

Battery Anode Material

24 November 2017

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Purpose and Contents

Purpose

Provide further detail about our Battery Anode Material strategy (BAM) strategy and progress

Outline the Syrah Resources and Cadenza Innovation testing, benchmarking and product development scope

Explain what is important in BAM properties and performance

Share some Balama graphite preliminary performance testing and benchmarking results

Contents

Syrah Resources' progress and strategy

Battery Anode Material market overview – Cadenza Innovation

BAM properties and performance measurement, preliminary results – Cadenza Innovation

Syrah Resources next steps



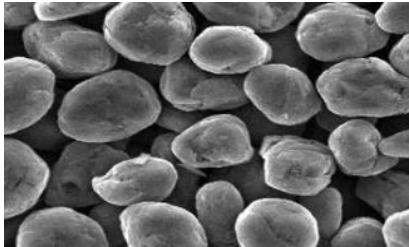

Syrah Resources Progress & Strategy

Balama has produced first saleable graphite

- Production of first bagged saleable flake graphite at Balama
- Flake graphite grade in excess of 95% fixed carbon
- Construction essentially complete
- Process plant optimisation underway



Syrah Resources overview

Focus of today			
Corporate & Development	Natural Graphite	Battery Anode Material	Optionality
<ul style="list-style-type: none"> Australian Stock Exchange: SYR S&P/ASX200 index member Market capitalisation ~US\$990m¹ Moving from project to operations Target cash flow positive H1 2018 	<ul style="list-style-type: none"> The world's largest and one of the lowest cost flake graphite mines World class ore grade of 17% Mine life of over 50 years World's largest graphite supplier by 2018 and ~40% global market share by 2020 CY18 production of 160 - 180kt² CY19 production of 250 - 300kt 	<ul style="list-style-type: none"> Aim to be the first integrated BAM producer outside of China Capture additional cash margin and establish key position in the supply chain of global battery market Targeting sales into USA domestic market as well as exports to other major battery making regions Collaboration with industry leaders 	<ul style="list-style-type: none"> Balama expansion the lowest cost incremental tonne of supply Battery Anode Material expansion; when market conditions suitable Processing of vanadium by-product
			

(1) As at 22 November 2017

(2) Refer to ASX announcements titled "Syrah finalises Balama Graphite study and declares maiden ore reserve" released on 29 May 2015, "Syrah increases Balama Reserves and awards Laboratory Contract" released on 15 November 2016. All material assumptions underpinning the production target in these announcements continue to apply and have not materially changed.

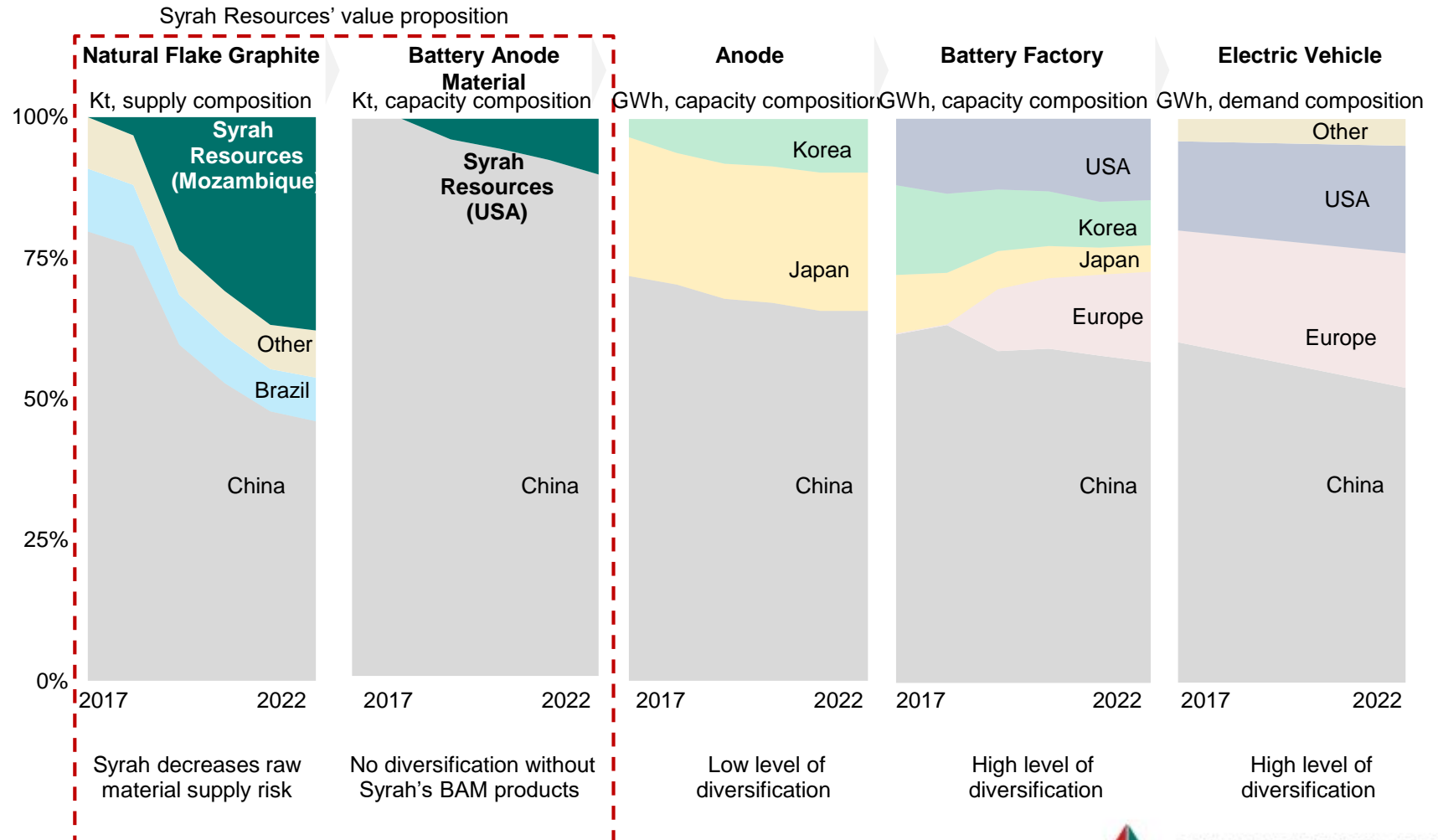
Production of BAM is a key foundation of our strategy and value proposition to shareholders

