

Graphene has many roles to play in improving battery performance

The biggest event this week was the crunching of the markets in New York on Thursday and the flow through effects on our Friday. That confirmed a breakdown of the very strong uptrend in our All Ords. Maybe this will lead to a period of further weakness, but this should not be surprising as a reaction to the extraordinary strength over recent months is overdue.

It has been another week of strong prices for EVs and battery inputs metals, as well as for iron ore. Copper prices are approaching a 10 year high. Metal prices normally peak during the later stages of economic cycles but there is nothing normal about what we are seeing today. This time around you need to consider the high levels of liquidity available to speculators and the disruptions to supply of commodities that have come with the virus. The enthusiasm for EV and battery inputs is somewhat of a wild card as projections are based on expectations rather than firm orders. Volatility continues to be the order of the day with the risk being on the upside.

Keeping an eye on interest rates

Yes, US interests rate have strengthened a little lately, which might not be a surprising response to combat the falling dollar, but as far as official policy is concerned, Powell has re-stated that monetary policy stimulus will continue and interest rates will remain low at least until 2022. However, this statement wasn't enough to stop the markets becoming spooked by the prospects of inflation that might result from the huge stimulus package proposed. What is more important though, is that this boost to liquidity will fuel market speculative activity further and that will take stock prices even higher. It is too early to be concerned about inflation.

We are seeing comments on economic activity around the world being closely related to the vaccination program and expectations of recovery, but remember that a recovery is a catch-up for past failings. The movements of stock markets over the past year have largely ignored the speed bumps to growth that the virus imposed on the economies and they have moved ahead of previous trend lines. They have received their impetus from the flood of liquidity into markets rather than evidence of economic growth.

At what point will pure fundamentals come back into play as the dominant driver of markets? Do we have to see liquidity drained from the system first? Quite possibly, but that will require higher interest rates and a tightening of money, but no government is advocating that approach in the foreseeable future. The virus has caused plenty of slack in the economy so demand pull inflation isn't an issue for some time. When the economy starts to get overheated it can be brought back under control through either higher taxes. It doesn't have to be achieved with interest rate hikes alone.

Where does graphene fit into batteries and energy storage technology?

I am frequently asked about where graphene fits in with battery materials and whether a company such as First Graphene has a strong role to play in this field. A simple answer is yes. Graphene will be important in a number of areas but the exact applications of graphene are varied and still subject to continuing research and optimisation. It is probably not going to be a direct substitute for anything in particular but depending upon the type of graphene and how it is applied, we should expect to see that it will facilitate improvements in many different battery and supercapacitor energy storage devices.

Today, graphene is being used several ways in existing lithium ion and lead acid batteries, including in some commercial products. In lithium ion batteries, graphene is being utilised in five main ways;

- i) conducting additives in existing electrodes,
- ii) conducting additives within particles of cathode material,
- iii) shielding of lithium metal anodes,
- iv) improving the performance of anodes containing silicon-based material and
- v) improving the performance of existing aluminium and copper foil electrodes by coatings.

As a generalisation, in these applications graphene has improved efficiency, safety and longevity of the batteries.

I have summarised key points from some scientific papers on these applications but unfortunately they are still rather technical. If you need to know more, please contact us.

Redox flow batteries get a boost with graphene

Vanadium is a speciality alternative energy metal that has particular relevance to flow batteries. It comes up in despatches from time to time but the high cost, limited cycle performance and incompatibilities associated with the commonly used carbon-based electrodes tend to undermine hybrid redox flow cells (HRFC) commercial viability.

Redox flow batteries (RFBs) have been extensively investigated since the 1960s for large-scale stationary energy storage because their engineering flexibility can be better than alternatives such as pumped hydro or compressed air systems. RFBs promise a long cycle life, decoupled power and energy characteristics, and round-trip energy efficiencies as high as 85% (normally operating below a current density of $\sim 120 \text{ mA cm}^{-2}$), but their commercial exploitation has been limited by high capital costs due to the use of expensive vanadium-based electrolytes (about $\sim 43\%$ of system cost for a 4 MWh all-vanadium RFB) and membranes.

