

The Crucible

How to tackle Air Pollution

Niobium Rising

Lithium in Cornwall



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MMTA News in Brief

Having recently been contacted by several MMTA members, James Peer, MMTA Chairman, and Maria Cox, General Manager, visited the offices of Metal Bulletin in February to discuss concerns raised by members regarding recent changes in MB's subscription structure for price reporting, as well as the timing and communication of these changes.

Metal Bulletin is currently considering holding a meeting for MMTA members to discuss its price reporting agency in detail.

If any member wishes to contact Metal Bulletin directly, please contact Alex Harrison, or alternatively, get in touch with the MMTA Executive Team, who will be happy to forward to Metal Bulletin on your behalf.

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The MMTA is the world's leading minor metals industry organisation.



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Heat-free soldering with Liquid-Metal particles

Researchers at Iowa State University have produced novel micro-sized particles filled with liquid metal that retain their liquid state at room temperature. These particles are also able to meld with each other. These liquid/solid hybrids have practical applications in heat-free soldering and electronic circuit damage repair.

The discovery of this new metallic form was made when researchers looked for a way to prevent liquid metals from returning to their solid state, even at temperatures below the point at which they normally solidify. Known as "undercooling," the technique has often been used to analyse the inner workings of metal structures and to look at alternative ways of processing metals. However, the greatest hurdle in this area is that it is difficult to create significant amounts of stable quantities of these undercooled metals.

Looking at this problem in a different way, the Iowa State team had the idea of shrouding minute droplets of liquid metal with a thin, uniform coating that held the liquid inside a sort of particle capsule, to form a balanced batch of particles containing undercooled liquid metal.

To create these particles, the researchers used a high-velocity rotary cutting tool to slice the liquid metal into minute droplets and then suspend them in an acetic acid/diethylene glycol mixture. When the particles were exposed to oxygen, the surface of the material oxidized and created a bubble with the liquid metal trapped inside. Once the oxidization was complete, the team then

polished this layer until it was smooth.

"We wanted to make sure the metals don't turn into solids," said assistant professor Martin Thuo. "And so we engineered the surface of the particles so there is no pathway for liquid metal to turn to a solid. We've trapped it in a state it doesn't want to be in."

Unlike metal glues* used as solder, which join two disparate substances together, the Iowa State material is created using liquid-metal particles of the same metals. In this case, Field's metal (an alloy of bismuth, indium and tin) and other particles containing an alloy of just bismuth and tin were used to produce the liquid metal bubbles.

Only about the size of red blood cells at round 10 micrometres in diameter, these bubbles were tested by the team to repair microscopic defects, to perform micro-soldering, and to join macroscopic pieces of metal together in heat-free soldering.

"We demonstrated healing of damaged surfaces and soldering/joining of metals at room temperature without requiring high-tech instrumentation, complex material preparation or a high-temperature process," said the team in their paper.

Thuo has filed a patent on the technology and formed a start-up company to help bring this new product to market, and he is currently working on testing and improving the electrical conductivity and mechanical reliability of the new material.

The team's paper appears in the journal Scientific Reports.

Source: Iowa State University

*See page 14 for Gallium used as an adhesive

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Cornish Lithium: Interview with Jeremy Wrathall

Demand for electric vehicles rose 36% in 2016. Technology has ramped up, and the performance of lithium-ion batteries has allowed electric vehicles to enter the mainstream. Now, meeting the demand for raw materials has become a major challenge. The Tesla Giga-factory is eating up current supplies.

Away from the main suppliers of lithium in Chile, Canada and Australia, the UK has a chance to get in on the action. Cornish Lithium Ltd has recently won the mineral rights to a large area of land covering around 30,000 hectares, or around 3,000 square kilometres in Cornwall, at the South West tip of England. The deal has been made with three major landowners: Tregothnan Estates, Mineral Exploration Limited and Strongbow Exploration, owners of South Crofty Mine at Pool.

Cornwall has a long history of mining and mineral extraction dating back thousands of years. Tin and copper have been mined traditionally, but as with many industries in the UK, underwent a major decline in the 80s and 90s. However, granite and china-clay extraction has continued on a large scale. The Drakelands tungsten and tin mine at Hemerdon is a recent example of a metal mining renaissance, but this project has suffered some teething problems from decreasing demand for tungsten and higher than expected running costs.

Cornish Lithium has spotted an opportunity to take advantage of a growing market for a material that looks to be under-supplied for the foreseeable future. The UK represents a secure, low risk destination for investment, with excellent infrastructure across grid power, road and rail. Cornwall itself is increasingly becoming a centre for renewable energy in the UK, hence any initiative that supplies a key material for the storage of such power will be well received by local communities.