Strategic Goals	Logic	Enablers	Timing
1 Be the pre-eminent supplier of flake graphite	<ul style="list-style-type: none"> Industrial for baseload demand Lithium-ion battery market growth 	<ul style="list-style-type: none"> Low cost High quality Large volume 	<ul style="list-style-type: none"> First saleable product this month First revenue in early 2018
2 Be the first integrated battery anode material producer outside China	<ul style="list-style-type: none"> High value-add product First mover advantage Diversification in the global supply chain 	<ul style="list-style-type: none"> Electric vehicle market growth Energy storage Consumer goods 	<ul style="list-style-type: none"> Qualification product in Q2 2018 Commercial product in Q4 2018
3 Maximise value of other options	<ul style="list-style-type: none"> Large scale deposit Lithium-ion battery market growth Vanadium 	<ul style="list-style-type: none"> Expansion of Balama mine Battery anode material expansion Processing Vanadium 	<ul style="list-style-type: none"> Options under development

Our Values and People underpin how we execute our strategy

Deliver value for stakeholders and shareholders

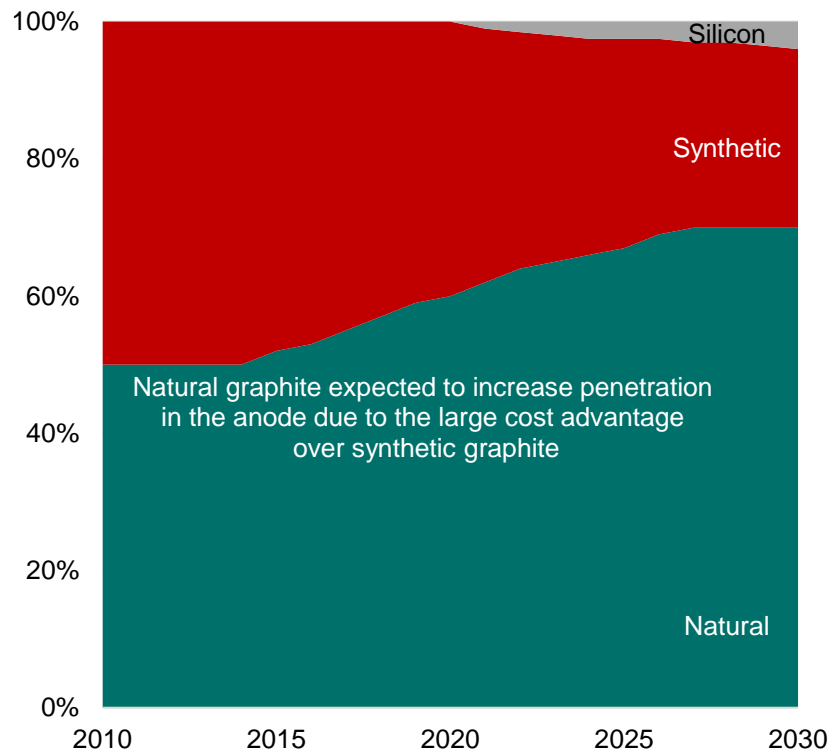
BAM production in USA provides global battery supply chain a strategic and valuable alternate source of anode material



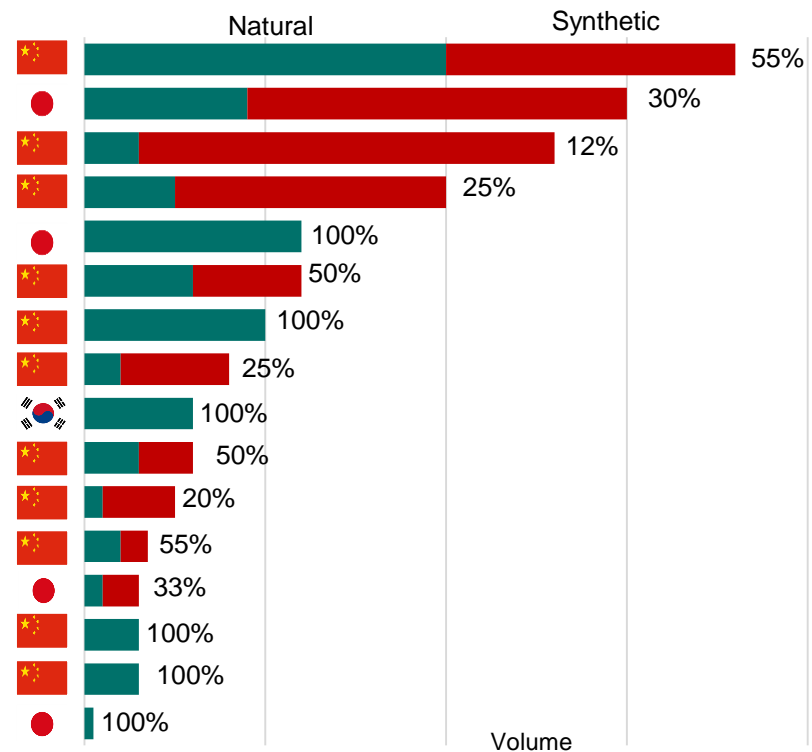
SYRAH RESOURCES

Blending natural and synthetic graphite in anodes enables a balance of performance and cost

