

Innovative Energy Storage Materials



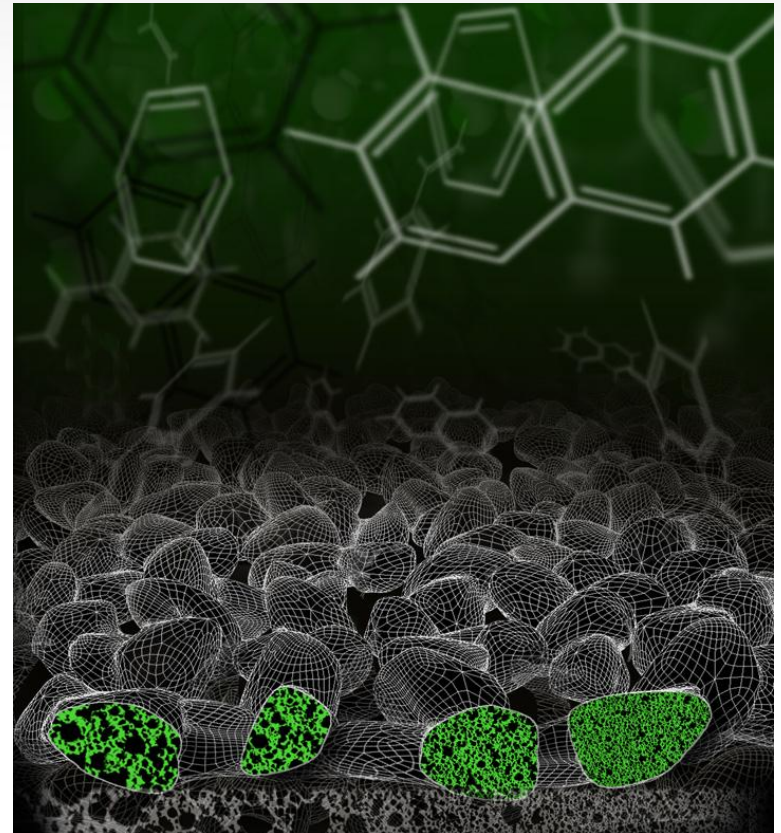
enerG2
NEXT GENERATION ENERGY STORAGE

AICHE | American Institute of Chemical Engineers
Puget Sound Local Section
Serving Chemical Engineers in Western Washington

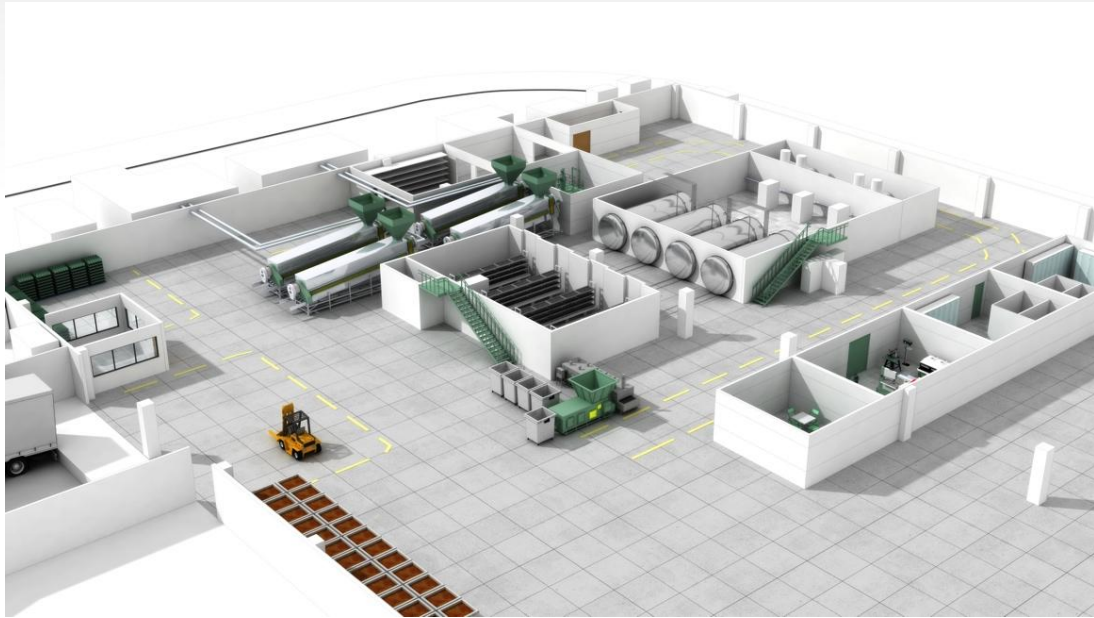
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Research Associate
22Feb 2012