Jeremy Wrathall, the Chief Executive of Cornish Lithium was kind enough to speak to the MMTA about the company's plans.

When did you see the potential for a lithium project in Cornwall?

We first saw the potential for lithium to be extracted around 15 months ago at the start of 2016. As a student of mining history, I was aware of the historical reports of lithium in Cornwall. (the presence of lithium was first noted in around 1860) After further research, records of lithium in brine were unearthed. There were also other reports of hot water flooding mines, a big problem for these mines at the time, but a clue to the opportunity of extracting lithium.

In recent years, there have been great advances in extracting lithium from brine, and there are several viable technologies to perform this in a 'standard' plant.

What are your predictions for the lithium market?

There has been a fundamental shift in society in recent years and a realisation of the damage caused by the internal combustion engine. Lithium in electric vehicles, but also in battery storage, enables the increased use of renewable energies. I don't believe at all that the market is a 'flash in the pan'. Clean energy generation and clean transport are enabled by lithium-ion battery technology.

Jeremy points to recent announcements from car manufacturers beyond Tesla, demonstrating a serious commitment to electric vehicles from the traditional automotive industry. In November, VW announced the following objective:

"By 2025 we plan to sell one million electric cars per year, and by then we also want to be the global market leader in electromobility....Going forward, our electric cars will be the hallmark of Volkswagen."

VW brand chief, Herbert Diess

Conventional Lithium Extraction

As of 2015, most of the world's lithium production is in South America, where lithium-containing brine is extracted from underground pools and concentrated by solar evaporation. The standard extraction technique is to evaporate water from brine. Each batch takes from 18 to 24 months.

Lithium is also present in seawater, but commercially viable methods of extraction have yet to be developed.



The lithium source in Cornwall is from a geothermal well. The lithium is separated by simple filtration. The process and environmental costs are primarily those of the already-operating well; net environmental impacts may therefore be neutral

The conventional extraction of lithium, through the evaporation of brines, can have significant impacts on water resources and ecology. The conventional process evaporates water from brines in large ponds (thousands of acres), which are expensive to build and maintain. This one-way movement of water from the ground to the atmosphere can result in significant impacts on groundwater as well as land subsidence. Further, residual salt waste is collected and stored in massive salt piles that scar the landscape and present a risk to the environment.

Evaporation based lithium processing suffers from poor recovery, typically less than 50%, and is affected by precipitation and other aspects of the weather. The unpredictability of weather and climate can therefore impact project economics and time to market.

In addition, the high salt environment in and around the evaporation ponds can be toxic to flora and fauna; related leaching, spills, or air emissions can harm communities, ecosystems and food production. Evaporation technology can be expensive, potentially harmful, and does not necessarily optimise the resource.

The European Commission on Science for Environmental Policy states that lithium's "continued use needs to be monitored, especially as lithium mining's toxicity and location in places of natural beauty can cause significant environmental, health, and social impacts."

Brines are important sources of salt, iodine, lithium, magnesium, potassium, bromine, and other materials, and potentially important sources of a number of others.

In early March 2017, it was reported that electric vehicle charging network 'ChargePoint' has raised \$82 million in a round of funding led by German automotive giant Daimler, with participation from existing investors that include BMW i Ventures, Linse Capital, Rho Capital Partners, and Braemar Energy Ventures.

After the exploration phase, how long before the lithium is ready to sell? Is there a processing plant in place for the brine?

The first stage is to use modern geophysics to target the drilling to lithium brine structures. If there is success, samples will be taken and tested and a financial model created. Optimistically we're looking at a 5-year horizon until lithium from this source is ready to sell.

There is, however, a geothermal project starting to drill soon in the area, which may be an opportunity to access earlier samples. This project is planning to drill to 4.5km deep, whereas the lithium project will be between 400 and 1000m deep, so more akin to oil drilling than mining.

The processing of the brine is envisaged to happen adjacent to the well, but water can be easily piped anywhere. Eventually, secondary industries could be stimulated in the area, so potentially a whole new sector in the region.

What advantages are there for Cornish Lithium over other lithium projects around the world?

A Cornish source of lithium would offer more diversity to the current supplies. As we know, it is unwise to rely on limited geographic areas for sources of raw materials, as political stability of a region can change rapidly.

Lithium prices are rising rapidly, so investors are looking for new projects; they need to know supplies are there and know where to drill to access them.

Do you envisage any long-term environmental impact from the project?

