

Supporting Information

Highly Uniform Nitride-rich Artificial Solid Electrolyte Interphase Enabled by Nano-Silicon Nitride for Superior Performance in Advanced Sodium Metal Batteries

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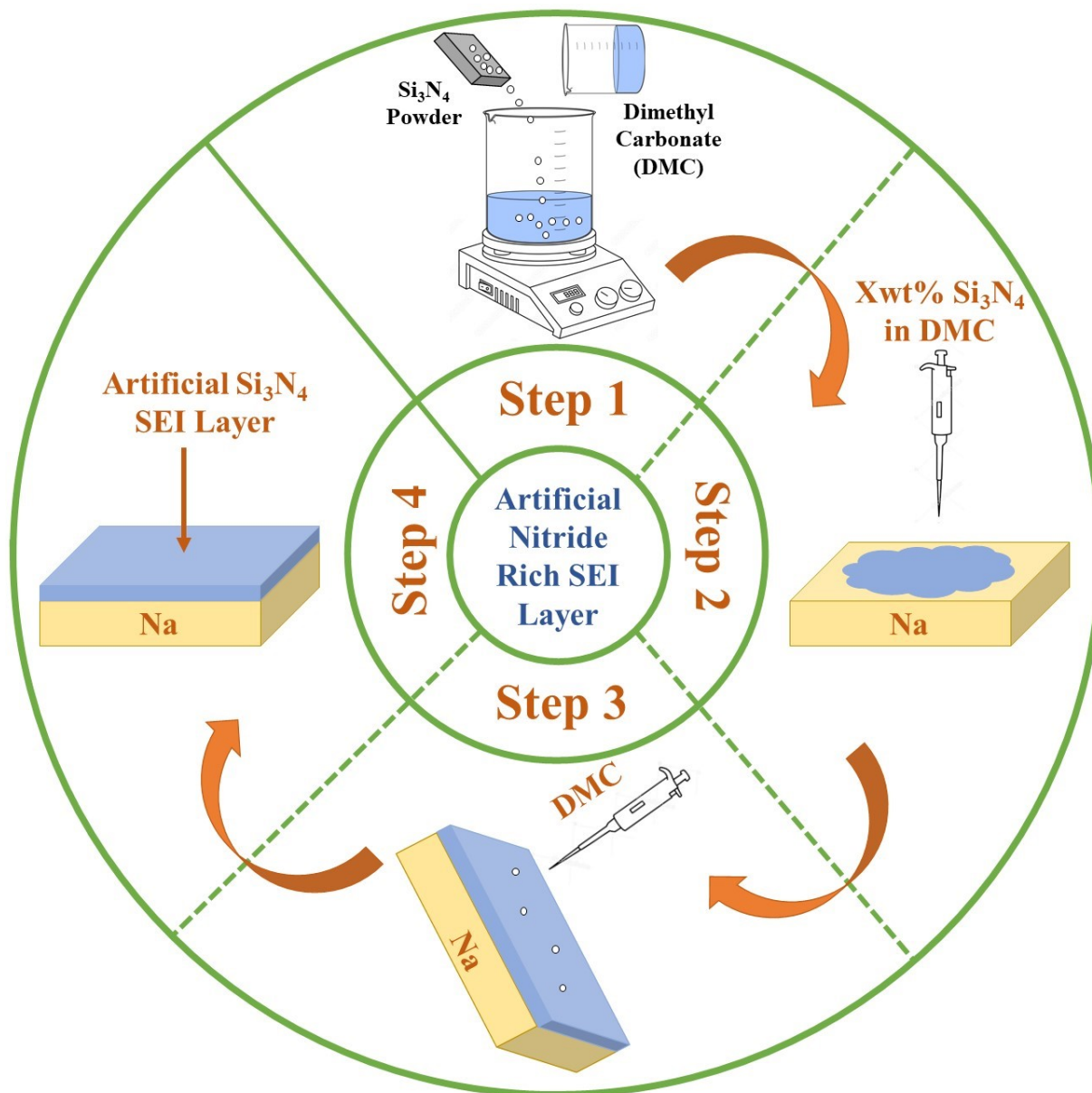
S1:

To fabricate the artificial solid electrolyte interphase (SEI) layers, a meticulous four-step process is followed using silicon nitride (Si_3N_4) as the key material. Initially, Step 1 involves preparing a homogeneous solution by dissolving nano-sized Si_3N_4 particles in dimethyl carbonate (DMC), ensuring a thorough mixture by stirring continuously for 24 hours. The utilization of nano-sized particles addresses the previously noted issues of uneven distribution associated with micro-sized counterparts, thus promoting a more uniform SEI layer formation.