EnerG2 Company Overview

- Founded in 2003
- Focused exclusively on manufacturing tailored carbons for energy storage chemistries:
 - *Ultracapacitors*
 - *Lead Acid Batteries*
 - *Next generation chemistries (metal air, metal sulfur, adsorbed gas)*
- Domestic and international intellectual property protection



Carbon Production Capabilities



	Phase I – Albany Operations	Phase II – Expansion	Phase III – Large Scale Plant
Timing	Currently under construction; online Q4 2011	Incremental equipment installed to meet demand in CY 2012 and 2013	Depending on customer demand – estimated 2015
Capacity	20-25MT / month	80-100MT / month	Projected 400-1000MT / month

Energy Storage Demand

Mature

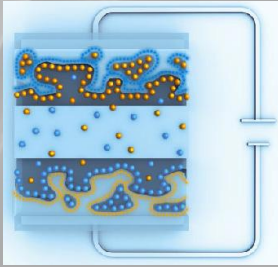
Growth

Emerging

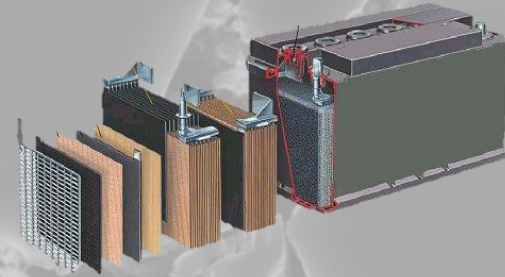


Carbon's Utility

Ultracapacitor Electrodes

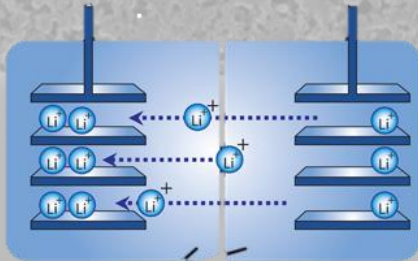


Advanced Pb-Acid Electrodes

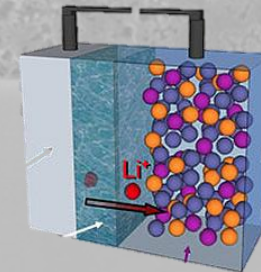