Developing large-scale electrochemical energy storage technologies without compromising energy efficiency,

power density, safety, and cost-effectiveness is one of the biggest challenges in enabling the transition into renewable energies, especially via grid-scale storage and back-up power storage for intermittent energy sources.

Recent research has shown that the addition of nanocarbon additives and carbon paper electrodes hold new promise. By coupling electrophoretically deposited nitrogen-doped graphene with carbon electrodes there are beneficial effects on three types of HRFCs;

- vi) hydrogen/vanadium (RHVFC)
- vii) hydrogen/manganese (RHMnFC)
- viii) polysulphide/air (S-Air).

RHVFCs offered a 70% improvement in efficiency, RHMnFCs a 30% increase and the S-Air cell has recorded a 300% improvement of kinetics compared to bare carbon paper electrodes.

Graphene coat improve solid state lithium anodes

Whatever material is being used for anodes today, there is an expectation that eventually metallic lithium (solid state) could be the next generational breakthrough. However, as with all battery breakthroughs, there are some issues to iron out first. Solid state lithium has a problem with an unstable solid electrolytic interface (SEI) which results in constant lithium consumption for the formation of fresh SEI, along with lithium dendritic growth during electrochemical cycling.

Scientists have learnt that the use of a fluorinated reduced graphene oxide layer on the metallic lithium surface provides a conductive layer and electronic insulator, and it suppresses the formation of high surface area lithium. Graphene derivatives have already shown themselves to be useful in suppressing dendritic growth. This latest finding extends the understanding of how well graphene oxide performs as a protective layer in a scalable drop casting coating technique. This also has positive implications for supercapacitors and fuel-cell applications.

75% improvement in the current cathode collector

Aluminum foil is the most accepted cathode current collector for lithium-ion batteries (LIBd) but it is susceptible to local anodic corrosions during long-term operations. Such corrosions could lead to the deterioration or even

premature failure of the batteries and are generally believed to be a bottleneck for next-generation 5 V LIBs.

Scientists have demonstrated that Al foil armoured by a conformal graphene coating exhibits significantly reinforced anodic corrosion resistance in both LiPF₆ and lithium bis (trifluoromethanesulphonyl) imide (LiTFSI) based electrolytes. Moreover, LiMn₂O₄ cells using graphene-armoured Al foil as current collectors (LMO/GA) demonstrate enhanced electrochemical performance in comparison with those using pristine Al foil (LMO/PA). The long-term discharge capacity retention of LMO/GA cell after ≈ 950 h straight operations at low rate (0.5 C) reaches up to 91%, remarkably superior to LMO/PA cell (75%).

The self-discharge propensity of LMO/GA is clearly relieved and the rate/power performance is also improved with graphene mediations. This work not only contributes to the long-term stable operations of LIBs but also might catalyze the deployment of 5 V LIBs in the future.

Similarly, it has been found that a layer of graphene has been found to stabilise copper current collectors, which can perform a similar task to aluminium collectors.

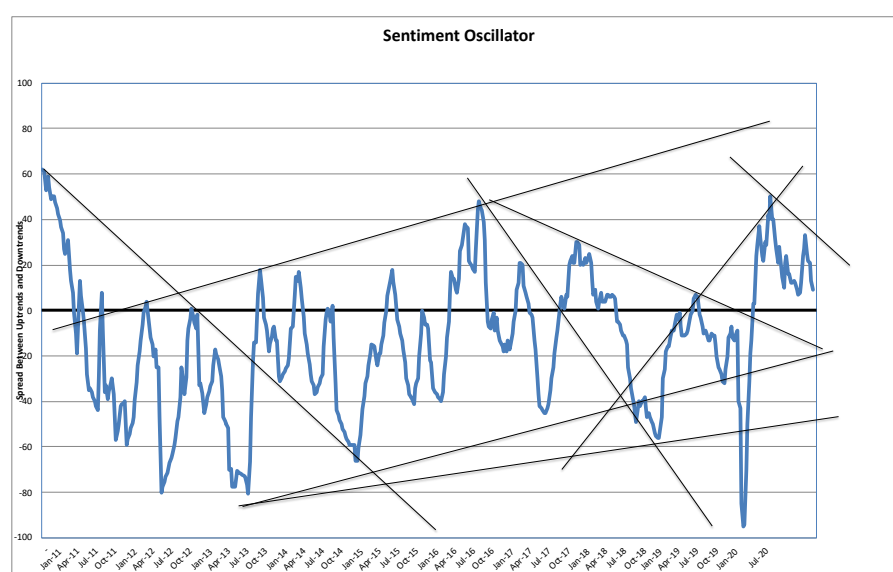
215 carat and 114 carat diamonds this week