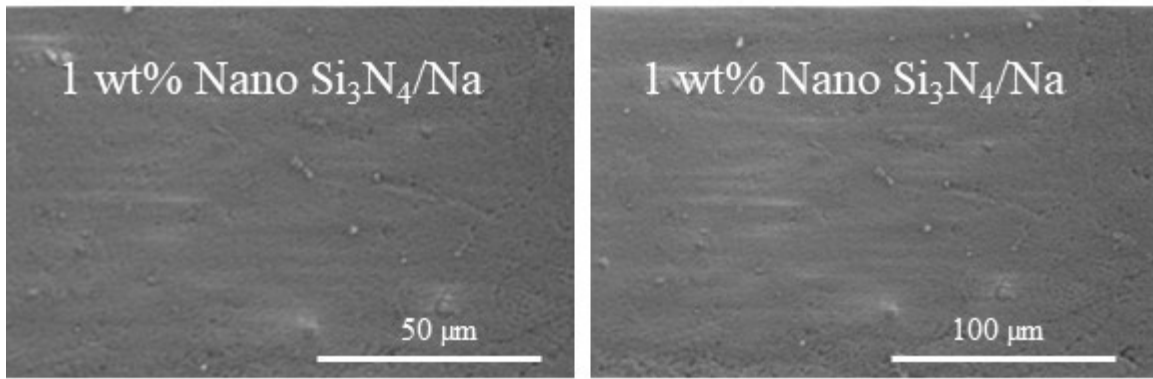
In Step 2, sodium (Na) metal substrates are prepared by cutting and polishing to obtain a flat, reflective surface. These substrates are fashioned into thin discs, onto which 50 μL of the well-stirred Si_3N_4 in DMC solution is precisely applied, ensuring consistent coverage.

Subsequently, Step 3 requires the coated Na discs to be left to dry at ambient conditions for 48 hours. This duration is critical for allowing the DMC solvent to evaporate fully, ensuring the proper deposition of Si_3N_4 particles onto the Na surface.

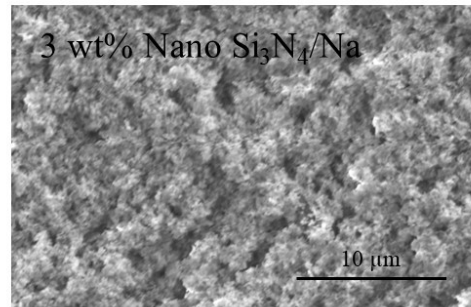
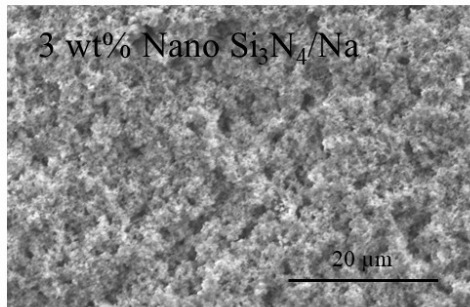
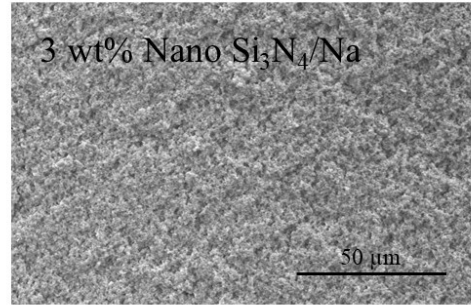
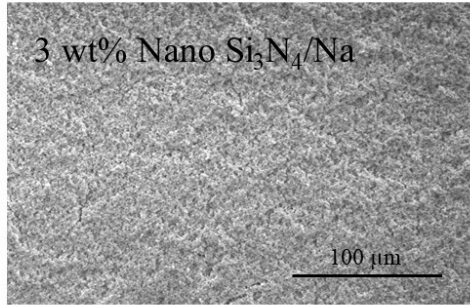
Finally, Step 4 involves a thorough rinsing of the Na discs with DMC to remove any unreacted or loosely adhered Si_3N_4 particles. Post-rinsing, the discs are subjected to an additional drying period of 24 hours to complete the preparation of the artificial nitride-rich SEI layer. This methodical approach, performed within an argon-filled glovebox to maintain an inert atmosphere, is crucial for the stability of Na electrodes and for enhancing their electrochemical performance by preventing dendrite formation during electrochemical cycling.