Natural graphite penetration expected to increase



Anode composition by major anode producer



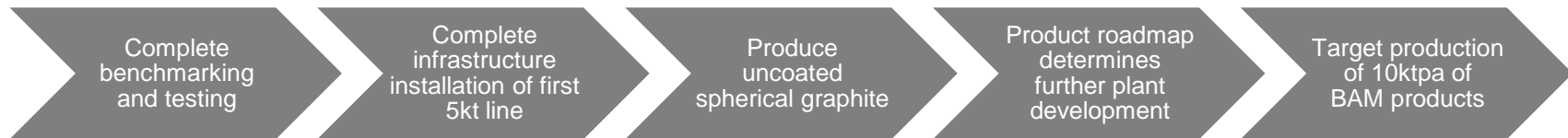
Source: Syrah Resources

BAM strategy driven by detailed value-in-use assessment, product development, and commercial relationships

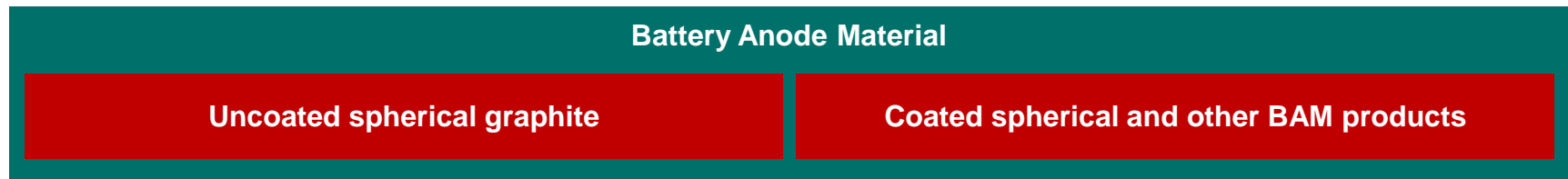
There are four key elements to our strategy...

Research	Louisiana	Products	Commercial
<ul style="list-style-type: none">• Service agreement with Cadenza Innovation to provide internal capability for intellectual property development• Highlight quality and value in use of Balama graphite through testing and benchmarking	<ul style="list-style-type: none">• Build BAM capacity to provide supply security and diversification benefit in global auto and battery supply chain• Be located in one of the major auto making regions	<ul style="list-style-type: none">• Uncoated spherical graphite for established market participants• Moving towards coated spherical graphite and other BAM options	<ul style="list-style-type: none">• Leverage existing and establish new relationships to move down the value chain

We are working through a detailed project plan



And targeting multiple BAM products...



SYRAH RESOURCES

Syrah has engaged Cadenza Innovation to benchmark material and fast-track cost-effective and competitive BAM

Cadenza Innovation is providing battery anode testing and product development services to Syrah Resources.



A joint team is established and operating in the USA, focused on:

- State of the art laboratory testing and benchmarking of Balama graphite
- Carbon processing expertise
- Established Li-Ion industry experience and manufacturing networks
- For rapid anode product development

Battery Anode Material (BAM) – Cadenza Innovation

Multiple market segments are being disrupted by the improving performance and lowering cost of lithium-ion batteries

Mobility Revolution

- Technology Innovations

Change in the Economy

- Energy Security
- Oil Independence
- Government Support

Portable Power



- Lithium-ion cell demand growing to \$16Bn by 2018
- Requirements: dependable run time, fast charge, safe

Transportation



- EV market for lithium-ion batteries expanding to \$30Bn by 2020; \$175B 2025
- Requirements: Extended range, safe, affordable

Utility



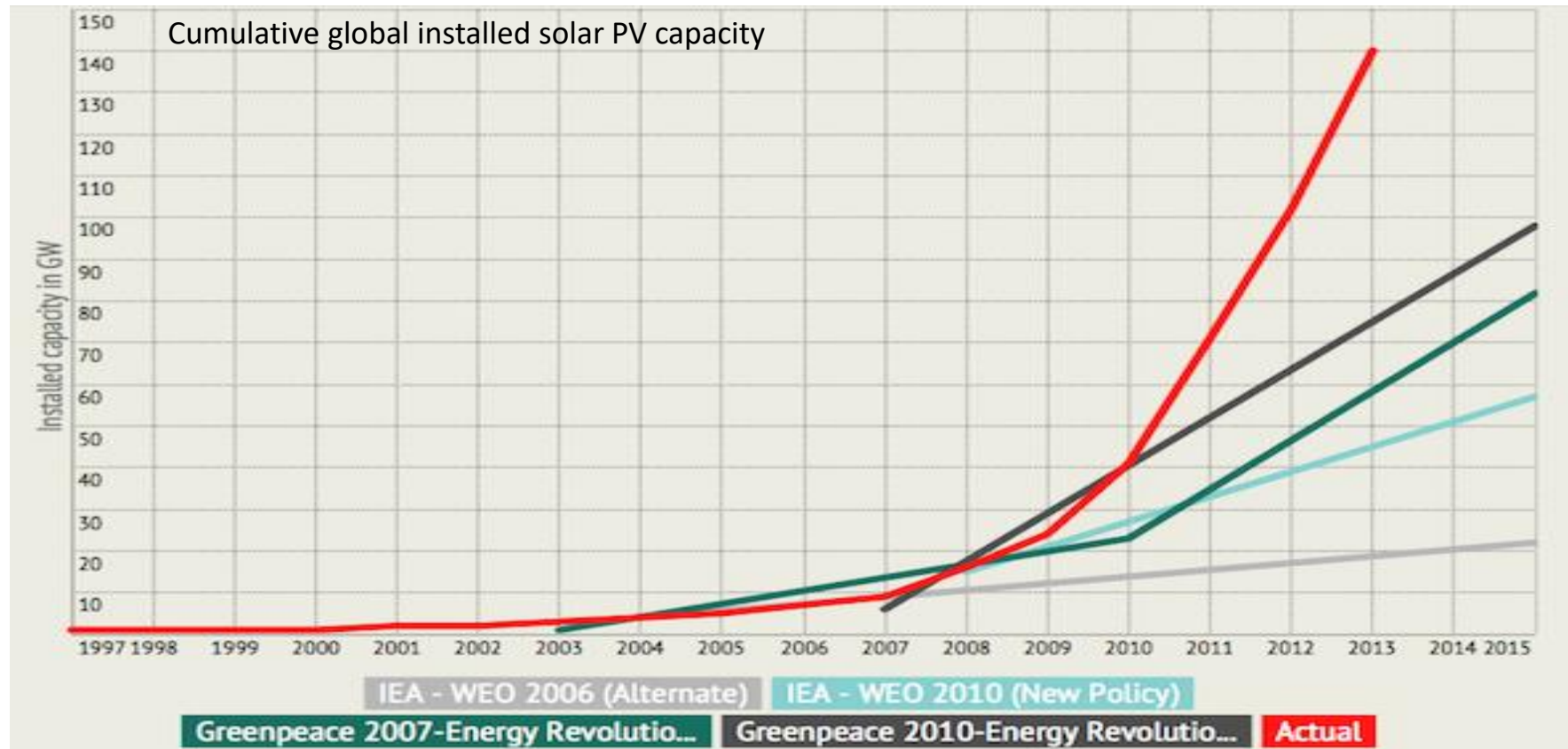
- Lithium-ion batteries will be one technology with a clear and possibly extraordinary growth trajectory estimating \$30B by 2020 to \$400B by 2030
- Requirements: Compact & modular, reliable, safe, affordable

