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)

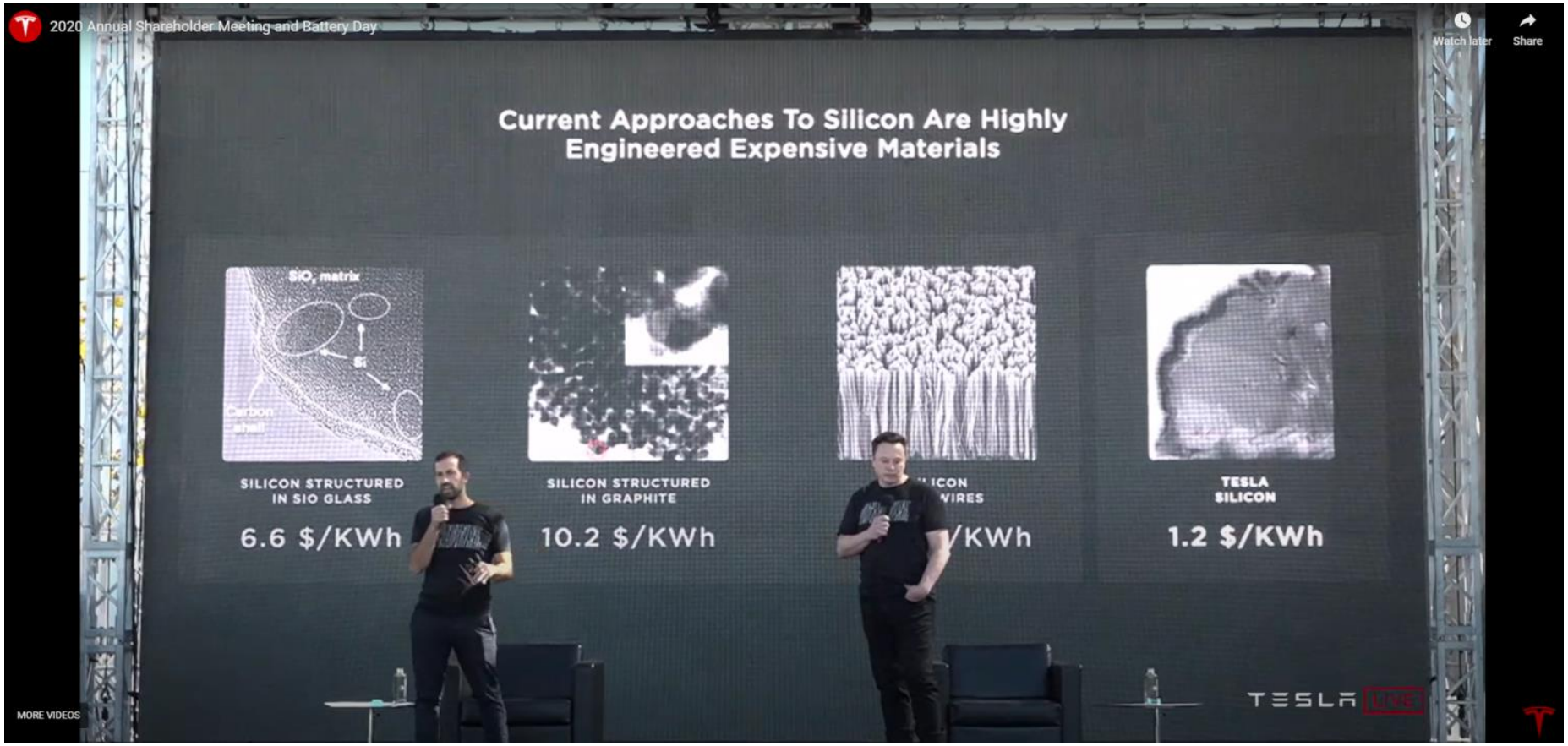
Honeycomb Battery Co. (HBC)/Global Graphene Group (G^3)