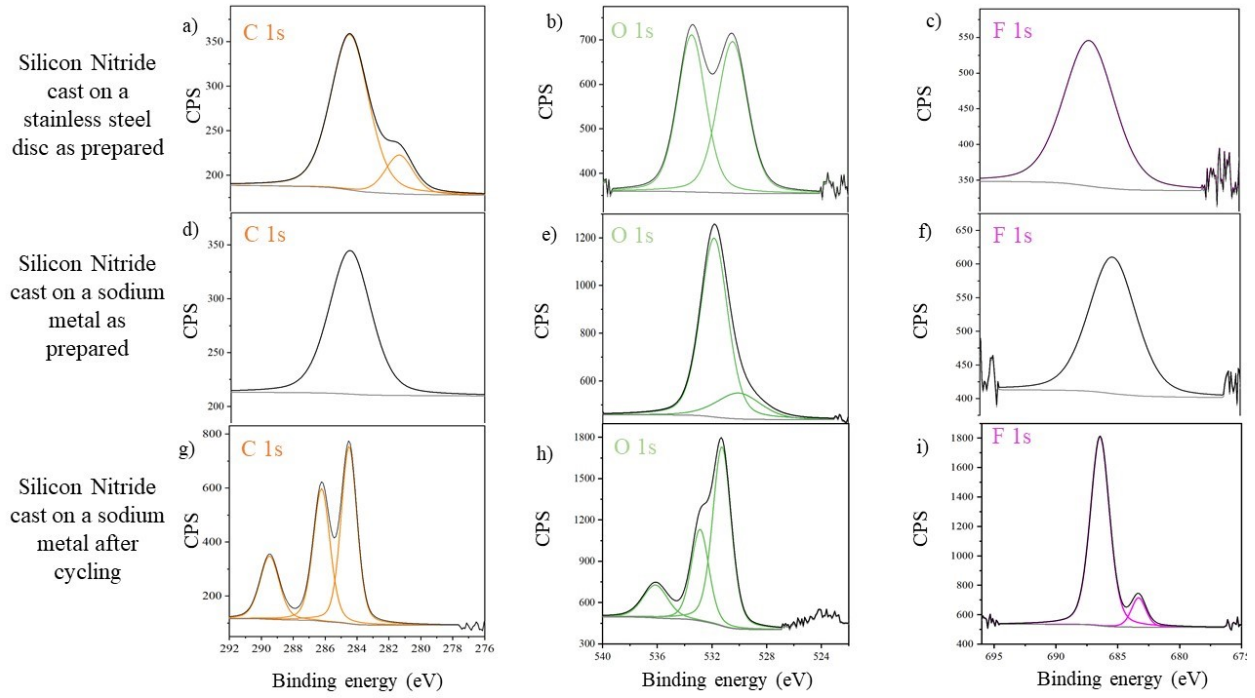
S1: Schematic illustration of Artificial Si_3N_4 SEI layer formation on the Na metal surface procedure.



S2: High-resolution top-view SEM images of nano-size 1wt% Si₃N₄/Na as prepared

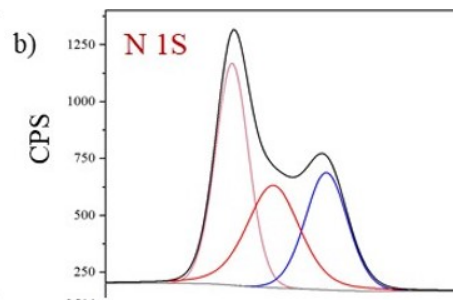
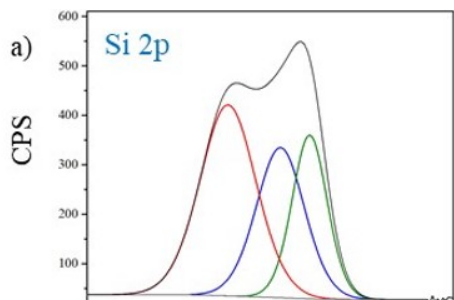


S2: High-resolution top-view SEM images of nano-size 3wt% $\text{Si}_3\text{N}_4/\text{Na}$ as prepared

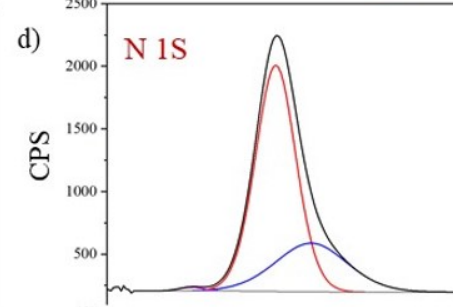
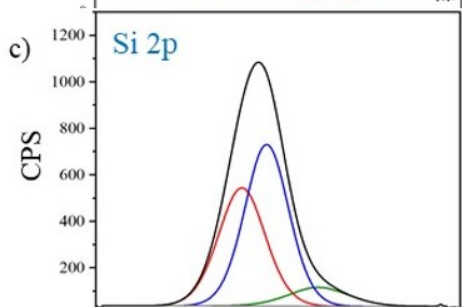