Electrochemical Performance Depends on High Purity and Optimized Nanostructure

Improved Li-Ion Anodes



Advanced Chemistries



Traditional Carbon Process

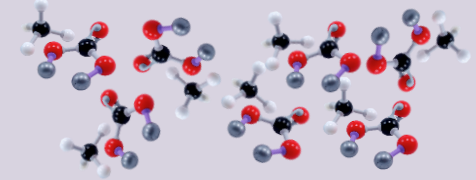
Limitation

Solution – EnerG2 Carbon Technology Platform



Start with Agricultural Waste

- High and varying levels of metallic impurities
- Fixed natural pore structure

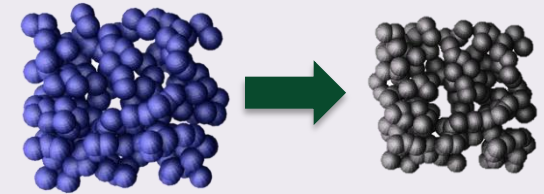


Synthesize ultra-high purity polymer sol-gel with controlled pore structure

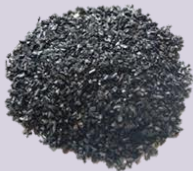


Pyrolyze Natural Precursor

- Fixed pore structures non-optimized for varying electrochemical systems

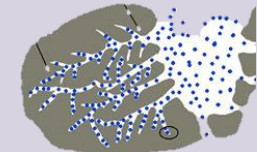


Proprietary drying and carbonization process maintains engineered pore structure



Steam or Alkali Activation

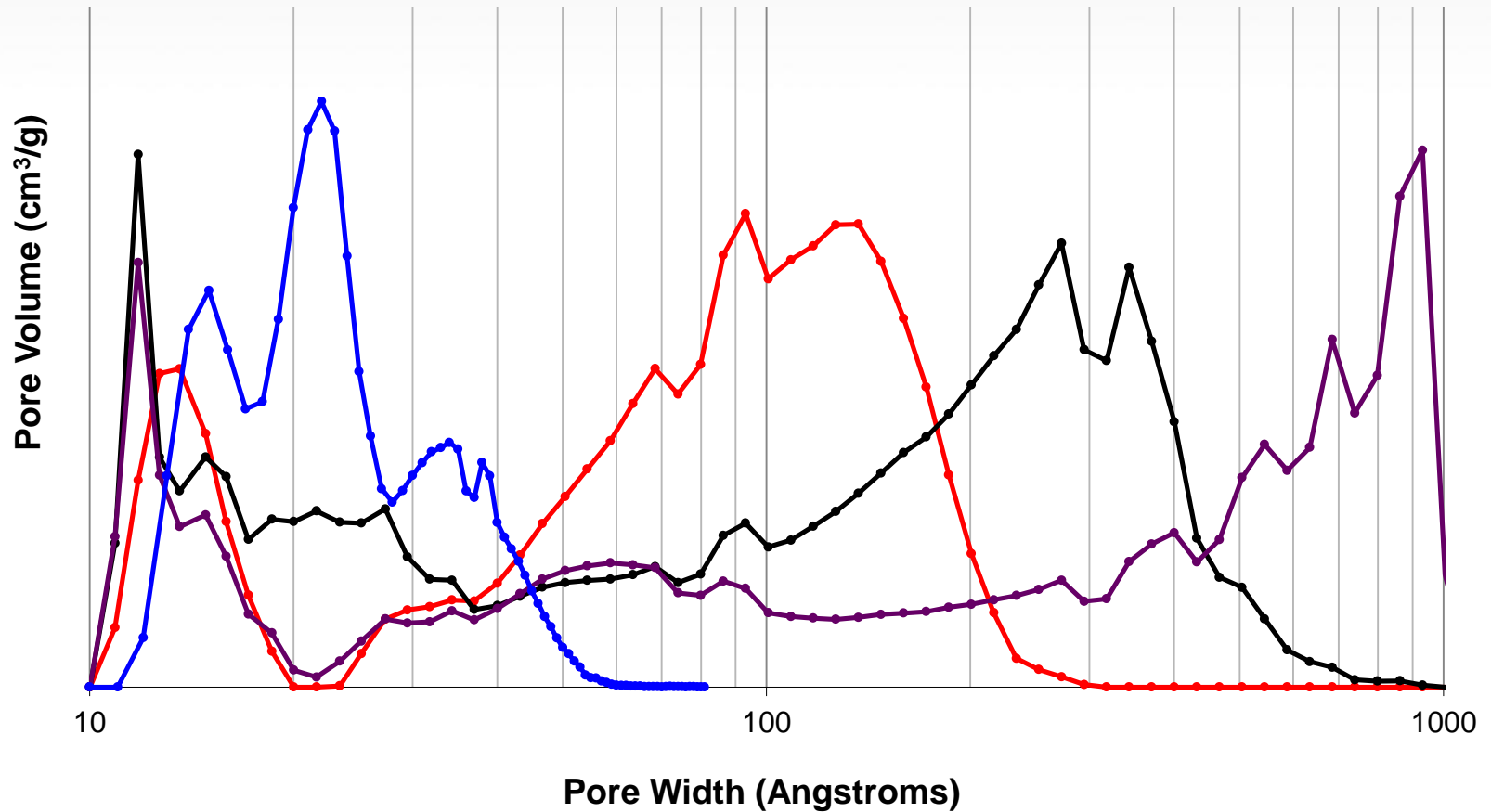
- Alkali activation is costly
- Fixed pore structure remains non-optimized with lot-to-lot variation
- High surface functionality