September 23, 2020

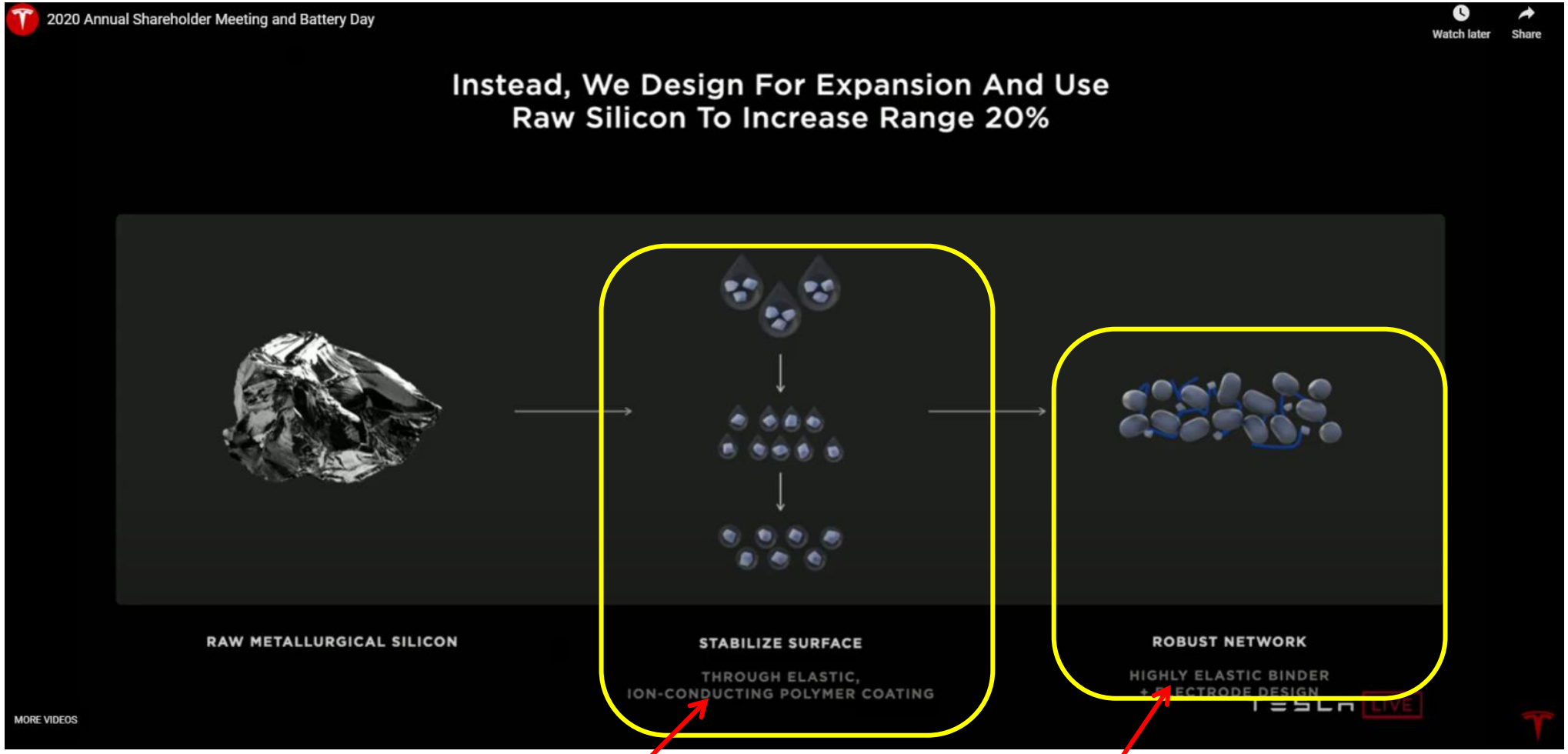
A Tesla Battery Day Story:

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/G^3 IPs in Elastic Ion-Conducting Polymer Coatings and Highly Elastic Binder:

- G^3 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/G^3's patents and know-how will enable you to get there faster.