S4: High-resolution XPS spectrum of C1s, O1s and F1s of as prepared 3wt% micro-sized Si_3N_4 cast on a,b,c) stainless steel disc, d,e,f) on sodium metal, g,h,i) after cycling

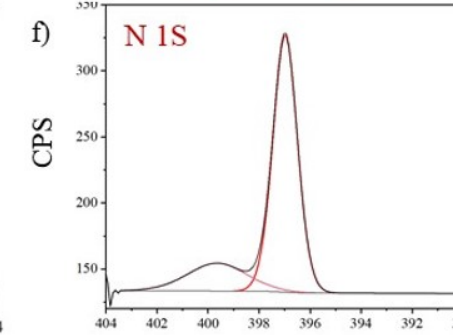
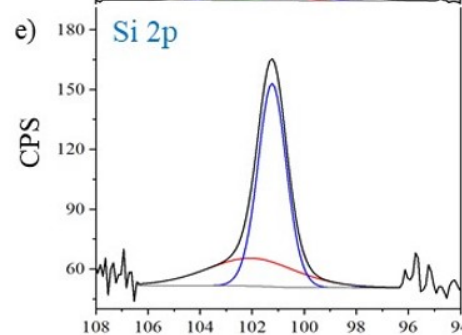
Silicon Nitride
cast on a stainless
steel disc as
prepared



Silicon Nitride
cast on a sodium
metal as prepared



Silicon Nitride
cast on a sodium
metal after
cycling

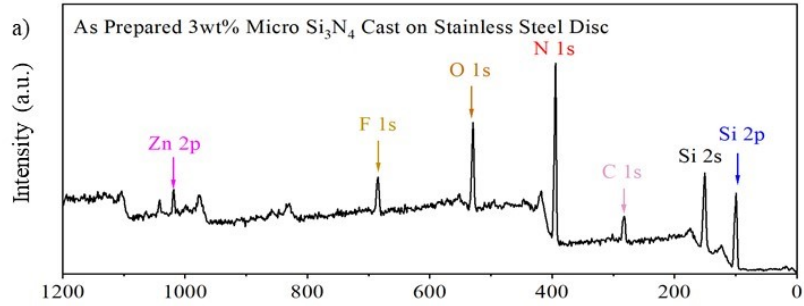


Binding energy (eV)

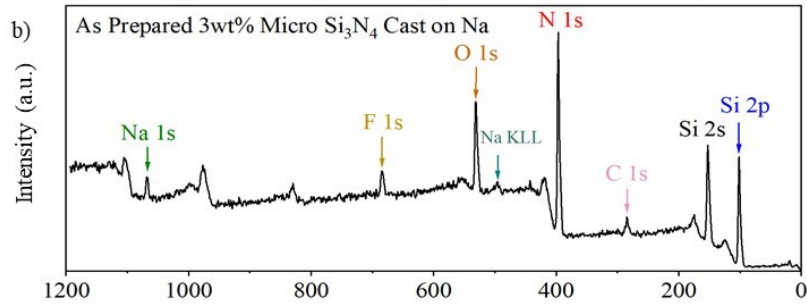
Binding energy (eV)

S5: High-resolution XPS spectrum of Si 2p and N 1s of as prepared 3wt% micro-sized Si₃N₄ cast on a,b) stainless steel disc, c,d) on sodium metal, e,f) after cycling

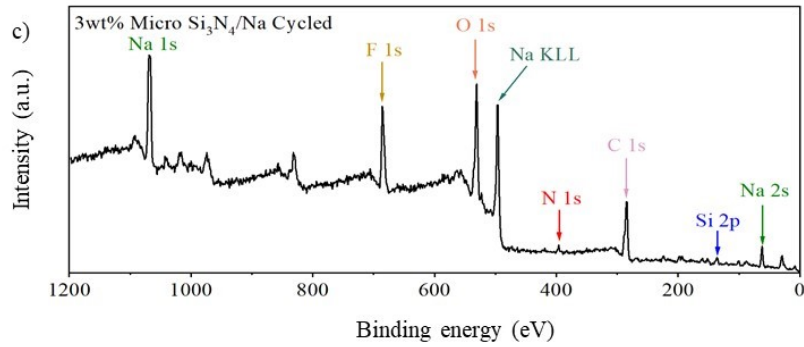
Silicon Nitride cast on a stainless steel disc as prepared