Lucapa must be wondering what it has to do to get some love from the market. A 215 carat D quality diamond obviously isn't enough, even though it is worth a significant amount of money. We won't know exactly how much until it has been polished and sold, but you can be certain this will be a highly sought after diamond.

But wait. There is more. Yesterday Lucapa announced the recovery of a 114 carat Type Ila D-colour white diamond from Block 46 at Lulo. That makes it the third +100 carat diamond recovered from this Block in the last eight weeks. The added significance is the proximity to the Ganguige catchment where kimberlites are being assessed. It is looking more and more likely to be the hard rock source.

Occasionally you get bargain situations like this that are totally overlooked by the market, but eventually there is an inflection point and aggressive buying. It is only a matter of time.

Disclosure: Interests associated with the author own shares in Lucapa Diamond Company, and have received capital raising fees.



Sentiment Oscillator: Sentiment weakened slightly. There were 43% (46%) of the charts in uptrend and 34% (33%) in downtrend on Friday's close.

Detailed Chart Comments

NB. Only the bold comments have been updated. Comments in grey type are from previous weeks and will be less relevant. Please note that this list is a cross section of the market. It IS NOT a list of recommendations.

Indices	Code		Trend Comment	
All Ordinaries	XAO		off its high	
Metals and Mining	XMM		correcting lower	
Energy	XEJ		breaching uptrend	
Stocks	Code		Trend Comment (updated comments in bold)	Main Interest
Alpha HPA	A4N		new high	HPA
Adriatic Resources	ADT		surge higher then pullback	zinc, polymetallic
Aeon Metals	AML		still in downtrend	copper + cobalt
Alkane Resources	ALK		breached uptrend, heading down	gold, zirconia
Alicanto Minerals	AQI		sideways	base metals, silver, gold
Allegiance Coal	AHQ		surge through downtrend, then pullback	coking coal
Alliance Resources	AGS		pullback	gold predevelopment
Alto Metals	AME		down	gold exploration
American Rare Earths (was BPL)	ARR		breached downtrend (COB holding)	rare earths
Apollo Consolidated	AOP		down	gold exploration
Arafura Resources	ARU		pullback	rare earths
Aurelia Metals	AMI		down	gold + base metals
Australian Potash	APC		holding shallower uptrend	potash
Auteco Minerals	AUT		softer	gold exploration
BHP	BHP		new high	diversified, iron ore
Base Resources	BSE		near highs	mineral sands
Beach Energy	BPT		LT downtrend continuing	oil and gas
Beacon Mining	BCN		sideways	gold production
Bellevue Gold	BGL		down on release of feasibility	gold exploration
Blue Star Helium	BNL		slump to support trend line	gas, helium
Boab Metals	BML		named change from Pacifico Minerals	silver/lead
Breaker Resources	BRB		sideways	gold exploration
Buru Energy	BRU		on support line	oil
Calidus Resources	CAI		down	gold
Capricorn Metals	CMM		down	gold
Caravel Minerals	CVV		in pullback phase	copper
Celsius Resources	CLA		testing uptrend	uptrend
Central Petroleum	CTP		rising gently	oil/gas
Chalice Gold	CHN		back to support line	nickel, copper, PGMs, gold exploration
Chase Mining	CML		rising from lows	nickel/copper/PGE
Chesser Resources	CHZ		down now	gold exploration

