Uniform bottom-up Li deposition behavior in nanoneedle arrays on modified three–dimensional carbon film

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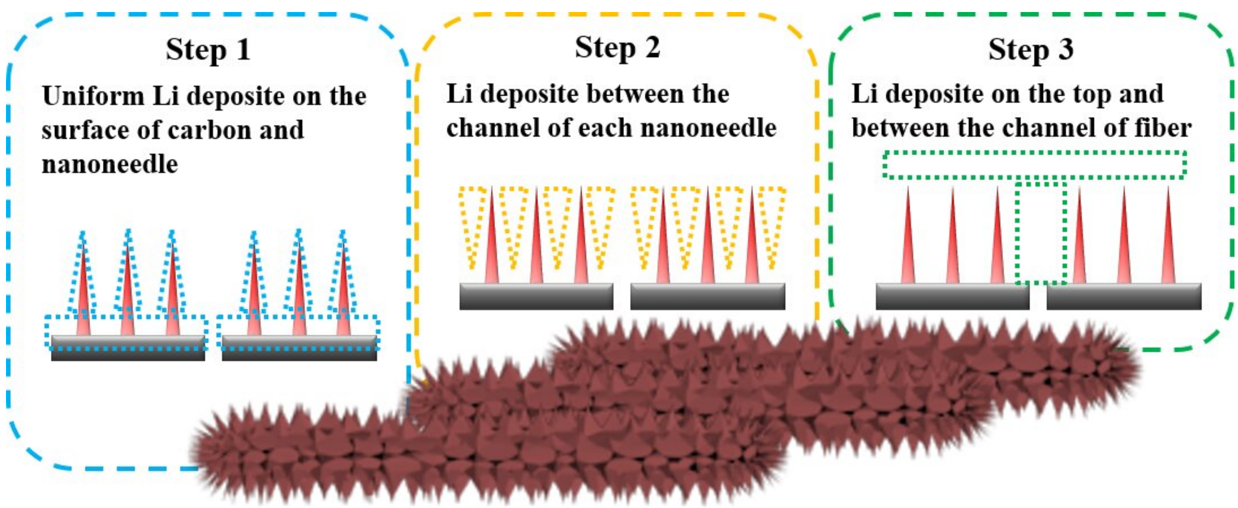

Bottom–up uniform Li deposition behavior realized by unique three–dimensional nanoneedle arrays. Credit: *Journal of Energy Chemistry* (2022). DOI: 10.1016/j.jechem.2022.10.023

Human lives have been revolutionized since lithium-ion batteries (LIBs) were successfully commercialized. However, modern portable electronics have increased energy demands and thus require batteries with high energy density. Directly using Li metal as an anode is considered a promising strategy due to its ultra-high capacity (3860 mA h g^{-1}) and low negative electrochemical potential (- 3.04 V versus the standard hydrogen electrode).

However, using Li metal is currently not possible due to unsatisfactory cyclability, serious safety issues, and poor rate capability. A particularly important issue is the formation of a weak solid-electrolyte interphase (SEI) layer. The SEI layer is formed when Li metal reacts with the electrolyte. Owing to its instability, the SEI layer often breaks down because of the large volume variation of lithium metal.

The breakdown of SEI leads to the exposure of unreacted Li, which subsequently reacts with liquid electrolytes to form more SEI and thereby causes cell failure during the cycling process. Additionally, uneven nucleation and the forming of needle-like Li dendrites are other key issues restricting the use of Li metal as anodes. These result from increased local current density and eventually pierce the separator causing safety concerns. It is necessary to develop an effective strategy to inhibit the growth of lithium dendrites.

Recently, Prof. Zhifeng Zheng's team from Xiamen University published a manuscript entitled "Homogenous metallic deposition regulated by abundant lithiophilic sites in nickel/cobalt oxides nanoneedle arrays for lithium metal batteries" in *Journal of Energy Chemistry*.

Rock salt type NiO and CoO nanoneedle arrays were grown on lignin-derived carbon film to achieve reversible lithium stripping/plating cycling under high current density. The rational structure of the 3D networks plays an important role in promoting homogeneous Li-ion flux and alleviating local current density.

The abundant lithiophilic sites in the film inhibit the Li dendritic growth and "dead" Li formation. Uniform bottom-up Li deposition can be facilitated by the unique three–dimensional nanoneedle arrays. Because of its unique structure, the NCO-CNF electrode displayed stable lithium stripping/plating cycling up to 4000 h.

Furthermore, the bottom of the unique structure has the strongest lithiophilic properties, followed by the surface of the nanoneedles and the surrounding channel. A NCO-CNF/Li‖LFP full cell with an N/P ratio of three exhibits impressive reversibility at 0.5 C up to 80 cycles. In conclusion, the study proposes a rational strategy for designing lithiophilic substrates to induce homogenous metallic deposition, which is a potentially useful method for mitigating the dendrite issues in next-generation lithium metal batteries.

More information: Fenqiang Luo et al, Homogenous metallic deposition regulated by abundant lithiophilic sites in nickel/cobalt oxides nanoneedle arrays for lithium metal batteries, *Journal of Energy Chemistry* (2022). DOI: 10.1016/j.jechem.2022.10.023

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