

Scaling Up Silicon-Dominant Anodes: Rheological Control and Bio-Based Binders for Pilot-Scale Battery Electrode Manufacturing

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The **GIGAGREEN** project targets the transition of innovative and sustainable high energy density lithium-ion cell manufacturing technologies from laboratory-scale validation (**TRL 3-4**) to scalable pilot-line manufacturing (**TRL 5-6**) and finally to industrial scale (**TRL 7-8**).



- ❑ *Target Formulations:* Scaling sustainable, water-processable anode slurries incorporating **10 wt.% silicon**.
- ❑ *Target Formulations:* Scaling sustainable, water-processable cathode slurries incorporating **LNMO**.
- ❑ *Process Transferability:* Scaling aqueous slurry formulations from laboratory scale to continuous pilot-line processing.
- ❑ *Manufacturing Reliability:* Overcoming slurry processing bottlenecks to achieve defect-free, uniform coatings at commercial mass loadings.
- ❑ *Design-to-Manufacture (DtM):* Aligning sustainable material choices with high-throughput, energy-efficient Gigafactory requirements.



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❑ *Target Formulations:* Scaling sustainable, water-processable cathode slurries

❑ *Process:* Scaling sustainable, water-processable cathode slurries

❑ *Manufacturing:* Scaling sustainable, water-processable cathode slurries

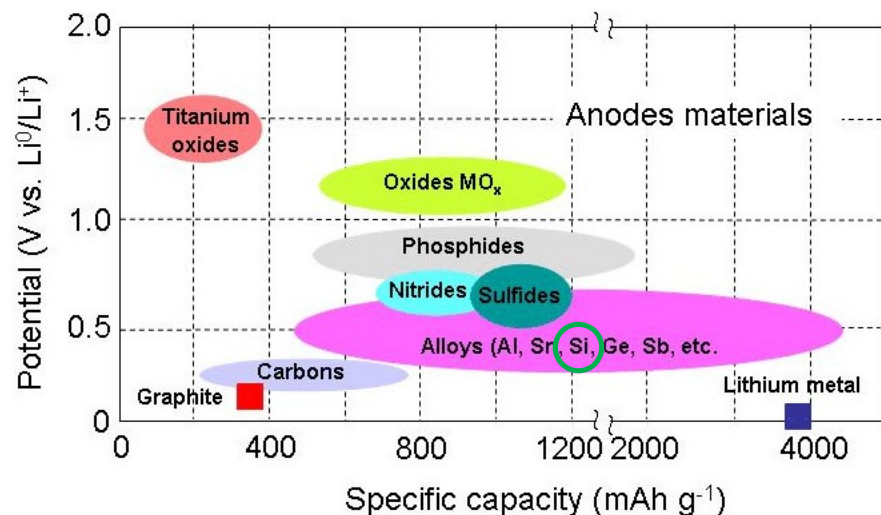
❑ *Design:* Scaling sustainable, water-processable cathode slurries



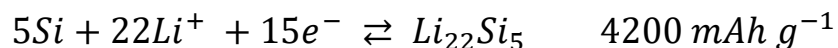
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from
bottlenecks to
loadings.
al choices

Anode Materials: From Graphite to Silicon (80%)