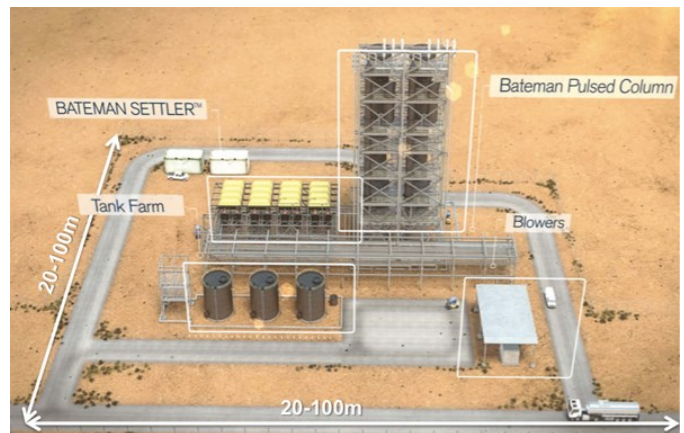
The extraction of the brine is similar to a water well or a geothermal well (but not at all like fracking!) and is a well-established technology, and very different to traditional mining

The environmental impact would be limited to the well and a relatively small processing plant adjacent.

What about the local community? Is there support for the plans?

We were very pleasantly surprised by the reaction of the local community. MPs and the local council have been extremely supportive of the company's plans.

Due to the chemistry of the brine and the geology of the area, there is also potential for potassium to be extracted and even for the heat from the hot brine to be used as a geothermal energy source. In addition, other metals such as tin and copper may be present in the same source.



A design for a lithium from brine plant using Tenova Bateman Technologies (TBT) Source: <http://www.pureenergyminerals.com>

Do you think the future looks bright for Cornish mining in general?

Although there have been teething problems at the Drakelands mine, the mining future of Cornwall looks positive.

South Crofty mine is starting a tin mining project which could also include various by-product metals, such as indium.

In the past, gaining mining rights has been difficult in Cornwall, and there has been very little exploration of many areas with modern techniques.

Cornish Lithium is excited to explore the very large area of land using the new techniques. At the moment the focus is on lithium and geo-thermal energy, but who knows what else may happen in the future.

Cornish Lithium is currently raising money for the next phase of their exploration. For more information visit their website:

www.cornishlithium.com

Jeremy has over 25 years of experience in the field of mining finance. Following his graduation from the Camborne School of Mines in Cornwall, he spent three years working as a mining engineer in the South African gold mining industry. He then pursued a career in mining investment banking in London and has financed mining projects globally, including companies listed on all of the world's major mining exchanges.

Having held various senior roles in the investment banking industry, Jeremy currently works for Investec Bank. Jeremy was formerly the Chairman of ASX listed Glory Resources, which sought to develop the Sapes gold discovery in Greece, until its takeover by Canadian listed Eldorado Gold. He also held positions as Chairman of AIM listed Zambezi Nickel and Non-Executive Director of AIM listed Zambezi Resources.



How to tackle air pollution

2017 had scarcely begun before London residents were informed that air pollution limits for the entire year had been breached in several areas. Just 5 days in to the New Year hourly levels of toxic nitrogen dioxide (NO₂) rose above the 200 micrograms per cubic metre (µg/m³) limit more than 18 times in the borough of Lambeth which is situated south of the river Thames.

NO₂ pollution is produced largely by diesel vehicles. Thousands of early deaths every year are attributed to these emissions. The cold weather in January in London also heightened the effect of the pollution on people with lung conditions. Air pollution has also recently been linked to Alzheimer's and miscarriages. New data has also revealed that modern diesel cars produce 10 times more NO₂ pollution than heavy trucks and buses per litre of fuel, which experts say is due to the much tougher testing faced by heavy vehicles.

In November 2016, data from the European Environment Agency revealed the UK is second only to Italy in Europe for the highest number of annual deaths from NO₂. It also ranked London's Marylebone High Street as the most polluted site in Europe.

In December, Paris, Madrid, Athens and Mexico City pledged to ban polluting diesel cars from their centres by 2025, and a number of cities outside the UK have already taken action, such as banning cars on specific days or making public transport free.

In China, toxic smog also covered large areas in the north of the country in January and again since then. This smog is caused by burning coal rather than diesel vehicles specifically. Coal is not only used as a cheap heating source, but also the reliance on coal power stations. There are 22 coal power stations circling Beijing. The Chinese Government said it will dramatically slash its coal production, and recently announced it would spend 2.5 trillion yuan (\$489 billion) on renewable energy to ease the pollution crisis. In reality, it seems that China still has big plans for coal. Two hundred coal-fired power plants will be built in the coming decade. Some of the older plants will be decommissioned, but even by 2020, coal capacity is estimated to increase by 20 per cent.