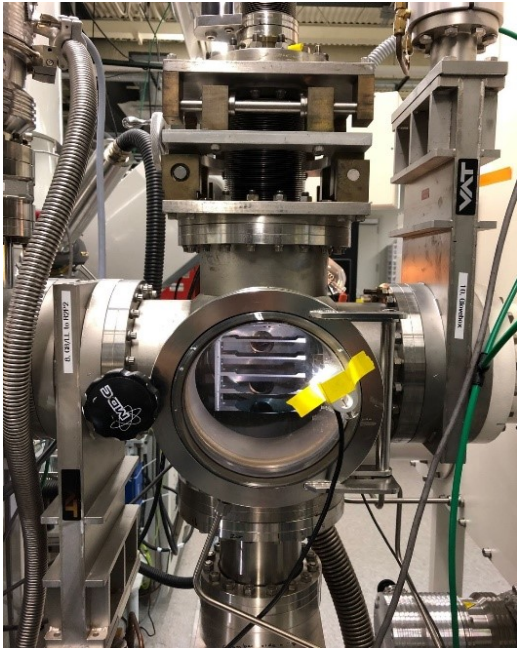
Silicon Nitride cast on a sodium metal as prepared



Silicon Nitride cast on a sodium metal after cycling



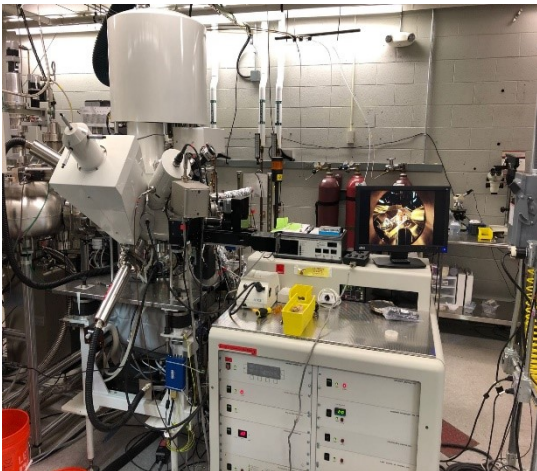
S6:) XPS survey spectra of a) as prepared 3wt% micro-sized Si_3N_4 cast on stainless steel disc, b) on sodium metal, c) after cycling



Glovebox Load Lock



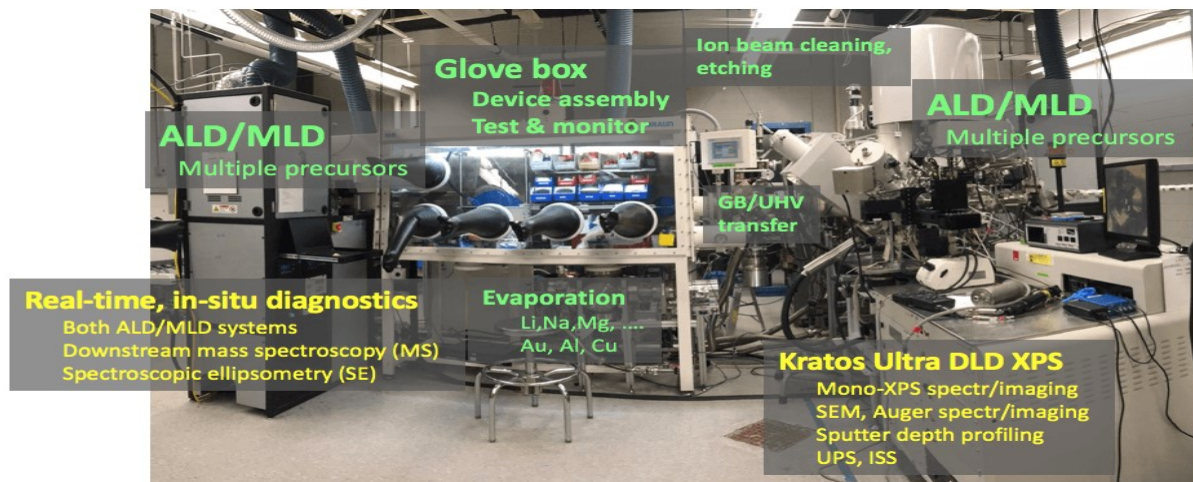
UHV Integrated System



Surface Analysis System



Integrated System Glovebox



S7: Integrated XPS -glovebox system under UHV