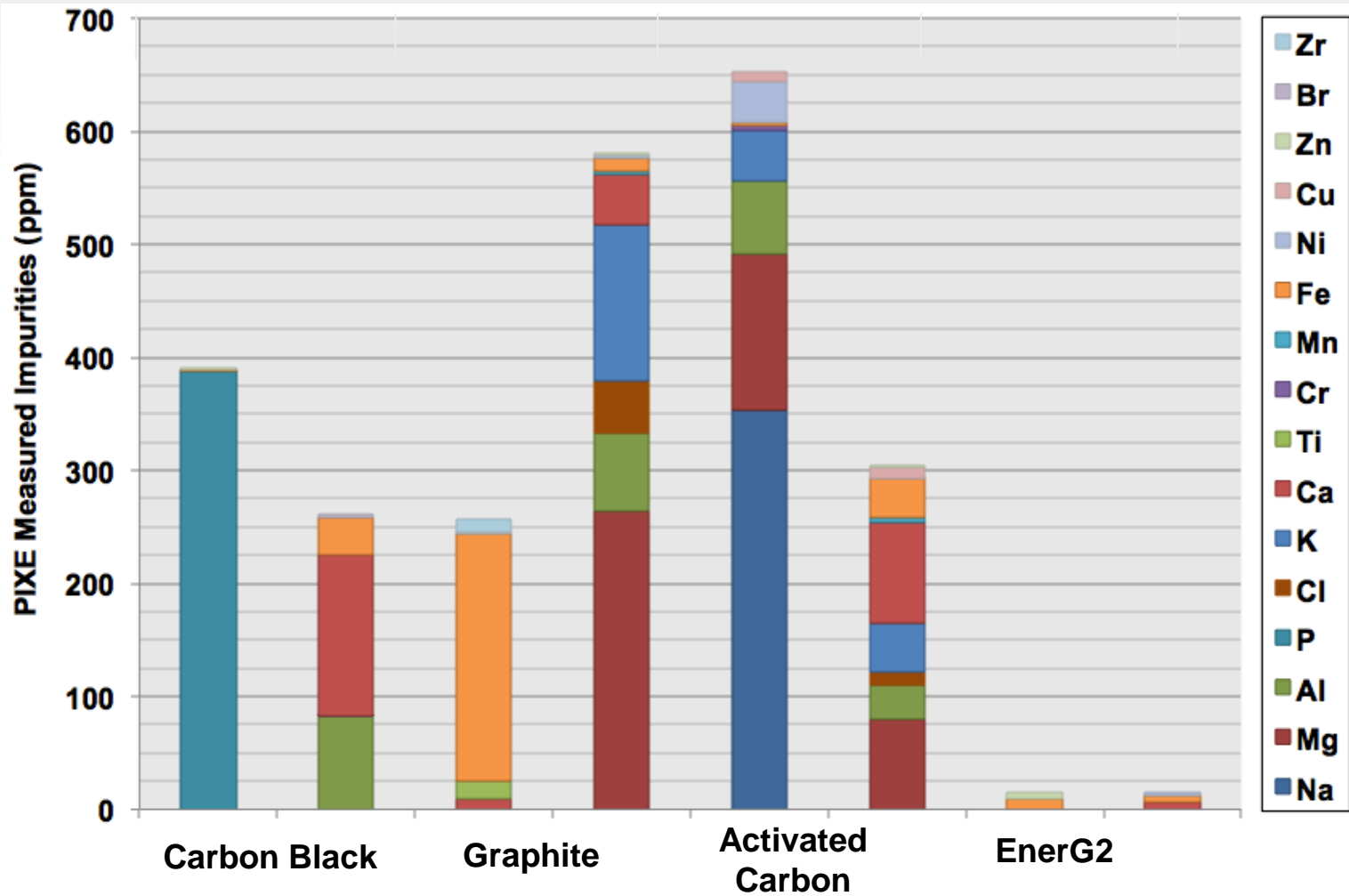
Proprietary activation maintains purity, desired pore structure, and controls surface chemistry