Designer face masks

You may be struggling to breathe, but it doesn't mean that style has to go out the window!

Companies such as Vogmask have seized the opportunity to make fashionable face masks for the style conscious city dweller.

By combining fashion with function, people in different cities are slowly warming to the idea of donning face masks beyond their more common sight in the far East.

Leading face mask manufacturers are making products equipped with advanced filters which can professedly block out particulate matter as tiny as 0.3 microns.

Vogmask's designer mask range boasts vivid paisley motifs and geometric prints. These were a part of a designer's Spring/Summer collection showcased at the Paris Fashion Week recently, where the audience tried on the designer masks and posed for pictures.



What needs to be done?

To tackle air pollution caused by diesel vehicles, there needs to be a many-pronged attack. No single technology is the 'golden bullet' to fix this issue.

Below are some technology scenarios, which combined could make the gains needed, not only to make legislative requirements but also to protect the health of city dwelling citizens.

Gas to Liquids: a move to alternative fuels, such as "gas to liquid" (GTL) fuel derived from natural gas which is a "drop in" replacement for diesel (i.e. the engine requires no modification). Testing has shown that the use of GTL in heavy duty vehicles such as trucks, buses and ships could reduce Nitrogen Oxide (NO_x) emissions by 5-37%, and Particulate Matter (PM) emissions by 10-38%, depending on the vehicle age. GTL fuel is already being produced in significant quantities globally, and is available commercially in the Netherlands, but its use is currently very limited

in the UK. Similarly, natural gas can also be converted into dimethyl ether (DME) – another potential alternative to diesel. It is thought that the use of DME reduces NO_x emissions by around 25% (compared to a standard diesel), and virtually eliminates PM emissions. DME is less straightforward to implement than GTL, in the sense that it requires some engine modification, although manufacturers such as Ford and Volvo are apparently investigating the potential to bring vehicles to market which use DME as a fuel.

Hydrogen Fuel Additives: Improving the fuel combustion cycle in existing vehicles through the use of additives. The ezerol technology produced by UK developer CGON does this by feeding small amounts of hydrogen into the vehicle air intake such that it creates a more efficient burn. Independent tests show that this increases fuel efficiency, whilst reducing emissions of NO_x, PM, Hydrocarbons and Carbon Monoxide. The technology can be retrofitted to existing cars and vans (petrol or diesel) and is available commercially, although to date has only been sold in relatively small numbers.



Autonomous vehicles: one of the mega-trends in the automotive sector is the move towards autonomous vehicles or “self-driving cars”. This could fundamentally change the way that vehicles use the road network, reducing the stop-start nature of traffic (which is partly caused by the way that we humans drive cars), and opening up the possibility of “vehicle platooning” on motorways. A range of studies have estimated that autonomous vehicles could improve fuel efficiency by 15–40%, reducing emissions of local pollutants as well as greenhouse gases, not to mention the benefits in terms of safety and congestion.

Liquid air: New technologies are also being developed to address very specific sources of pollution. For example, a growing source of pollution in cities comes from refrigerated vans and trucks. It has been estimated that there are around 84,000 transport refrigeration units on the road in the UK, each of which emits 29 times as much PM and six times as much NO_x as a modern truck. Whilst trucks are subject to emissions standards, the auxiliary engines used to power refrigeration units are largely unregulated and are highly polluting. Technology company, Dearman, is developing an alternative system based on the use of “liquid air”, which produces zero emissions on the road.

Photo-catalytic materials: Deployment of technologies which remove pollution from the ambient air. For example, a number of companies are developing photo-catalytic treatments which remove pollutants from the air in the presence of sunlight. These treatments can be applied to a range of surfaces, for example roofing tiles, roofing felt or even the surface of roads. A recent report by the Environmental Industries Commission suggested that applying photo-catalytic treatment to roads is amongst the cheapest options to reduce PM and NO_x pollution, although it acknowledged that further trials of the technology would be required to understand its potential. However, contrary to this, a recent report for Defra found “no compelling evidence” that the use of these treatments would actually reduce NO_x pollution.

Air purification: Developers are also looking at other ways of cleaning air in urban environments. Studio Roosegarde, a Dutch design company, has developed the “Smog Free Tower” – an air purifying tower which sucks in pollution and expels clean air. The extracted pollution is, somewhat bizarrely, turned into pieces of jewellery. The first tower has been installed in Rotterdam (paid for

by a kickstarter campaign), and the designers claim that a single tower could clean 3.5 million cubic metres of air per day. They plan to roll out the smog-free towers across other global cities.