Military



- Lithium-ion battery demand driven by growing need for transport, surveillance & communications
- Requirements: lightweight, safe, long-life, rugged, green

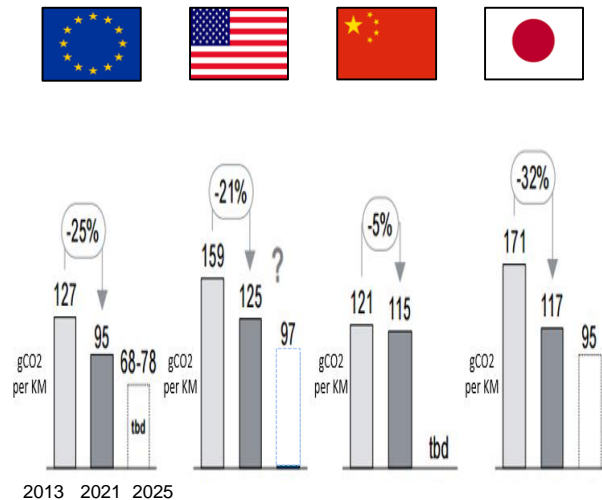
The PV boom was underestimated by nearly all and helped create new players and new partnerships to facilitate market growth



Source: International Energy Agency, World Economic Forum, Greenpeace

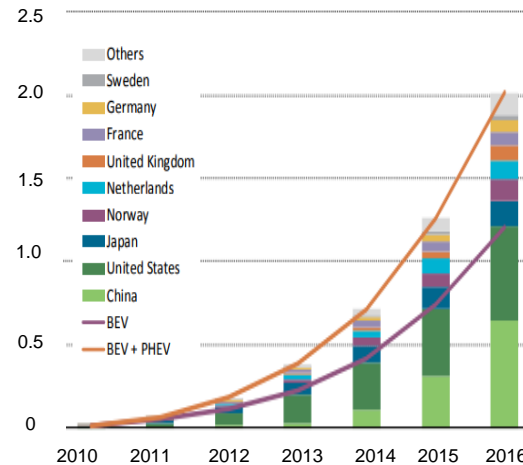
Global policy, sales momentum and industry investment continue to build for the electric vehicle market

Government regulations driving change



EV fleet surpassed 2 million in 2016, ~1 million more to be added in 2017

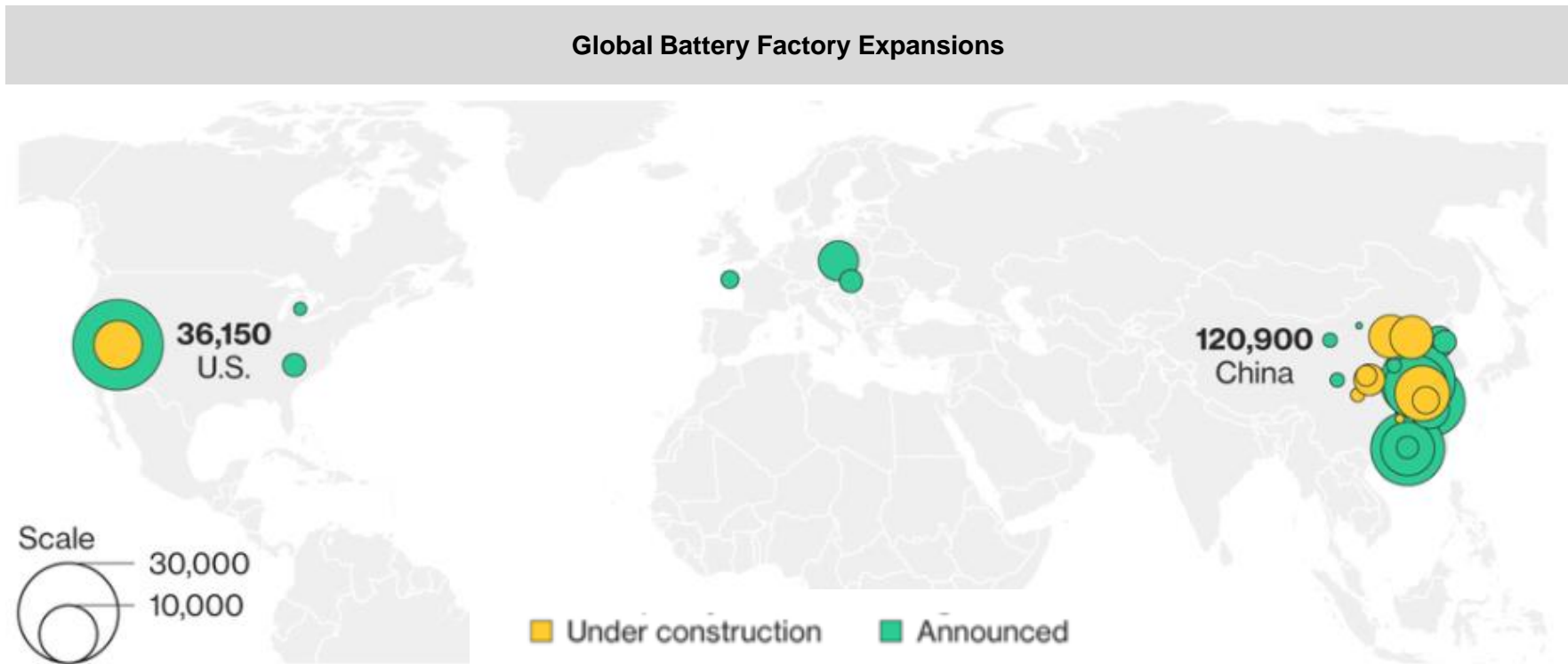
Stock of EVs (millions)