Processing Route

Nanoengineering for Desired Pore Structure



Unprecedented High Levels of Purity

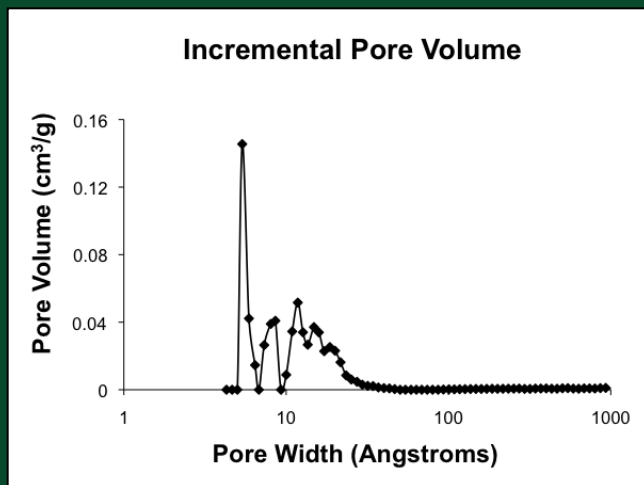


Product – Ultracapacitors

V2 Series

Unrivalled combination of energy density & stability

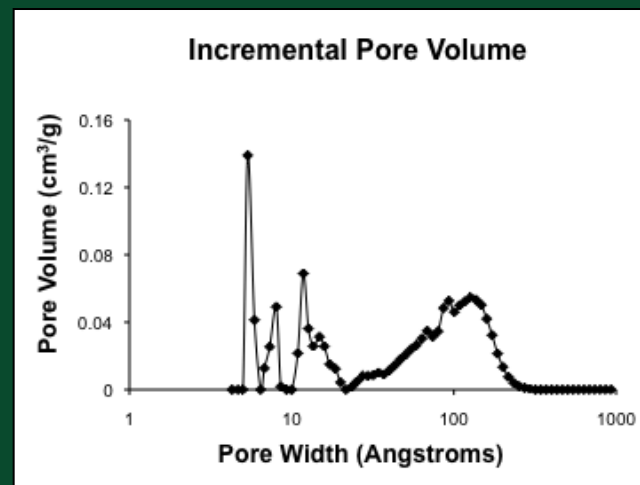
- High volumetric capacitance
- Improved durability
- Improved voltage stability
- Low surface functionality



P2 Series

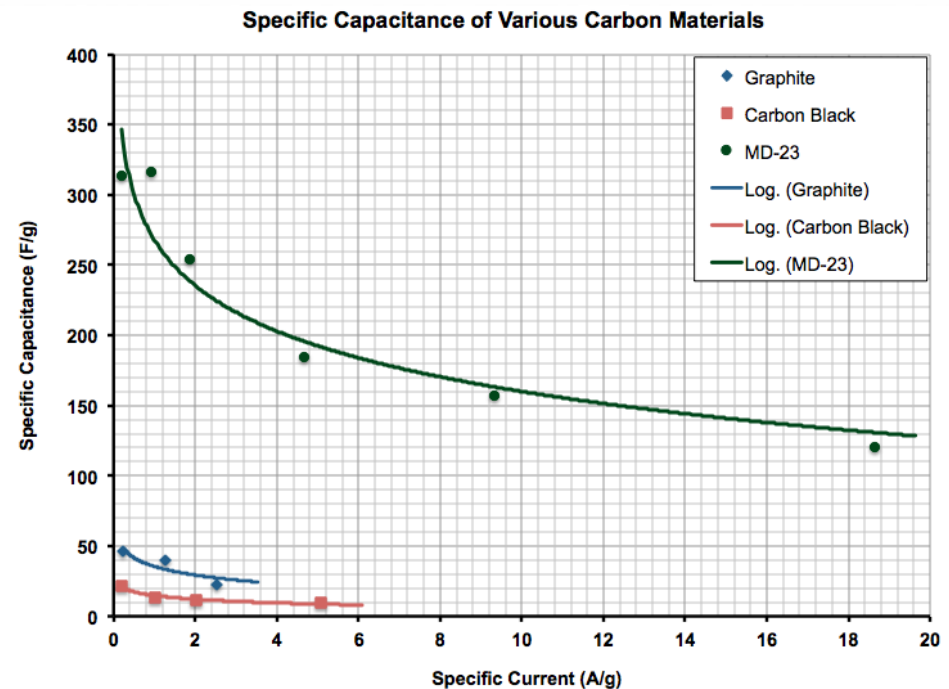
Unmatched stability and power performance in any temp. range