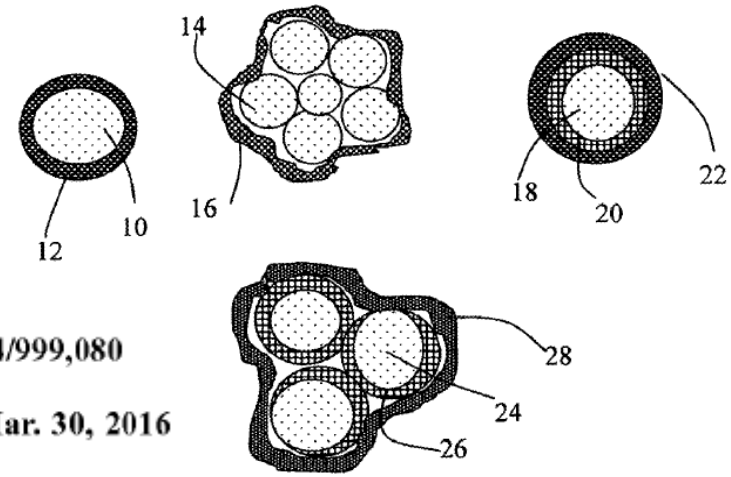
(12) **United States Patent**
Zhamu et al.

(10) **Patent No.: US 10,734,642 B2**
(45) **Date of Patent: Aug. 4, 2020**

(54) **ELASTOMER-ENCAPSULATED PARTICLES OF HIGH-CAPACITY ANODE ACTIVE MATERIALS FOR LITHIUM BATTERIES**

H01M 4/387; H01M 4/483; H01M 4/661; H01M 4/134; H01M 4/625; H01M 4/131; H01M 4/604; H01M 4/523;
(Continued)

(21) Appl. No.: **14/999,080**
(22) Filed: **Mar. 30, 2016**



We claim:

1. An anode active material layer for a lithium battery, said anode active material layer comprising multiple particulates of an anode active material, wherein a particulate is composed of one or a plurality of particles of a high-capacity anode active material being encapsulated by a thin layer of elastomeric material that has a fully recoverable elastic deformation from 2% to 1000%, a lithium ion conductivity no less than 10^{-7} S/cm at room temperature, and an encapsulating shell thickness from 1 nm to 10 μm, wherein said thin layer of elastomeric material is capable of expanding and shrinking congruently with expansion and shrinkage of said one or a plurality of particles of said high-capacity anode active material, and wherein said high-capacity anode active material has a specific capacity of lithium storage greater than 372 mAh/g.

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.

GLOBAL GRAPHENE GROUP

Next-Gen EV Battery Anode Materials?

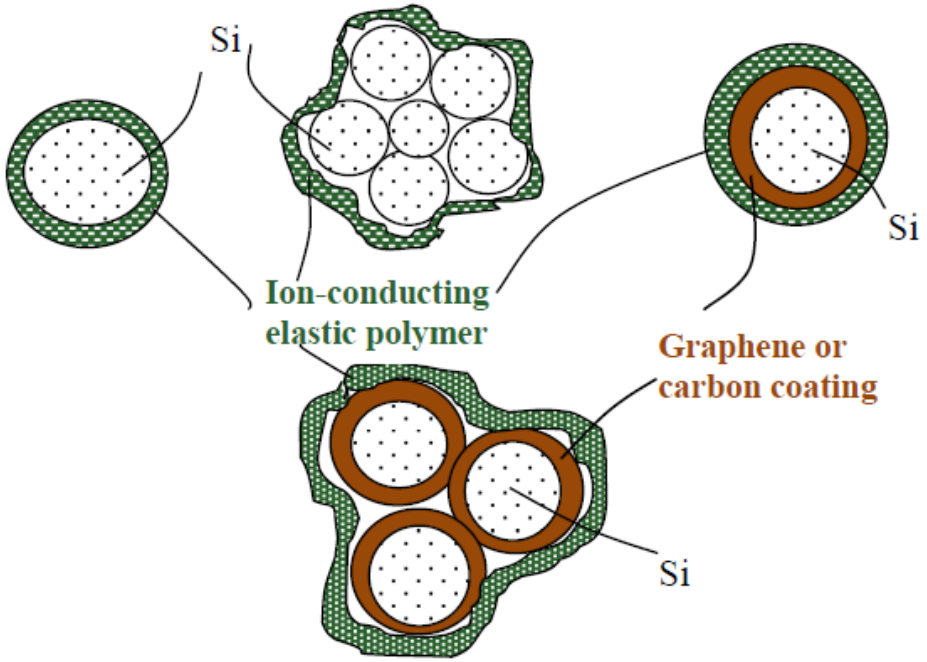
A leading EV OEM stated during its Battery Day that the best Si anode should have the following features:

- **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)

- G^3 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.



Elastic ion-conducting polymer-coated Si particles, with or without a carbon or graphene pre-coating layer

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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