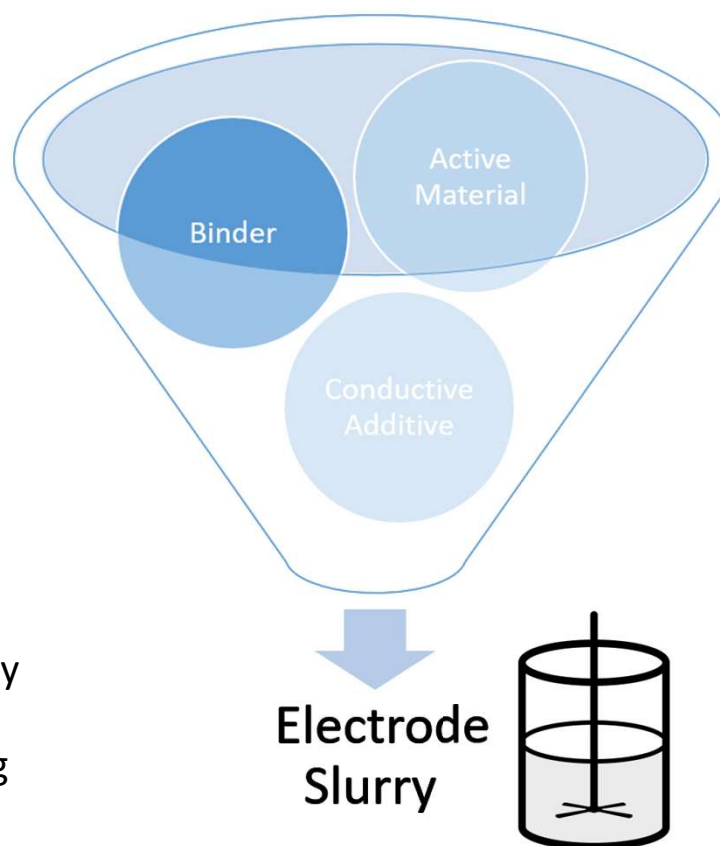


Innovative & Promising Material



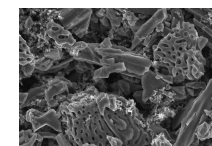
- ✓ Higher specific capacity → higher energy density
- ✗ Huge expansion during charge/discharge cycling

How to overcome these issues?



Material Level

Synthesis of material with specified shapes and dimensions



E-MAGY
on with silicon

Electrode Level

Use of linear, branched, and crosslinked binders



Mechanical Properties
Robustness vs. Elasticity

Laboratory Production Limitations & Challenges

Electrode Production Process

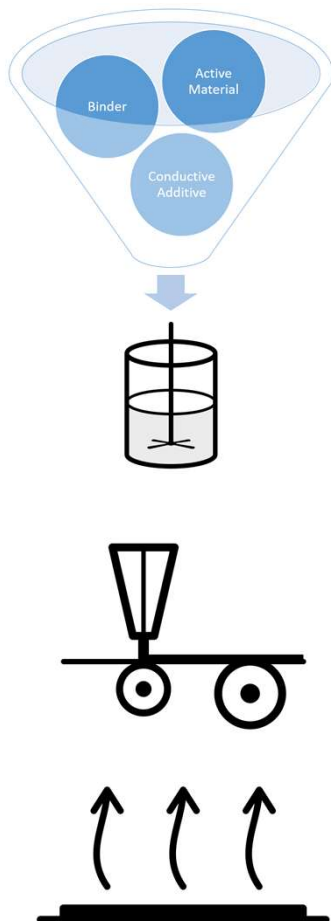
Mixing



Coating



Drying



Laboratory Level (TRL 3-4)



Small Pilot-line (TRL 5-6)