- Superior frequency response
- Lowest resistance
- Superior low temp performance
- Low surface functionality

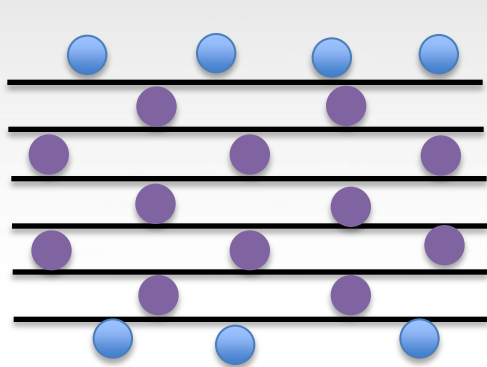


Product – Lead Acid Carbons

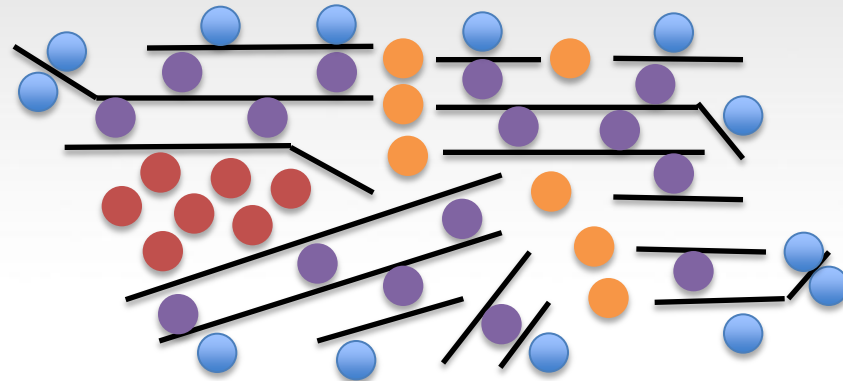
- Building on ultracapacitor carbons, EnerG2's MD-23 Lead Acid Carbon offers the highest specific capacitance (F/g) in sulfuric acid
- Specific Power increased by 3x
- Partial State of Charge Cycle Life increased 10x
- Charge Acceptance increased by 3x
- Failures by sulfation are virtually eliminated