Traditional OEMs responding to EV development and competition

- VW**: Invest up to \$24 billion to produce more than 3 million EVs pa by 2026
- BMW**: Has sold 100,000 EV/PHEV in each of the last 3 years
- Mercedes**: EVs to be 15-20% of sales by 2025
- Nissan**: All sales to be EV/PHEV by 2019
- Volvo**: 50% of sales to be EV/PHEV by 2020
- Peugeot**: 80% of core models to be EV/PHEV by 2023
- Nissan**: 20% of EU sales to be EV/PHEV by 2020
- Honda**: 65% of all sales to be EV/PHEV by 2030
- Hyundai**: 31 new models and 300,000 EV/PHEV sales by 2020
- Mitsubishi**: Partnering with Nissan/Renault to launch 12 new EV/PHEV models by 2022
- GM**: 10 EV/PHEV models by 2020
- Ford**: 13 EV/PHEV models by 2022, including F-150 hybrid
- Global Electric Vehicle Leaders**: Over 500,000 full electric cars and trucks planned
- Tesla**: Leading Chinese EV car and bus producer
- BYD**: Leading Chinese EV car and bus producer

Battery factory capacity expansion is a global trend; China leading the development



Source: Bloomberg

Graphite will maintain dominance for the foreseeable future and natural graphite will increase market share as cost pressure increases

Artificial Graphite Anode material xEV, grid	Natural Graphite Anode material xEV, portable electronics	Silicon Alloy Anodes Emerging but mixed with graphite presently
<div>more energy</div>		
<div>better cycle life</div>		
Key issues <ul style="list-style-type: none"> • High cost • High graphitisation energy use Mitigating solutions <p>Mix with natural graphite</p> <p>Develop graphitization process</p>	Key issues <ul style="list-style-type: none"> • Low temperature performance • Historical environmental impact Mitigating solutions <p>Surface coating/modification</p> <p>Particle morphology design</p>	Key issues <ul style="list-style-type: none"> • Cycle life • Electrode expansion/cell dimensional stability • Low first cycle efficiency Mitigating solutions <p>Si-nano-particles composite</p> <p>Mix with larger percentage of natural and/or artificial graphite</p> <p>Limit discharge cut-off voltage</p>

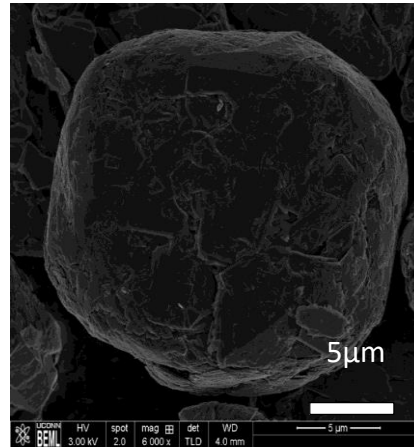
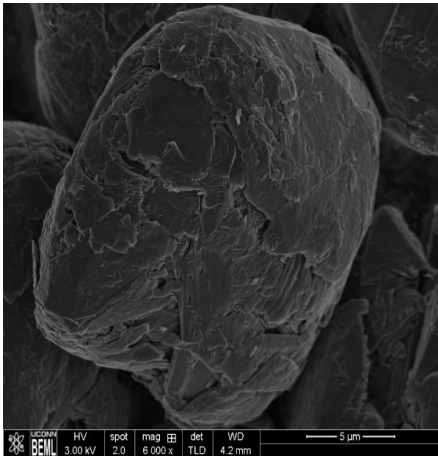
Many variables are being tested to allow Syrah Resources to better understand the performance of Balama graphite in the anode

Physical & Chemical	Composition	Structural	Performance
<ul style="list-style-type: none">• Size Distributions• Morphology• Surface area• Porosity• Tap density• Spring back• Adhesion• Electrolyte absorption	<ul style="list-style-type: none">• Elemental• Moisture• Ash content	<ul style="list-style-type: none">• Crystallinity• Graphitisation• Crystallite size	<ul style="list-style-type: none">• Specific capacity• First cycle efficiency• Cyclability• Rate capability

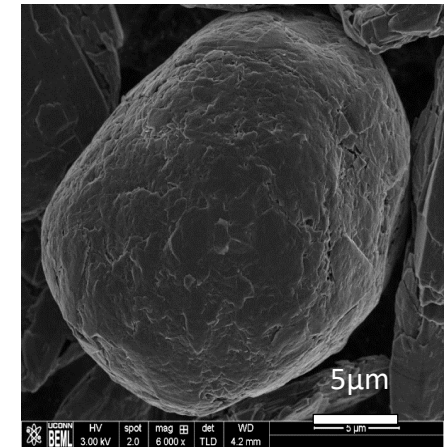
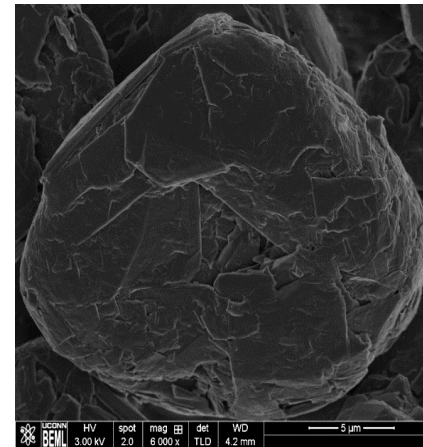
Benchmarking Data Based on Cadenza Innovation Laboratory Testing