Roll out of electric cars: We cannot leave out electric vehicles from the possible solutions to air pollution from cars. However, electric cars could cost five times as much per tonne of pollution reduction compared to the other technologies modelled. They are sure to play a major part to cleaner cities in time, but not immediately.

There are also some more “mundane” ways to tackle air quality issues, which may be more palatable for cash strapped governments.

- Retrofitting old buses with the latest emissions control exhaust systems
- Scrappage scheme for old diesel vehicles – paying drivers to hand in their old gas-guzzlers for more economical models
- Changes to taxation levels, for example the planned erosion of LPG duty differential should be reviewed, and any future change in fuel taxation should take account of the impact of local air pollution as well as CO₂
- Investment in development of zero-emission vehicles such as electric vehicles should be balanced by funding for trials of innovative technologies which offer realistic prospects of cost-effective air pollution reductions – such as photo-catalytic treatments.
- Indicator boards displaying real time air pollution data (referenced to any legal limits) should be set up in major urban centres.
- Dual carriageway speed limits should be reduced to 60mph (100 Km/h) where such roads pass through pollution hotspots.

Sources:

<https://policyexchange.org.uk/6-new-technologies-which-could-improve-urban-air-quality/>

<https://qz.com/829359/vogmask-designed-by-manish-arora-a-trendy-pollution-mask-for-delhis-rich-and-beautiful-all-the-way-from-the-nevada-desert/>

<http://www.eea.europa.eu/themes/air>

<http://www.abc.net.au/news/2017-01-08/chinese-air-pollution-crisis-caused-by-ongoing-coal-use/8168702>

Space, the final (littering) frontier

Littering and fly tipping are the bane of many a community. But already, the human race has managed to pollute space with numerous pieces of junk. Currently, an estimated 100 million human artefacts are drifting above in perpetual orbit. Amongst these artefacts are decommissioned satellites, batteries and parts of rockets; not to mention space suits and, for a period of time, a spatula lost during a repair on a space station.

The debris is a risk to working satellites, and there are often collisions with space junk. If the current rate of littering continues we'll be lucky to find a path through to travel to Mars or anywhere else.

However, science is trying to come to the rescue! To combat this trend, various inventions are in the pipeline to clean up space, including 'janitor' satellites, laser tractor beams and an

electro-magnetic tether, to capture the rubbish. I don't think I need to talk the enormous technical challenges these ideas face, and just not dumping things in the first place may be somewhat simpler. Or failing that, making sure the pieces left are small enough to burn up in the Earth's atmosphere. The end of space junk doesn't look likely to happen soon, 4500 more satellites are soon due to be launched into low Earth orbit to enable global Broadband coverage. I hope end-of-life plans are in place for these new additions!

The oldest redundant satellite orbiting currently is a weather satellite that has its own Twitter account. Fengyun has been orbiting Earth at 28,000 Kilometres per hour since 2007. Now heading towards imminent destruction by the atmosphere, Fengyun is spending its final months sending some poignant tweets on the nature of life and the universe.

You can find the satellite on twitter @FengyunAdrift

This account, as well as music recordings and a short documentary called Adrift' *'exploring the troubling, beautiful, dangerous and fascinating world of space junk'* were created by a group of artists .

To find out more, visit: <http://www.projectadrift.co.uk/>



Like a firework...

Many pieces of space junk are made of titanium, which with its 1670 °C melting temperature, won't burn up on re-entry to Earth.

The French space agency has proposed a solution: using thermite. Thermite is a mixture of metal powder, fuel and metal oxide, which releases heat when ignited, as with fireworks and welding processes.

Most varieties are not explosive, but can create brief bursts of high temperature in a small area. Thermite attached to the metal parts

would ignite when entering the upper atmosphere creating holes in the structure and increasing the likelihood of the pieces breaking up on re-entry.

Thermite has diverse compositions. Fuels include aluminium, magnesium, titanium, zinc, silicon, and boron. Aluminium is common because of its high boiling point and low cost.

Oxidizers include bismuth(III) oxide, boron(III) oxide, silicon(IV) oxide, chromium(III) oxide, manganese(IV) oxide, iron(III) oxide, iron(II,III) oxide, copper(II) oxide, and lead(II,IV) oxide.

Niobium: US\$6.1Bn and mounting. Why?

Within the space of a few short years, the face of the global niobium industry, particularly ferroniobium, has changed almost out of recognition. As recently as 2011, the Brazilian niobium and ferroniobium giant CBMM was wholly owned by the Salles family, with Anglo American providing the balance of the country's ferroniobium output. The only other significant ferroniobium producer, Canada's Niobec, was in the hands of the Toronto-listed miner IAMGOLD.