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Cobalt Blue	COB		new high	cobalt
Cyprium Metals	CYM		stronger	copper
Dacian Gold	DCN		strongly higher	gold
Danakali	DNK		steeply higher	potash
Davenport Resources	DAV		rising again	potash
De Grey	DEG		shallower downtrend	gold
E2 Metals	E2M		correcting lower, ST downtrend	gold exploration
Ecograp (was Kibaran)	EGR		heavy pullback	graphite
Element 25	E25		pullback	manganese
Emerald Resources	EMR		coming back to support line	gold
Euro Manganese	EMN		breaching uptrend	manganese
Evolution Mining	EVN		down	gold
Firefinch	FFX		strongly higher	gold
First Graphene	FGR		consolidating	graphene
Fortescue Metals	FMG		pullback - uptrend breached	iron ore
Galaxy Resources	GXY		testing uptrend	lithium
Galena Mining	G1A		at recent highs	lead
Galilee Energy	GLL		higher	oil and gas, CBM
Genesis Minerals	GMD		down	gold
Gold Road	GOR		down	gold
Hastings Technology Metals	HAS		uptrend being tested	rare earths
Hazer Group	HZR		heavy pullback	hydrogen
Highfield Resources	HFR		rising	potash
Hillgrove Resources	HGO		breached downtrend	copper
Iluka Resources	ILU		strong rise	mineral sands
Image Resources	IMA		testing support	mineral sands
Independence Group	IGO		pullback	gold
ioneer (was Global Geoscience)	INR		new high	lithium
Ionic Rare Earths (Oro Verde)	IXR		new high	rare earths
Jervois Mining	JVR		rising again	nickel/cobalt
Jindalee Resources	JRL		correcting lower	lithium
Kin Mining	KIN		downtrend	gold
Kingston Resources	KSN		down	gold
Kingwest Resources	KWR		back to support line	gold
Legend Mining	LEG		turned down at resistance line	nickel exploration
Lepidico	LPD		down	lithium
Lindian Resources	LIN		softer	bauxite
Lithium Australia	LIT		pullback	lithium
Los Cerros	LCL		on support line	gold exploration
Lotus Resources	LOT		new high	uranium
Lucapa Diamond	LOM		breaking downtrend	diamonds
Lynas Corp.	LYC		new high	rare earths
Mako Gold	MKG		down again	gold exploration
Manhattan Corp	MHC		down	gold exploration

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Marmota	MEU		testing downtrend	gold exploration
Marvel Gold	MVL		off its lows	gold exploration
MetalTech	MTC		testing downtrend	gold
Meteoric Resources	MEI		testing uptrend	gold exploration
MetalsX	MLX		new high	tin, nickel
Metro Mining	MMI		breaching downtrend	bauxite
Mincor Resources	MCR		testing uptrend	gold/nickel
Musgrave Minerals	MGV		down	gold exploration
Myanmar Minerals	MYL		breaching downtrend	lead, zinc, silver
Nelson Resources	NES		new high	gold exploration
Neometals	NMT		near high	lithium
Northern Minerals	NTU		pullback	REE
Northern Star Res.	NST		down	gold
NTM Gold	NTM		new high	gold exploration
Oceana Gold	OGC		down	gold
Oklo Resources	OKU		down	gold expl.
Orecorp	ORR		down	gold development
Orocobre	ORE		down	lithium
Oz Minerals	OZL		new high	copper
Pacific American Holdings	PAK		breaching ST downtrend	coal
Pantoro	PNR		breached support line	gold
Panoramic Res	PAN		holding shallower uptrend	nickel
Peak Minerals	PUA		broeken resistance upside	copper exploration
Peak Resources	PEK		new high	rare earths
Peel Mining	PEX		breached new uptrend	copper
Peninsula Energy	PEN		breached uptrend	uranium
Poseidon Nickel	POS		sideways	nickel
Pensana Metals	PM8		pullback	rare earths
Perseus Mining	PRU		testing uptrend	gold
Pilbara Minerals	PLS		pullback	lithium
Polarex	PXX		breached downtrend	polymetallic exploration
Queensland Pacific Metals	QPM		new high	nickel/cobalt/HPA
Ramelius Resources	RMS		continuing down	gold production
Red5	RED		down	gold
Red River Resources	RVR		breached uptrend	zinc
Regis Resources	RRL		down	gold
Regergen	RLT		heavy pullback	gas, helium
Resolution Minerals	RML		new low	gold exploration
Resolute Mining	RSG		down	gold
RIO	RIO		new high	diversified, iron ore
Rumble Resources	RTR		back in downtrend	gold exploration
Salt Lake Potash	SO4		down	potash
St Barbara	SBM		secondary downtrend	gold
Sandfire Resources	SFR		breached downtrend	copper