At x6000 magnification, purified, and purified & coated Syrah BAM material show similar surface morphology

Purified, not coated Syrah BAM

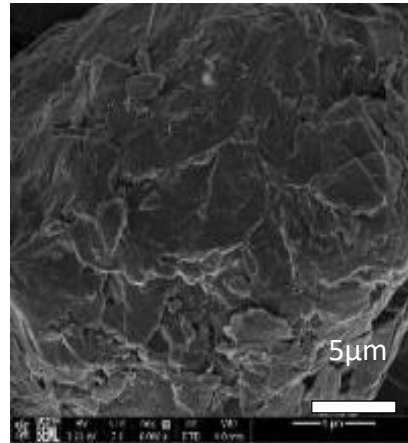
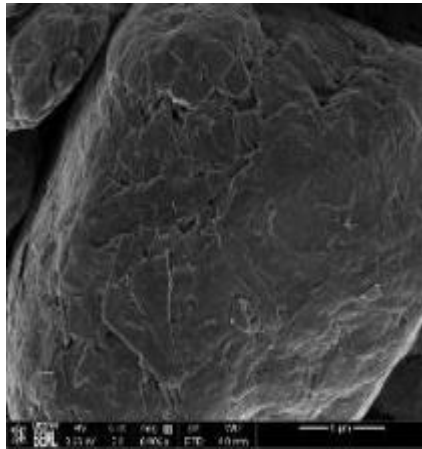


Purified, pitch-coated Syrah BAM

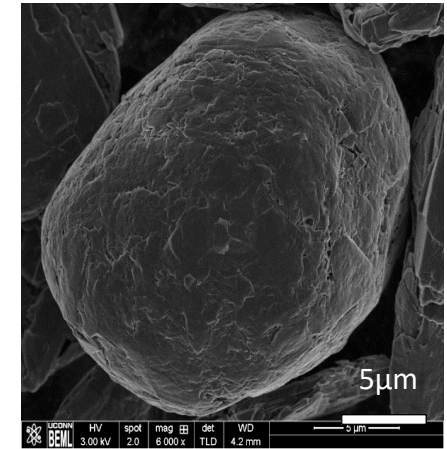
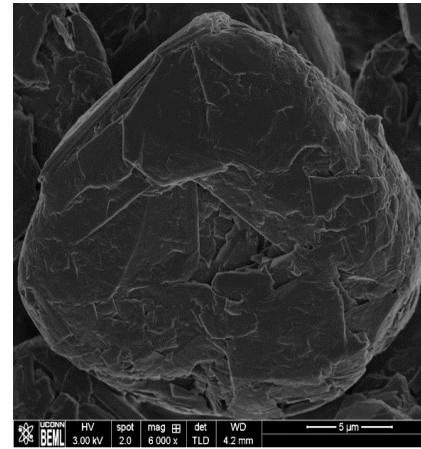


Purified & coated Syrah BAM material shows similar surface morphology to anode material from a global tier 1 anode maker

Material from tier 1 global anode maker

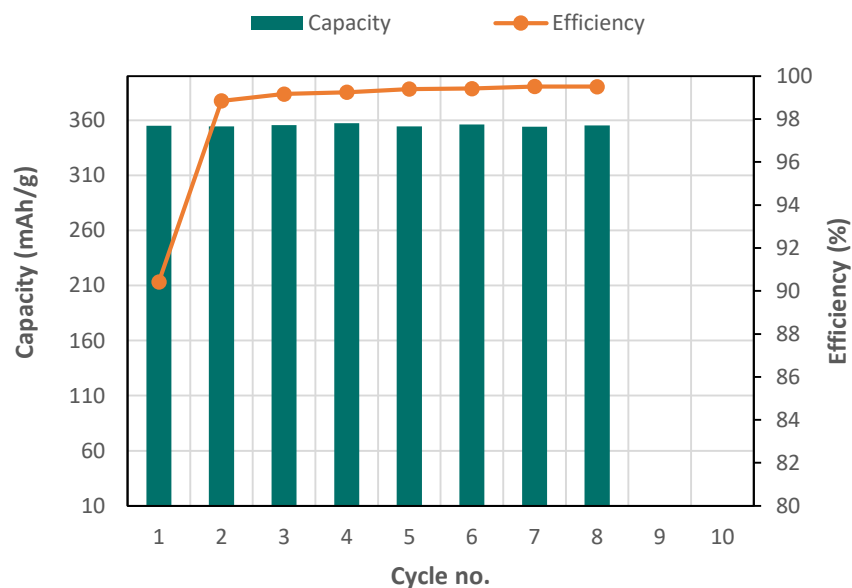


Purified, pitch-coated Syrah BAM material

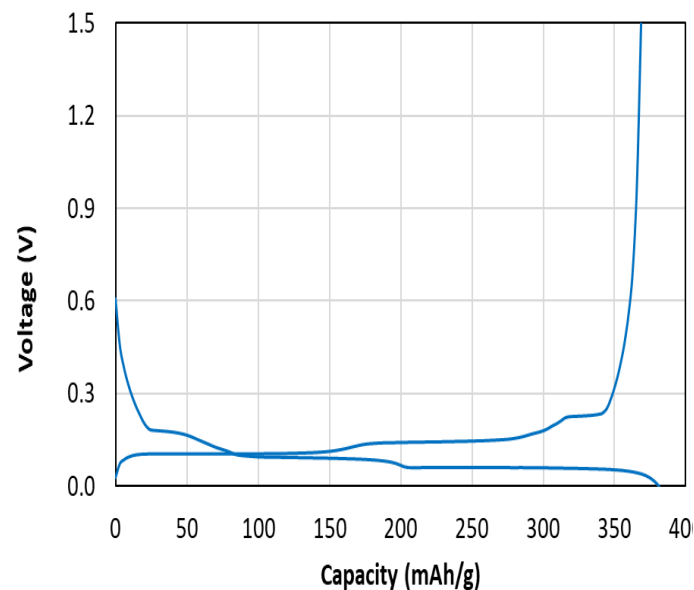


Syrah's BAM highlighted a competitive capacity and efficiency, with stable initial cycling