Things look very different today. During 2011, CBMM sold 30% of itself for US\$3.9Bn to two consortia of Asian investors, one Japanese/Korean, the other Chinese. Both groups include steelmakers (i.e., CBMM's own clients). In 2015, IAMGOLD sold Niobec to the Toronto-based private-equity firm Magris Resources, which is backed to a large extent by investors in Singapore and Hong Kong. That deal was worth US\$0.5Bn. Not to be left out, Anglo American offloaded its Brazilian niobium and phosphate business in 2016 to China Molybdenum (CMOC) for US\$1.7Bn, an earnings multiple that surprised most in the industry, and quite possibly even Anglo American.

For a metal that many people have never even heard of, US\$6.1Bn of investment in less than five years is pretty impressive. Equally remarkable is that, from a standing start, Asian investors have gained control of, Roskill estimates, at least a third of global ferroniobium production capacity.

The reasons why the three ferroniobium producers divested are fairly clear. CBMM certainly didn't need the money; it wanted to lock-in some of its largest customers. IAMGOLD had acquired Niobec as part of a purchase of another gold miner. It did not really see Niobec as a core business, and it definitely needed the money to plug a gaping gold-related hole in its balance sheet. Anglo American simply wanted to get rid of non-core businesses, not to mention a large pile of debt.

Why other companies would have wanted to invest in this industry is somewhat less obvious. Demand for ferroniobium went through a growth spurt during the 2000s, more than doubling during the first half of the decade and continuing to grow until the global financial crisis kicked in. There are two main reasons for the growth. One is that consumers gained better understanding of the benefits of using ferroniobium in steel. When added to steel in fractions of a percent of the weight of steel, ferroniobium results in much-higher strengths. Less steel overall is needed, which offers major cost savings in large steel structures. The other driver was the explosive growth in global steel production, particularly in China.

The global financial crisis caused a huge fall in demand for steel and for ferroniobium but it recovered quickly and in recent years has remained within a fairly narrow range close to the peak level of the late 2000s. The outlook for global steel production now seems starkly different to what it was just a few years ago, especially in China. Overall growth in steel production is not going to be the main future driver of demand for ferroniobium, Roskill contends.

So why are people still investing very large sums of money in the industry, when growth prospects for steel are not stellar and even the current ferroniobium production capacity is far bigger than demand and will remain so?

One reason is that there is good potential for the incidence and intensity of ferroniobium use to increase. Ferroniobium is not being used in all the steel applications it could be, and some countries/regions lag far behind others in

terms of usage. Ferroniobium usage is currently lowest in countries where it has the greatest potential to grow, either through higher steel production or just because of a move to making higher-quality steel. Another reason, and one that applies mainly to CMOC, is the desire on the part of China to gain greater influence over its raw materials' supply chain (and CMOC is part-controlled by the Chinese government).



An enduring characteristic of the niobium market in general, and ferroniobium in particular, is the role of CBMM and its behaviour. CBMM largely created the niobium industry as we know it today and has long been the dominant player and price setter. Its production cost is not reported but is believed to be much lower than its competitors'. It could, in theory, have priced the competition out of the market a long time ago but has never done so. Roskill considers that there are several reasons for this. For one thing, it is important to CBMM that price and supply are seen as stable and secure. Getting steelmakers to switch to niobium-containing steels was not a rapid process and it would probably not have happened had CBMM been a monopoly producer. Trying to become a monopoly supplier by slashing prices would be a PR nightmare, unsettle consumers in the steel industry and could actually cost CBMM money – Roskill calculates that CBMM would make a lot less if it tried to corner the market at price levels designed to drive the competition out of the game.

There is a further twist. Although the ferroniobium market is already comfortably met by existing (huge) surplus production capacity, and will remain so, new producers are trying to enter the market. There are several projects in the pipeline and at least two of them are at, or near, the financing stage. They would not be large in tonnage terms by CBMM standards, but is there even a place for them? It all boils down to the market's desire for diversity of supply of what is, essentially, a commodity product and made using similar and well-understood processes by existing producers; processes that would also be used by any new producer. For any project these days, securing offtake agreements is key to securing project finance, particularly debt finance (which makes getting equity finance rather easier, too).

The niobium industry in its current form is really only a few decades old. It has seen big changes over the last decade or so, and there may well be more to come.