✓ Higher amount

✓ Continuous Process

✓ Good Reproducibility

✗ Non-continuous process

✗ Amount

✗ Reproducibility

Silicon-Dominant Anodes Production

Composition

80 wt.% Nanoporous Silicon

5 wt.% Graphite

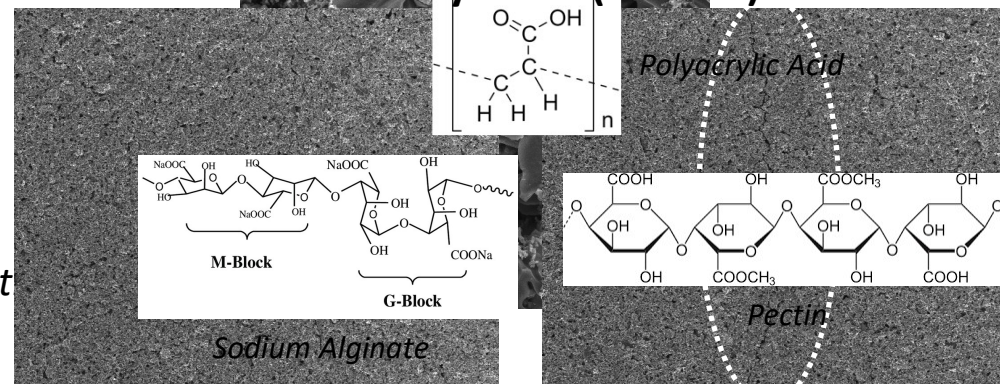
5 wt.% Carbon Black

10 wt.% Polyacrylic Acid

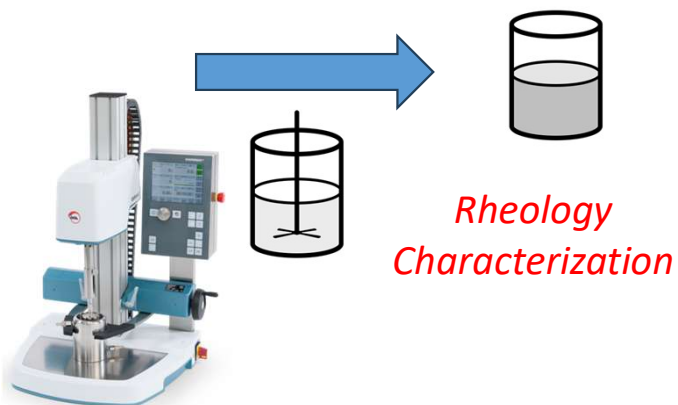
E-MAGY
on with silicon

9 wt.% Polyacrylic Acid (PAA)
1 wt.% Sodium Alginate (ALG)/Pectin

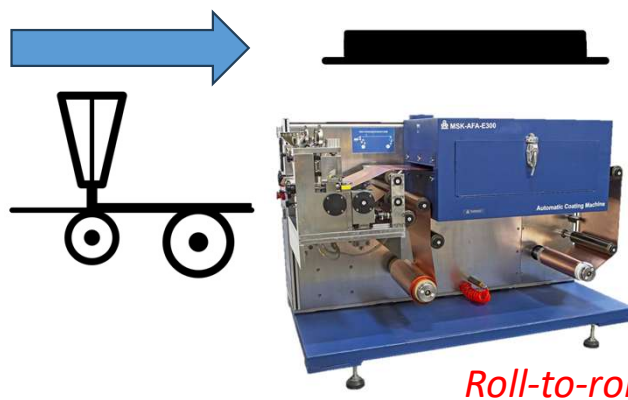
Laboratory Level (TRL 3-4)



