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Atomic Layer Deposition Processes for All-Solid-State Lithium-Ion Batteries

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Atomic layer deposition (ALD) is a thin film deposition method in which gaseous precursor pulses react with a substrate surface and are separated from each other with inert gas purging. These sequential reactions result in self-limiting, surface controlled film growth, which in turn leads to many beneficial film properties, such as film uniformity, good conformality and easy thickness control.

Since 2009, interest in depositing lithium containing materials by ALD has increased rapidly, with many groups now working towards a 3D, all-solid-state thin film Li-ion battery. Many of the well-known Li-ion battery materials have already been deposited by ALD. $LiCoO_2$ is achievable with plasma enhanced ALD, and materials such as $Li_4Ti_5O_{12}$ and VO_x can be deposited using the more traditional thermal ALD processes. The biggest challenge thus far has been the deposition of Li-ion electrolyte thin films: the demanding list of material properties combined with the complex stoichiometries of known Li-ion conducting materials has pushed ALD near its limits. However, many potential electrolyte materials have already been deposited, such as $LiTaO_3$ and Li_3AlF_6.

The Laboratory of Inorganic Chemistry at the University of Helsinki has a long history with ALD, dating back to the early 1990s. The laboratory leads the Finnish Centre of Excellence in Atomic Layer Deposition, with one of its major research focus areas being materials for energy technologies. During recent years, a range of possible Li-ion battery materials have been deposited in our laboratory, such as Li_3PO_4, Li_2SiO_3, LiF and AlF_3, to name a few. This presentation will cover recent developments in ALD of Li-ion battery materials, with an emphasis on the results of the Laboratory of Inorganic Chemistry at the University of Helsinki.

Keywords: Atomic layer deposition; ALD; Lithium-ion battery; Thin films