Capacity and efficiency

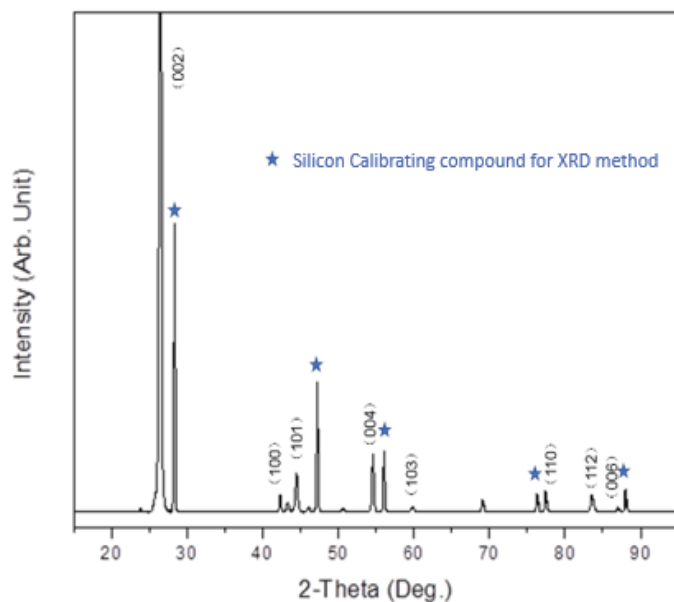


1st cycle charge/discharge curve



XRD results indicate a high degree of crystallinity

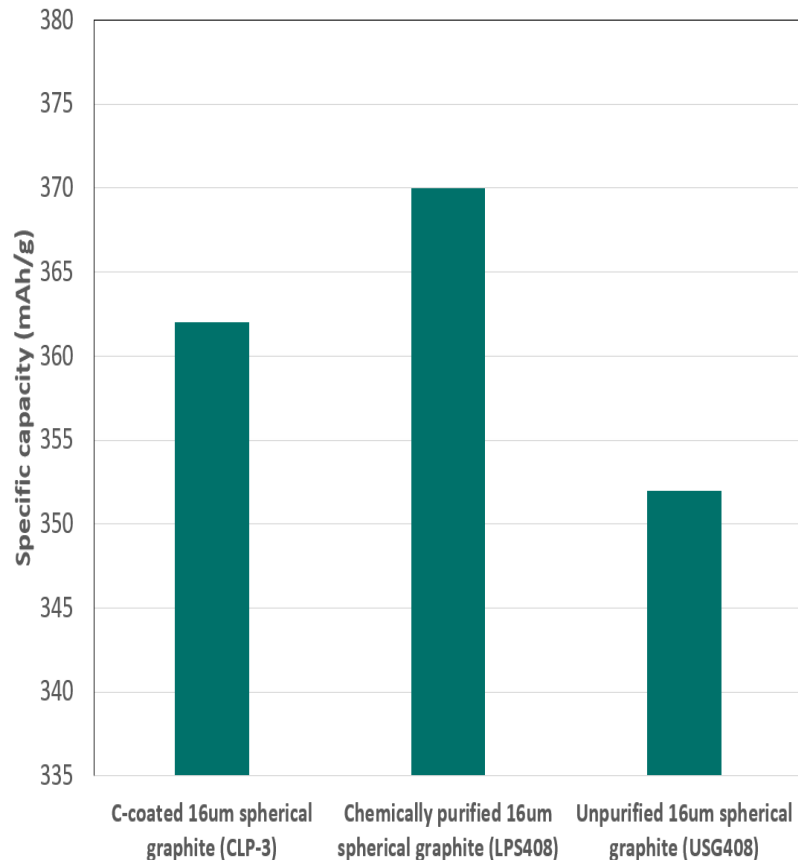
X-ray diffraction (XRD) spectrum of Syrah pitch-carbon coated sample



Parameters	Average	Standard Deviation
d_{002} (Å)	3.3579	0.0003
Degree of Graphitisation (%)	95.48	0.32
Lc (002) (nm)	40.969	0.871

Syrah's BAM highlighted a competitive capacity and efficiency, with stable initial cycling