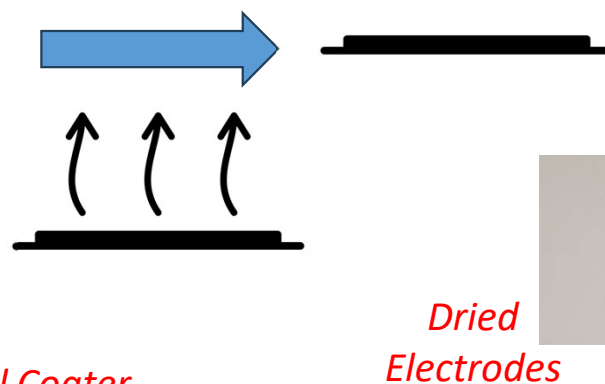
Mixing



Coating



Drying

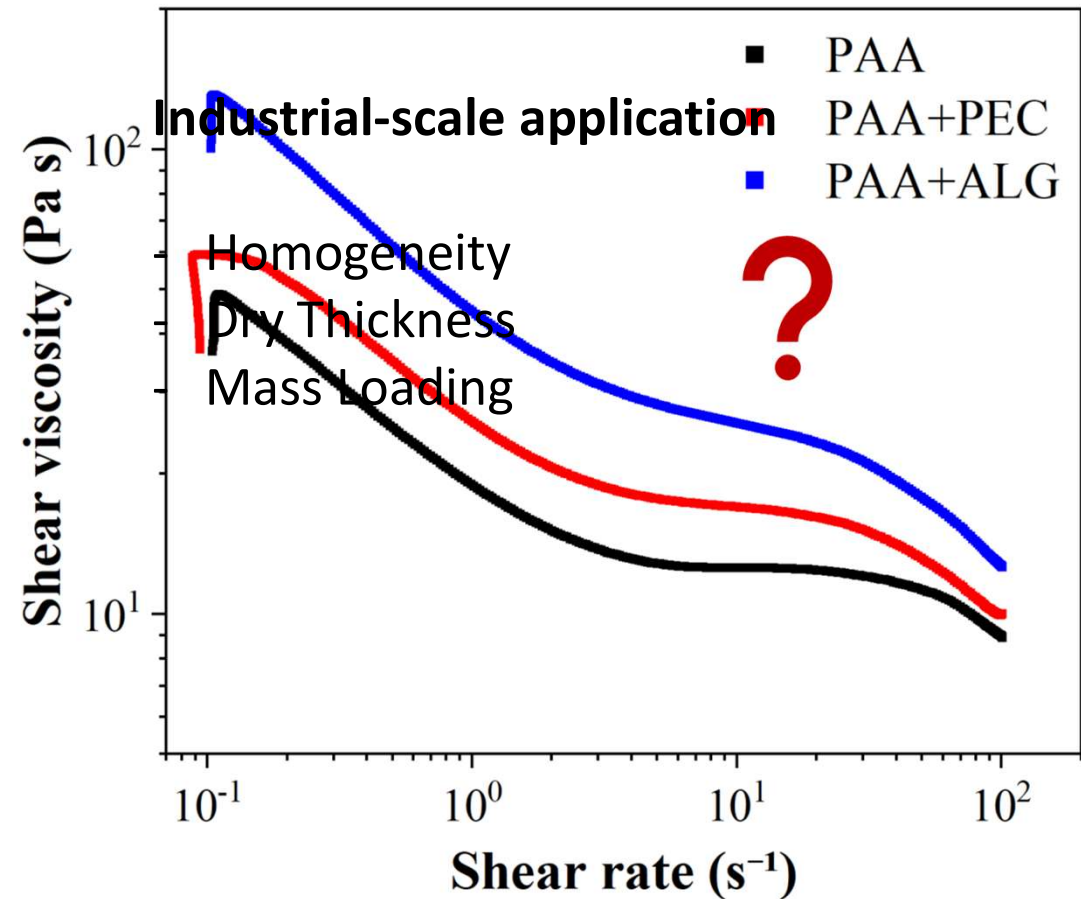


Rheology: Flow Curve



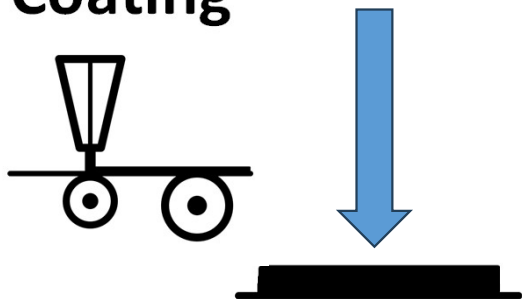
Shear Thinning Behavior ✓