Patrick Stratton, Roskill

Niobium: Global Industry, Markets & Outlook is available to pre-order

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LETTER FROM NORTH AMERICA

Dear Members

After a stunningly hard week in Vienna, I am, finally, back in New York to welcome in March after the usual “interminable” month of February.

As some of you may know, for some years now I have been involved in the [Zero Project](#), an initiative of the Essl Foundation, a philanthropic organisation based in Vienna. We work for a world without barriers, hence the “zero”, for persons with disabilities. This year marked our sixth annual conference. And, for the last four years, we’ve held it at the UN Headquarters in Vienna in the building next to that housing the IAEA. (Sometimes we see some quite interesting people!)

Apart from helping to host it with my colleagues at the foundation, this year I had the honour of moderating two separate “couch” discussions in front of an audience of more than 500 from some 60 countries from around the world. Our discussions covered workplace accommodations for persons with disabilities and integrating persons with intellectual disabilities and learning difficulties into the workplace. You should check out the sessions on the Internet, all the experts were just great. It was only sad that, in both instances, our chats were cruelly truncated because of other people overrunning their allotted times!

Anyway, back in New York on Sunday, I received an interesting follow-up email about Afghanistan from my friend Ted Callahan, pointing me in the direction of an article from The Wall Street Journal about the new railway between China and Afghanistan. I have to say that it came as a complete surprise to me that one actually existed at all. But it does – as part of China’s Silk Road initiative.

Whilst it appears that freight can travel happily north-south, the opposite is not true, and trains are returning, through Uzbekistan and Kazakhstan to China empty. And, indeed, there lies the rub. Apparently, worried that the trains “could be used to smuggle narcotics and precious stones, which fuel criminal and terrorist networks in the regions,”¹ the Uzbek government is refusing transit to Afghan goods. Amongst other things, the Afghan government had hoped that the railway would provide a cheap way of exporting the country’s natural resources and, thereby, attract investors in the country.

So, yet another cautionary tale for anyone thinking of doing a bit of mining in Afghanistan – for whatever: even if you could dig it out of the ground (which you cannot), currently you couldn’t get the stuff out of the country by train, if you wanted to.

Back here in the U.S., there’s been a deal of talk recently about getting rid of the 2010 Dodd-Frank Act – in whole or in part. Back at the end of January, Michael Piowar, the SEC’s acting Chairman, said the agency would reconsider enforcement of the reporting regulation regarding conflict minerals. The hope for many was that it would soon be shown the door. Last Friday (February 24), however, Shelley Parratt, acting Director of Division of Corporation Finance at the SEC, announced that companies must continue to comply with the reporting rule.

Whether or not anything happens anytime soon remains moot. Whilst a new act of Congress will be required to repeal the original act, any changes to the rule need a commission vote. But, unfortunately, the commission is operating with only two out of a full complement of five commissioners – Piowar, a Republican, and Kara Stein, a Democrat. So, obviously, nothing’s going to happen for the time being. Or at least not until President Trump names two further Republican commissioners.

I shall keep my eyes open and report back on any developments.

In the meantime, though, as always, I remain, with best wishes from New York

Yours

Tom Butcher, February 28th, 2017

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¹The Wall Street Journal: [Afghanistan Struggles to Access China’s New Silk Road](#), February 25, 2016

IN BRIEF

UK: Building our Industrial Strategy

This consultation closes at 11:45pm on 17 April 2017

The UK Government is seeking views on their approach to building a modern industrial strategy, with the aim of delivering an economy that works for everyone.

"We want to build an industrial strategy that addresses long-term challenges to the UK economy. Our aim is to improve living standards and economic growth by increasing productivity and driving growth across the whole country."

This green paper sets out our approach and some early actions we have committed to take. It is not intended to be the last word, but instead to start a consultation.

We hope anyone with an interest will respond. We want to hear from every part of the country, every sector of industry and businesses of every size – and from the people who work in them and use them."

If you would like to comment individually, please visit the following website.

The MMTA will be contributing comments through the various industry networks in which we participate.

The green paper can be found on the following site www.gov.uk/government/consultations/building-our-industrial-strategy and includes instructions on how to submit comments.

3D Printed Gas Turbine Blades

Siemens has produced its first 3D printed gas turbine blades. A multi-national team, including the company Materials Solution, a 3D printing facility in the UK, has made these blades from high performing polycrystalline nickel super-alloy from powder form. These blades have been fully revised from previous designs and have an improved internal cooling geometry.

