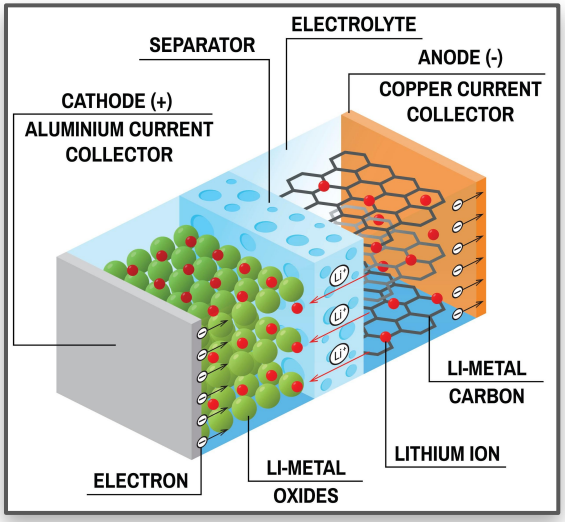
Rethinking Batteries

Improving capacitance, charging speed, temperature sensitivity of batteries with **graphene balls**

Lithium-Ion Batteries



Energy Density

- 100-265 Wh/kg
- **2x** energy density as lead acid

Voltage Capacity

- 3.6 V
- **3x** higher than Ni-Cd, Ni-MH

Discharge Rate

- **1-2%** per month
- 12% per month with lead acid

Common Issues

Temperature
Inconsistencies

Increase in discharge rate and can cause lithium plating, thus reducing battery life and length

Charging Speed
Decrease

Charging speed is limited due to current materials along with battery overheating which causes damage to the battery

Material
Inadequacies

Current materials and the chemical mixture limits several aspects of the battery due to specific material properties

Capacitance
Insufficiency

Capacitance of batteries is limited due to current materials

Charge Cycle
Reductions

As number of charge cycles increase, the deadzone percent of a battery also increases, reducing a batteries' life length

Issues with Capacitance

Within Lithium Ion + Lead Acid Batteries

300-500

Charging Cycles

Of full charge/discharge cycles before capacity drops below 80%

20%

Of Capacity Lost

After a full year of storage in an initially fully charged battery

60%

Of Initial Capacitance

At 0 degrees F, as opposed to 100% capacity at 80 degrees F. ½ of life is lost.

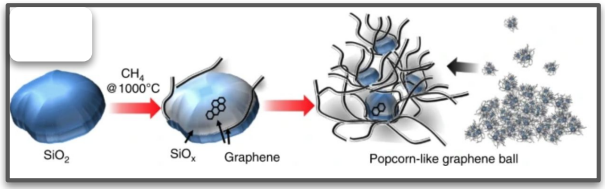
50%

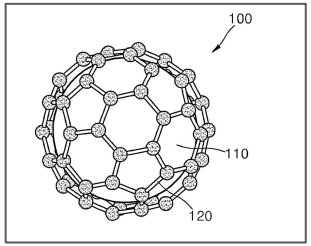
Reduction Of Battery Life

For every 15 degrees F the temperature rises, a typical car battery life is cut in half

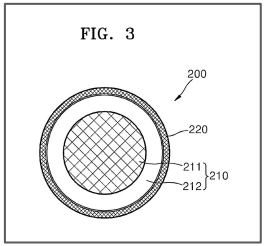
Patent Overview

Reaction Process





Popcorn-like Shape



Constituents

Approach

Propose a novel graphene ball as a coating on nickel cathode and lithium anode

Constituents

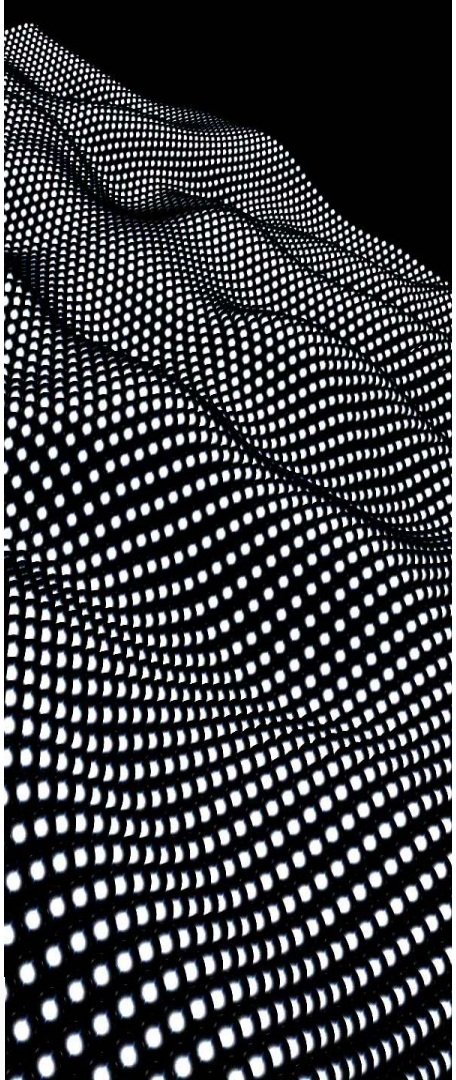
Graphene ball contains a SiOx nanoparticle center shaped like a popcorn (~ 20-30 nm diameter)

Formation

Grown at 1000 degrees celsius for 30 minutes through CVD → producing thin-film material through reactions in extremely hot mediums

Etching

Nobilta milling adds a uniform graphene layer onto the Nickel-rich cathode material (NCM).



Benefits of Graphene Balls

Easy to Implement Once Grown

Addition of graphene balls to slurry process of layering does not require substantial change

Able to homogeneously integrate the graphene balls into the slurry

Increased Capacitance

Increased capacitance by ~33.3% when applied on NCM electrode

Battery has high specific capacity of 86.1 mAH/g compared to 1 mAH/g for current lead-acid cathodes (all at 10 hours of charging)

Limitations of Graphene Balls

Scalability

Takes 40 minutes using CVD process to grow and apply graphene ball layer meaning that speed is a current limitation

Material Cost

Graphene costs $200/g - pristine quality

Silicon dioxide costs $162/ml

Methane costs $0.00075/m

0.1C (10 hrs charging) → $2943.13

Graphene Quality

Maintaining quality of graphene balls requires precise amounts of each component in its pure form

Impurities can result in inefficiencies and defects such as holes

Companies & Stakeholders

National Grid

Electricity & Gas, they provide battery storage systems in New York, Massachusetts and Rhode Island

Eversource

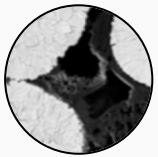
Energy provider in New England area, currently expanding its battery storage projects, ex. Martha's Vineyard

GE Energy

Runs ⅓ of world's electricity, creates renewable energy technologies and power networks

Cost Breakdown

To implement graphene balls for Eversource's Martha's Vineyard Battery Energy Storage Project from 2018, producing over **14.7 megawatts**.

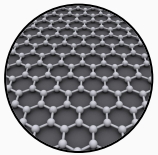


Nickel Cathode Material

$1027

Carbon Black

$46



Graphene

$1863

Materials Breakdown

MATERIALS	OPTION 1	PROVIDER	OPTION 2	PROVIDER
Pure Graphene	$239/g	MSE	$200/g	CheapTubes
NCM Oxide	$0.69/g	MSE	n/a	n/a
Carbon Black	$0.15/g	AliBaba	$0.63/g	MSE

Team

Nushaine

nushainef@gmail.com

Mukundh

mukundh.murthy@icloud.com

Alice

aliceliu2004@gmail.com

Vikram

vikrammenon03@gmail.com

THANK YOU