



WE'VE GOT IT COVERED

Cost-effective coatings for advanced materials.

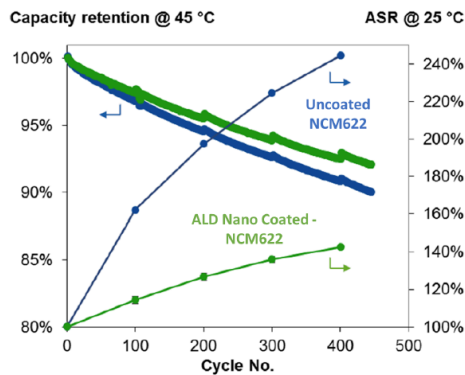
PROPRIETARY ALD-ENABLED SOLUTIONS FOR CAMS & OTHER LIB MATERIALS

In partnership with BASF, ALD Nano has created an ALD-enabled CAMs solution that enhances battery performance, lifetime and safety.

This solution combines atomic layer deposition (ALD) chemistries, process recipes, and reactor systems to enable the safe use of higher voltages for cathode active materials (CAMs), resulting in higher energy densities. ALD-coated CAMs include NMC, NCA, and LMNO, among others, for various applications with lithium ion batteries (LIBs).

Process licenses for the technology and the commercial equipment systems to deliver this solution are available. ALD Nano can supply and commission the continuous vibrating reactor (CVR) equipment system specifically designed for commercial-scale coating of CAM and other powders. These systems are cost-effective, compact, and process powder in a continuous fashion at atmospheric pressure.

CAM TESTS RESULTS (CYCLE STABILITY AT 4.2V)



Source: ALD Nano's Fortune 500 company partner.

BENEFITS OF OUR ALD FOR BATTERIES

Atomic Layer Deposition (ALD) is a gas-phase process technique used to functionalize and coat surfaces with atomic-level precision. ALD coatings are covalently bonded to the surface, conformal, uniform, continuous and pin-hole free on complicated substrates such as powders or porous polymers. ALD can coat the surface of almost any particle, polymer, or specialty object regardless of size or morphology.

Surface modifications and coatings by ALD reduce the unwanted chemical reactions that occur at the electrode-electrolyte interfaces. This results in a slowing of the area-specific resistance build up, results in higher retained capacities after 1000s of cycles, and enables higher operational voltages for higher energy densities. The graph above shows the capacity retention and resistance improvements that ALD coated CAMs yield compared with uncoated CAMs.

WE'VE GOT IT COVERED

At ALD Nano, we create cost-effective, precision coatings for advanced materials that are transforming industries. We're the world leader in atomic and molecular layer deposition (ALD) technologies on particles and other materials, with a broad IP portfolio.

GLOBAL LEADER IN ALD ON PARTICLES

We collaborate with world-leading companies that leverage our material designs and reactor systems to innovate products that benefit consumers globally.

ALD-ENABLED ADVANCED MATERIAL SOLUTIONS

For more than a decade, we have commercialized ALD technologies developed internally by our world-class team of scientists and engineers and externally by our partner research institutions.

CVR REACTOR SYSTEMS

Our CVR systems can coat 3-30 metric tons per day and have been extensively validated by our partner. Implementation milestones for the CVR technology include:

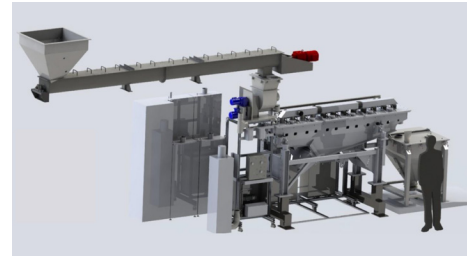
- **Commercial-scale production** of ALD-coated CAMs at our Colorado facility (2017).
- **Delivery** of a commercial-scale CVR system at a partner's commercial CAMs production facility (Q4 2018).
- **Commissioning and startup** (2019)
- **Total cost of ownership models** indicating that ALD coating is less than \$1/kg, or \$1,000 per ton of powder at commercial scale.

ALD Nano has developed ALD coatings for other LIB materials such as separators, anode active materials, solid state electrolytes, and formed electrodes. We can test our ALD methods on customer materials, license our IP, and provide continuous and batch reactors systems to support these various LIB materials.

LIB MATERIALS SOLUTIONS

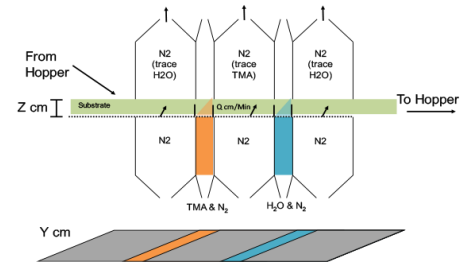
ALD NanoSolutions provides a cost-effective way to modify materials that meet the demands of current and next-generation battery systems. We can provide you with **materials sampling** for proof of concept work, **toll coating** for medium volume or interim commercial production, **equipment systems** for commercial production, and co-ordination of **intellectual property sublicenses** to support commercial sales. Please contact us to discuss how ALD Nano can help solve your LIB materials challenges whether for cathodes/anodes powders, formed electrodes, separators, or solid state electrolytes.

CONTINUOUS VIBRATING REACTOR



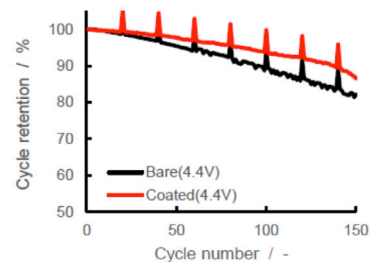
Commercial-scale CVR

CVR ALD REACTOR SYSTEM PROCESS



Contact ALD Nano for a site tour to see the CVR systems in use.

CYCLING PERFORMANCE AT 25DEG-C (3.0 - 4.4V)



ALD coatings enable longer lifetimes for same voltages **OR** equivalent lifetimes at higher voltages.

ALD nanosolutions™

Contact us for ALD-enabled advanced materials solutions.

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