ARRADIANCE ***Sneak Preview***

Long-life silicon anodes by conformal molecular-deposited polyurea interface for lithium-ion batteries

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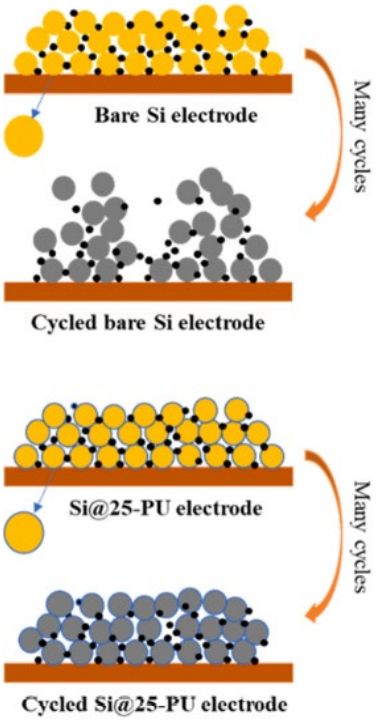
Green energy imposes increasing demands on lithium battery capacities, rates, and cycling lifespan. As a result, the electrochemical performance and cost of the battery anode become critical. Lithium-metal anodes, despite their high capacity, suffer from swelling, dendrite growth, and porosity that eventually lead to battery failure. A solid-electrolyte interface (SEI) plays a crucial role in mitigating these undesirable effects. Previously, consumable electrolyte additives and mechanically fragile inorganic films like Al2O3 and TiO2 were used for "good" SEI promotion.



An alternative approach is to create an artificial polymeric protective SEI layer that promotes lithium-ion diffusion and can accommodate significant volume changes of the anode during operation. Building on their previous work with lithium-metal anodes and polyurea, these researchers created a conformal MLD-deposited polyurea layer applied to the powder silicon electrode, which offers as high specific charge capacity (mAh/g) as lithium-metal, is cost effective and does not react with water vapor. Polyurea, an inert elastomer with strong adhesion to silicon, was made by molecular layer deposition (MLD) using 1,4-phenylene diisocyanate and ethylenediamine at a low temperature in an Arradiance GEMStar™ ALD reactor.

The polyurea film formed a stable, thin, and lithium fluoride-rich SEI. A peeling test with tape indicated that the silicon-polyurea electrode provides an adhesive force twice as strong as bare silicon and twice as high Young's modulus, as determined by AFM. The polyurea SEI reduced the interface impedance from hundreds to tens of ohms. Electrochemical, X-ray photoelectron and secondary-ion mass spectroscopy confirmed excellent uniformity of the polyurea film. The full-cell energy density reached 453.0 Wh/kg, and the charge capacity remained at 1010 mAh/g after 1000 cycles.

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GEMStar system enables polymer MLD and particle coatings needed in this research and other emerging battery areas. If you would like more information or wish to inquire about GEMStar ALD systems or foundry ALD film deposition services, please contact Arradiance