Capacity and efficiency



Early trial of purified, pitch-carbon-coated BAM

- 360 mAh/g (C/20 rate)
- Conclusion: as expected from a low-temperature process

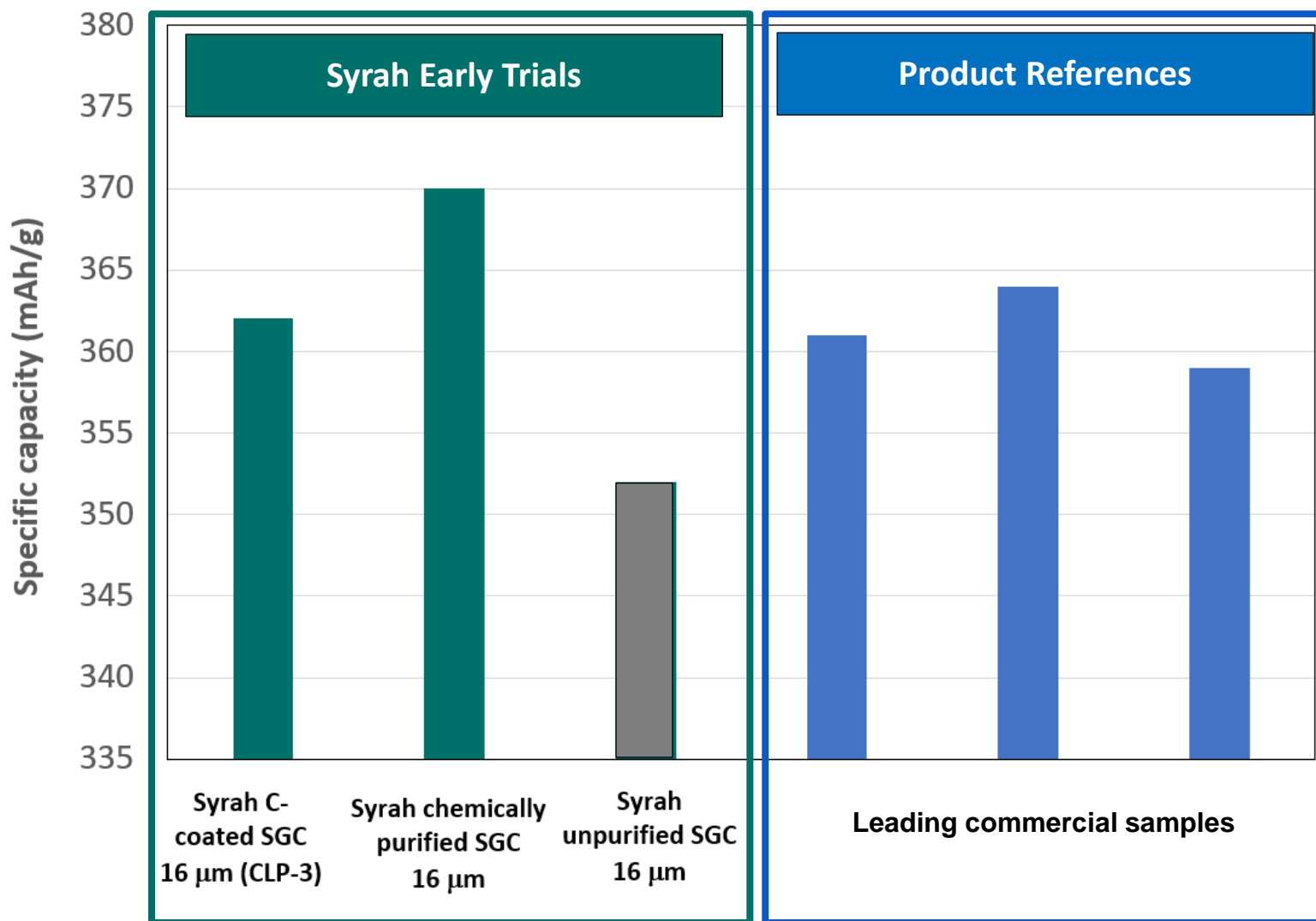
Early trials of chemically purified, non-coated BAM

- tests at 366-370 mAh/g (C/20 rate)
- Conclusion: no further heat treatment needed

Early trials of unpurified BAM

- tests at 340-360 mAh/g (C20 rate)
- Conclusion: a highly ordered precursor material

The Balama mine produces a superior precursor material, which Syrah/Cadenza are now refining into multiple BAM product options



As the global Li-ion battery market is expanding, carbon anode material focus increases - Syrah / Cadenza to update in March 2018

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 - Advances in Automotive Power Applications
 - Power Applications for Consumer Electronics
 - Alternatives to Energy Storage
- ENGINEERING STREAM**
 - Battery Safety
 - Battery Management Systems

▼ PLENARY KEYNOTES

-  **How Does the Electrolyte Change during the Lifetime of a Li-Ion Cell?**
Jeff Epler, PhD
MEREC/Toyota Canada, Dalhousie University
-  **User Needs - Presenting an Electric User/All-Purpose User**
Mark Moore
User
-  **Addressing Key Battery Issues from a Thermodynamics Perspective**
Rachid Yazami, PhD
Nanyang Technological University, Singapore
-  **Global Electrification and Li-Ion Cells**
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WEDNESDAY, MARCH 28

1:40 pm Plenary Keynote Sessions: Organizer's Remarks



1:45 Addressing Key Battery Issues from a Thermodynamics Perspective

Rachid Yazami, PhD, School of Materials Science & Engineering, Program Director, Energy Storage, Energy

Research Institute, Nanyang Technological University, Singapore

Rachid Yazami is a French Moroccan scientist best known for his research on lithium-ion batteries and on fluoride-ion batteries. He is the inventor of the graphite anode (negative pole) of lithium-ion batteries. In 2014 Rachid Yazami, John Goodenough, Yoshio Nishi and Akira Yoshino were awarded the Draper Prize by the National Academy of Engineering for pioneering and leading the groundwork for today's lithium-ion battery. In this presentation, we will show how online thermodynamics data collection and processing addresses the SOC and SOH determination. We found a universal rule, which applies to all LIB tested at any SOH (ageing), that is the SOC is a linear function of entropy and enthalpy. Linearity coefficients are LIB chemistry and SOH dependent. Therefore, the thermodynamics assessment method teaches on the type of cathode material and on the degree of anode and cathode degradation as the battery ages.

Battery Anode Material (BAM) – Next Steps

Testing and benchmarking continues; product development roadmap aligned with Louisiana facility; commercial discussions

- Louisiana BAM plant development progressing to plan – site, permitting, long lead items, services all on track
- Installation from Q1 2018, targeting earliest qualification material – first products known, next phase products researched
- Testing, benchmarking, and product development options in conjunction with Cadenza to continue in 2018
- March 2018 delivery of product roadmap and next phase of development plan
- Ongoing technical and commercial discussions with potential customers
- Exploration of other potential commercial relationships underway