Range of Viscosity: $10^1 - 10^3$ Pa s ✓



Electrode Characteristics

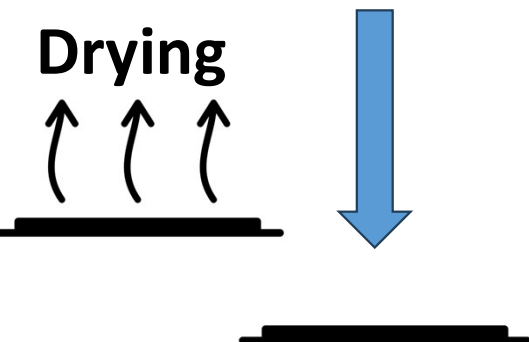
Coating



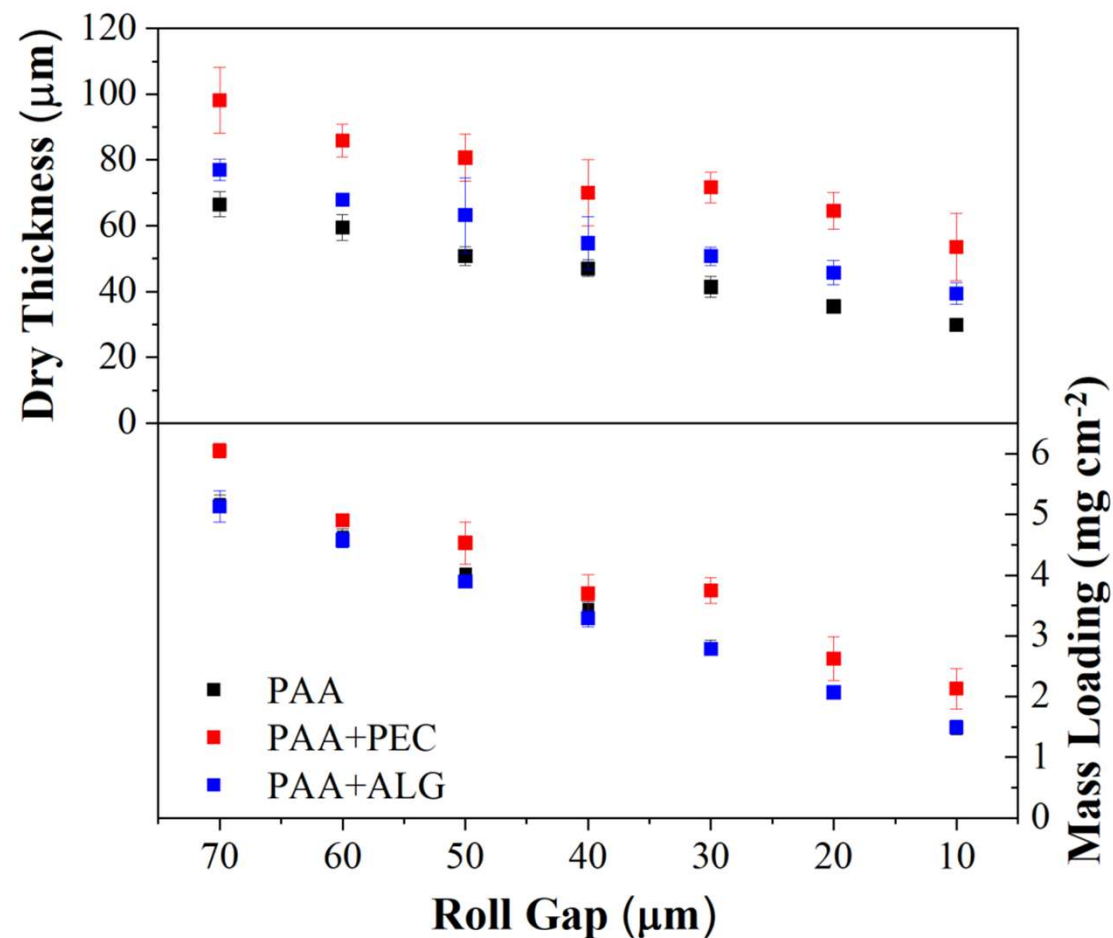
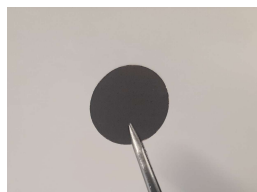
Roll-to-roll Coater