Carbon Mechanisms for Lithium Energy Storage



Graphite



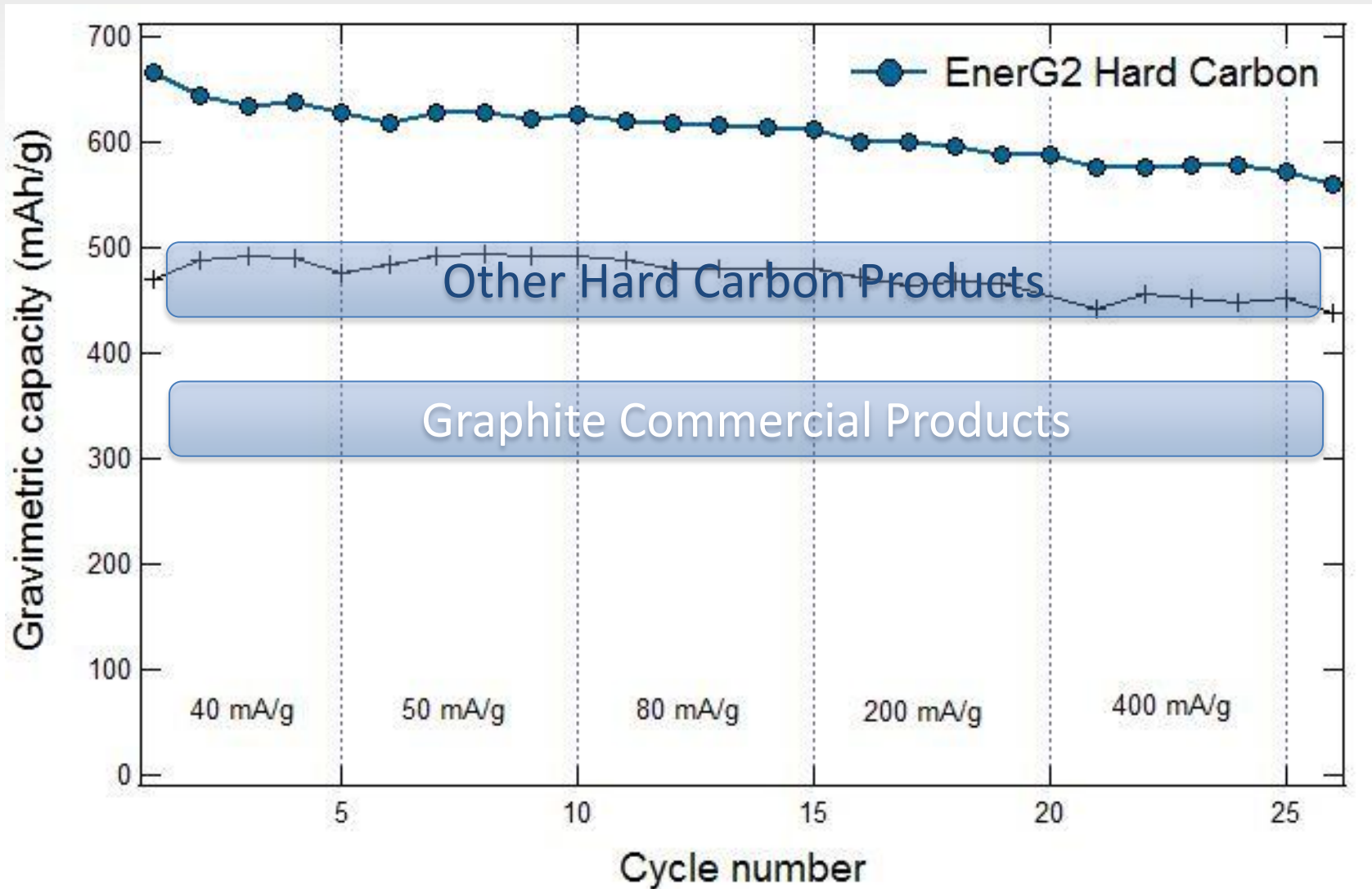
Hard Carbon

Li+ Storage Sites

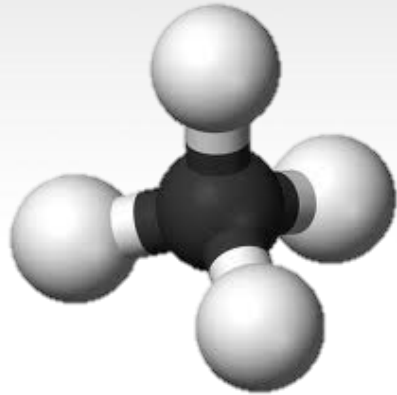
- Surface sites
- Uniformly spaced intercalation
- Cluster gaps
- Microvoids

Graphite Drawbacks	Improvements by using Hard Carbon
Low Power – 2D structure of long graphite sheets limits ion mobility	Shorten sheet lengths with near-surface storage improve kinetics and power output
Low Capacity – Lithium intercalation mechanism allows only 1 lithium per 6 carbon	Added Cluster Gap and Microvoid sites allow for an increase in storage capacity
Volume Changes – 10-12% change in volume during battery operation	Material more resistant to structural changes

Rate Performance of EnerG2 Hard Carbons



EnerG2 Advanced Carbon Platform



Adsorbed Gas



Ultracapacitors



Enhanced Lead Acid



Advanced Batteries

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Lithium Ion Anodes



Asymmetric Capacitors

EnerG2 is not just high performance materials, but a flexible energy storage technology platform built for continuous advancement.