Layer-Engineered Functional Inorganic-Organic Materials and Interfaces through ALD/MLD

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Abstract: The combined ALD/MLD technique is strongly emerging as a viable technology for the fabrication of new types of metal-organic materials and inorganic-organic interfaces. The technique is derived from the ALD (atomic layer deposition) technology commercially used for the fabrication of high-quality inorganic thin films, and from its less exploited counterpart for purely organic thin films, i.e. MLD (molecular layer deposition). In ALD/MLD the hybrid thin film is grown from gaseous metal and organic precursors through surface-saturated reactions which enables the hybrid film growth with atomic/molecular level precision. We have already developed well-controlled ALD/MLD processes for a wide palette of metal (alkali/alkaline earth metals, d-block transition metals and lanthanides) and organic (arenes, pyridines, nucleobases, azo molecules, etc.) constituents.[1-3] Also, the technique is capable of yielding in-situ crystalline thin films of structures similar to those known for so-called coordination polymer or metal-organic framework (MOF) materials synthesized from solutions, or even entirely new compositions/structures.[1,4,5] An exciting example of the latter case is the crystalline lithium quinone thin films; the structure contains the Li^+ cations in a coordinatively unsaturated three-fold coordination, which explains why it can not be synthesized through conventional solution synthesis. This material was long wanted though, as it is a promising organic cathode material for Li-ion microbattery with ultrathin layers.[6] Another interesting approach enabled by ALD/MLD is to build superlattices or gradient materials with precisely tailored inorganic-organic interface frequencies. Such layer-engineered thin films are useful for example for bandgap tuning,[7] and phonon blocking,[8] needed e.g. for enhanced thermoelectric energy harvesting. In this lecture, I discuss the fundamentals and future application possibilities of ALD/MLD.

Key words: Atomic layer deposition, Molecular layer deposition, Metal-organic materials, Inorganic-organic interfaces, Energy harvesting and storage

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