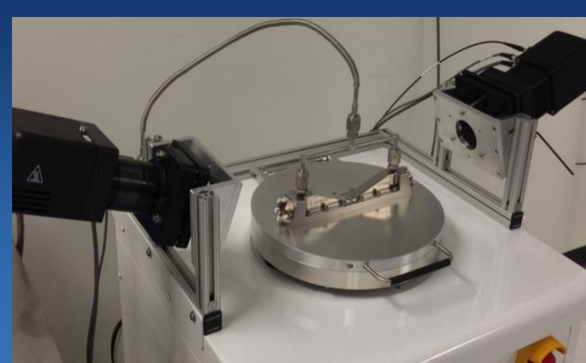


Deposition of $Li_{5.1}TaO_2$ solid electrolyte in high aspect ratio AAO with Li+ ion conductivity of 2E-8S/cm [2]



Conformal $LiFePO_4$ cathode film deposited on carbon nanotube exhibit excellent discharge capacity and rate capability [3]





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