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Santos	STO		strongly higher	oil/gas
Saturn Metals	STN		heavy fall	gold exploration
Sheffield Resources	SFX		rising	mineral sands
Sky Metals	SKY		back in downtrend	gold exploration
St George Mining	SGQ		down	nickel
Silex Systems	SLX		off its highs	uranium enrichment technology
Silver Mines	SVL		on support line	silver
Sipa Resources	SRI		down	general exploration - Ni,Cu, Co, Au
Stanmore Coal	SMR		breached steepest downtrend	coal
Strandline Resources	STA		still in downtrend	mineral sands
Sunstone Metals	STM		down again	
Talga Resources	TLG		breached support line, down	graphite
Technology Metals	TMT		back to highs	vanadium
Tesoro Resources	TSO		down	gold exploration
Theta Gold Mines	TGM		off its highs	gold
Thor Mining	THR		lower	gold exploration
Tietto Minerals	TIE		down again	gold
Titan Minerals	TTM		stronger	gold
Vango Mining	VAN		down	gold
Venturex	VXR		surge on funding	zinc
Vimy Resources	VMY		steeply higher	uranium
West African Resources	WAF		down	gold
Westgold Resources	WGX		down	gold
West Wits Mining	WWI		off its highs	gold
Western Areas	WSA		heavy fall	nickel
Whitehaven Coal	WHC		on support line	coal
Wiluna Mining	WMX		down	gold
Yandal Resources	YRL		down	gold exploration
Zinc Mines of Ireland	ZMI		breached downtrend	zinc
Totals	43%	64	Uptrend	
	34%	51	Downtrend	
		148	Total	

Guides to Chart Interpretations

- Charts usually go pass from one trend (up or down) into the other via a period of indecision and uncertainty during which the trend can either recover or change. This period is signified by the orange colour. The orange represent both the greatest risk and greatest reward possibilities.
- Once a chart is in confirmed up or downtrends it is not uncommon for 10-20% of that trend to have already transpired.
- There are trends within trends. The focus of this chart review is the immediate trend that affects the sentiment i.e. it can be a downtrend within a long-term uptrend.
- Not every chart warrants a new comment every week. The new comments are in bold type. Grey type comments may be dated.
- Individual charts provide a single view. It is valuable to look at charts of other companies in similar commodities, and the overall sentiment is also very valuable. Not many stocks can swim against the tide.
- We periodically add or delete charts, some times for obscure reasons. If a chart consistent gives poor signals or is very erratic, we may delete it. Sometimes we add a chart because we want to see what all the fuss is about. We do have a preference for charting stocks that we cover in our research as well.
- Errors and omissions may occur from time to time, especially in fast moving markets.

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Amber Lights in Tables: Just a reminder if when the amber light is used in the table – it is when the charts are ambiguous or when there is a change of trend taking place. If a chart is breaching a downtrend it can either be a positive sign or a trap. Only once it has done more work can it be confirmed as a new uptrend. Maybe it is a new uptrend (or conversely a new downtrend); the risk takers can decide to jump on board early (or sell). They will maximise their profits (or minimise their losses if indeed it is the start of the new uptrend (downtrend). More risk-averse investors should wait a little longer, being prepared to give up some of the gains in return for greater certainty.

Weightings of Sectors Represented in the Company Charts			
Sector	No. of Companies	Weighting	
Gold	36	24.3%	
Gold Exploration	25	16.9%	
Nickel	11	7.4%	
Copper	10	6.8%	
Oil/Gas	7	4.7%	
Lithium	8	5.4%	
Zinc/Lead	7	4.7%	
Rare Earths	8	5.4%	
Mineral Sands	5	3.4%	
Iron Ore/Manganese	5	3.4%	
Potash/Phosphate	5	3.4%	
Coal	4	2.7%	
Uranium	4	2.7%	
Graphite	2	1.4%	
Bauxite	2	1.4%	
Silver	2	1.4%	
Cobalt	1	0.7%	
Tin	1	0.7%	
Diamonds	1	0.7%	
Other	4		
Total	148		

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