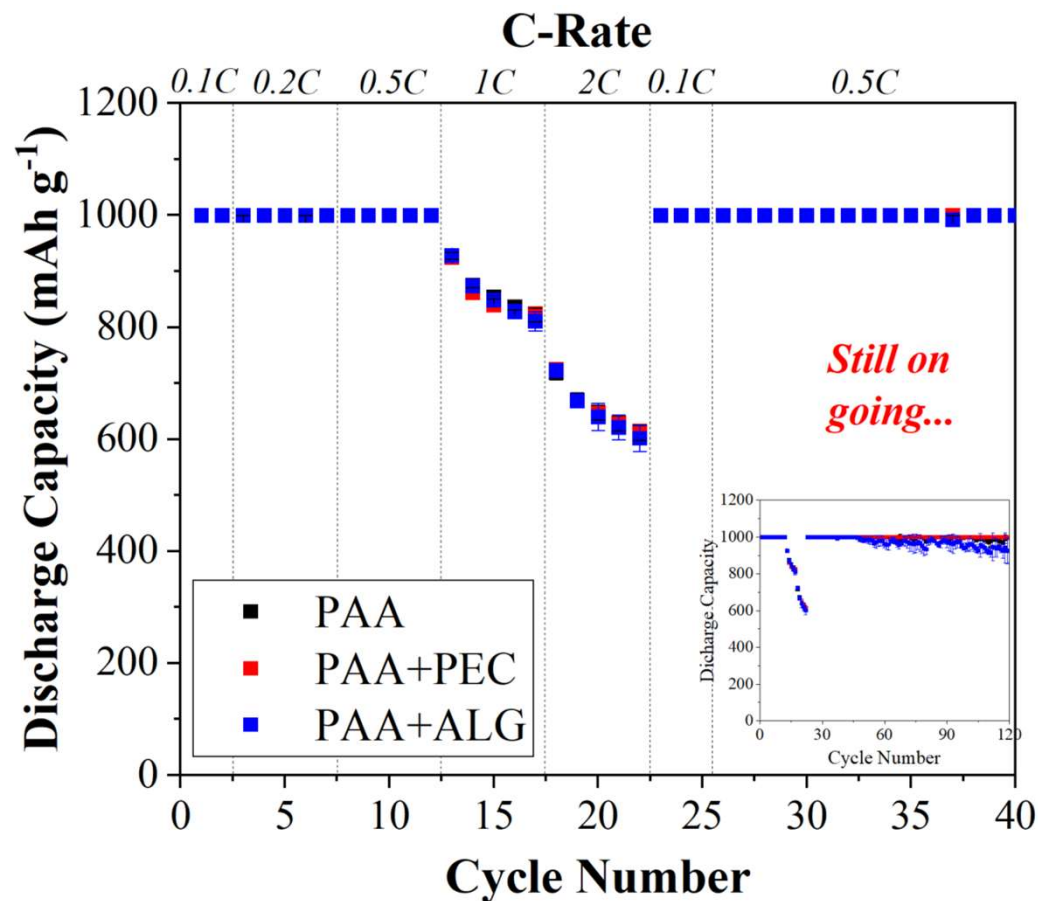


Drying



*Dried
Electrodes*





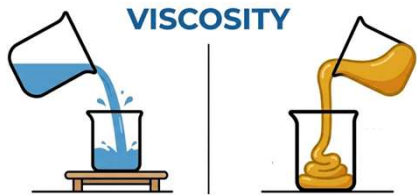
- **High-Rate Capability:** All binder formulations show full capacity recovery ($\sim 1000 \text{ mAh g}^{-1}$) after high C-rates.
- **Comparable Long-Term Stability:** Bio-based blends perform comparably to pure PAA over 120+ cycles.

Half Cell: Silicon Anode vs. Lithium

Anode Mass Loading: $1\text{-}2 \text{ mg cm}^{-2}$

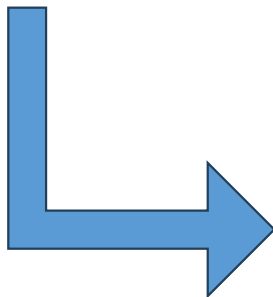
Electrolyte: $150 \mu\text{L}$ of 1 M LiPF_6 in EC:DEC 1:1 + 10% FEC + 2% VC

Conclusions and Perspectives



- ✓ **Rheology as a Predictive Tool:** Fundamental for tuning slurry behavior, ensuring processability, and preventing defects in continuous coating lines.

- ✓ **Pilot-Scale Process Control:** Strong parameter-property relationships allow precise tuning of mass loading and coating thickness for uniform electrodes.



Key Requirements for Lab-to-Industrial
Technology Transfer



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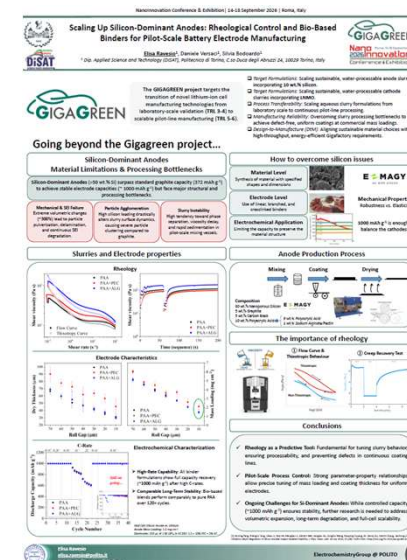


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Thank you for your attention!

*To discuss further, meet me
at poster PS.58*



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