Elastic Ion-conducting Polymer-Coated Si Particles and Highly Elastic Binder: Key to Low-cost High-capacity Lithium-ion Battery

A Response to Tesla’s Battery Day (09/22/2020)

Honeycomb Battery Co. (HBC)/Global Graphene Group (G³)
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A Tesla Battery Day Story:

Tesla appears to suggest that the best Si anode should have the following features:

• Low-cost Si particles (simple design, instead of highly engineered structures such as CVD Si; hence, low cost);
• Elastic, ion-conducting polymer coating that protects these Si particles; and
• Highly elastic binder used in the anode to maintain electrode structural integrity.
This battery technology will lead to a higher-energy EV battery (significantly extended driving range) at a lower cost ($/kWh)!

Stabilize Si surface through elastic, ion-conducting polymer coating

Highly elastic binder
HBC/G³ IPs in Elastic Ion-Conducting Polymer Coatings and Highly Elastic Binder:

- G³ has 35 US patents (issued or pending) on this specific subject area; quite likely this patent portfolio is second to none in the world.
- Examples of fundamentally significant patents on elastic, conducting polymer coating and highly elastic binder technologies; e.g. US Patent No. 10,734,642 (08/04/2020); No. 10,211,455 (02/19/2019); No. 10,256,459 (04/09/2019); No. 10,424,810 (09/24/2019); No. 10,573,894 (02/25/2020); No. 10,601,034 (03/24/2020); and Application No. 15/442,278 (02/24/2017).
- These patents cover a wide range of high-elasticity and ion-conducting polymers.
- These include composition patents, process/method patents, and application patents.
- Two examples are illustrated on next two slides.

**Extending Your EV Driving Range at a Lower Cost?**
These and other HBC/G³’s patents and know-how will enable you to get there faster.
This patent covers any high-elasticity and ion-conducting polymer that:

- has a fully recoverable elastic deformation from 2% to 1,000%;
- has a lithium ion conductivity no less than $10^{-7}$ S/cm; and
- coating thickness from 1 nm to 10 µm.

The particles may be pre-coated with a carbon or graphene material, pre-lithiated or non-prelithiated, etc.
World’s First Patent on Highly Elastic Binder

e.g. US Patent Application No. 15/442,278 (02/24/2017);
allowed and issue fee paid

POLYMER BINDER FOR LITHIUM
BATTERY AND METHOD OF
MANUFACTURING

We claim:

1. An anode active material layer for a lithium battery, said anode active material layer comprising multiple anode active material particles and an optional conductive additive that are bonded together by a binder comprising a high-elasticity polymer having a recoverable tensile strain from 5% to 700% when measured without an additive or reinforcement in said polymer and a lithium ion conductivity no less than $10^{-5}$ S/cm at room temperature.
Next-Gen EV Battery Anode Materials?

A leading EV OEM stated during its Battery Day that the best Si anode should have the following features:
- Low-cost Si particles
- Elastic, ion-conducting polymer coating that protects these Si particles
- Highly elastic binder used in the anode to maintain electrode structural integrity.
This technology can significantly extend the EV driving range at a lower cost.

(Disclaimer: this information reflects the understanding of G3 only and does not represent the position by any EV OEM)

• G³ has 35 US patents (issued or pending) specifically on elastic ion-conducting polymer coatings (out of a total of 80+ US patents on lithium-ion battery anodes); this patent portfolio is likely second to none in the world on this subject area;
• These patents cover a wide range of high-elasticity and ion-conducting polymers; including composition patents, process/method patents, and application patents.

US Patent No. 10,734,642 covers any high-elasticity and ion-conducting polymer that:
• has a recoverable elastic deformation from 2% to 1,000%;
• has a lithium ion conductivity no less than $10^{-7}$ S/cm.
Thank you!

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