"This is a groundbreaking success for the use of additive manufacturing in the field of power generation, one of the most demanding areas of application for this technology," says Willi Meixner, CEO of Siemens Power and Gas Division. "Additive manufacturing is a major pillar in our digitization strategy. The successful tests resulted from the efforts of a committed international project team comprising Siemens engineers from Finspong, Lincoln, and Berlin, as well as experts from Materials Solutions"

Gas turbine blades must withstand extreme conditions. Inside a turbine, they undergo high pressures, tremendous centrifugal forces, and high temperatures. At full power, blades rotate at 1,600 km/h and carry loads of 11 tons. The blades must also withstand tremendous heat because they are surrounded by 1,250°C gas when the turbine is in full operation. These new blades have been fully tested under these challenging conditions.

Conventional processing of turbine blades is by casting or forging, which are complex, costly and time-consuming. 3D printing greatly decreases the time to make a part and uses a laser beam to heat and melt fine layers of metal powder until the part is complete.

Source: <https://www.siemens.com/innovation/en/home/pictures-of-the-future/industry-and-automation/additive-manufacturing-3d-printed-gas-turbine-blades.html>



Gallium as a simple, reversible adhesive

Gallium has been found to have rather interesting new use. Researchers at the Max Planck Institute have created a reversible adhesive from the metal that displays glue-like properties. Potential applications for this discovery range from industrial electronics, pick-and-place processes and short-term silicon wafer bonding, to feet for climbing robots. Reversible, temporary adhesives are incredibly useful to any manufacturer that needs to rapidly move small, difficult-to-handle components. For robots, the temporary adhesive could allow the machine to climb up different surfaces.

Gallium's very low melting temperature of just 29.76° C—meaning it famously melts in the palm of your hand – has allowed scientists at the Max Planck Institute to introduce a droplet of liquid gallium between two objects, cooling it slightly to solidify, which then bonds the two objects together. To separate the objects, the temperature is simply raised slightly meaning they come apart with a negligible force.

"Wetting an object with a metallic liquid such as gallium that forms a bond when cooled slightly is a far more gentle process for fragile materials than sucking them up using a vacuum," said Metin Sitti, Director at the Max Planck Institute for Intelligent Systems.

The advantages of this gallium adhesive other the vacuum technique is that the bond doesn't require constant energy to maintain and only a quick blast of heat to release it.

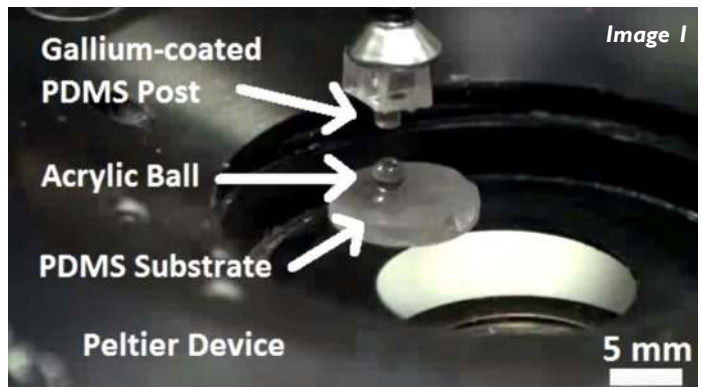
The gallium can also be used over and over again, as it is never depleted by leaving residues behind. There is the added bonus of gallium conducting electricity, meaning that it is able to be used in temporary circuit connections multiple times.

To test their theories on gallium as an adhesive, the researchers dipped the tip of a cylindrical elastomer rod in liquid gallium, then brought it into contact with a range of materials, including glass, plastic, and gold. The tip was then cooled to 23° C (73° F) with the aid of a peltier-effect, thermoelectric cooling device. (See Image 1) The resulting bond between the elastomer and the test materials was very strong for each material combination. Measurements of the adhesive strength in both liquid and solid phases of gallium were also tested.

"The behaviour of these two values tells us something about the true reversibility and switchability of the adhesion process," said Metin Sitti. "The greater the difference of the binding power between the liquid and solid state, the easier it is to reverse and switch the adhesive effect."

Gallium also worked particularly well in tests on rough surfaces and even worked when wet. This is considered unusual for most adhesives, as adhesives that have shown powerful sticking values on rough or wet surfaces had always had poor reversibility. A rough surface has a greater surface area for a traditional adhesive to cling to, which logically would make it likely that it would be more difficult to pull apart again.

"These are surface conditions that showed up as major weaknesses of



reversible micro/nanostructured adhesives proposed recently," said Sitti.

As a result of its performance in these conditions, the researchers believe gallium is a perfect fit for biological uses, and Sitti envisions that it may one day be used to move individual cells, tissue samples, or even entire organs, in laboratories or hospitals.

For now, the team will continue exploring potential applications, as well as looking at ways to optimise the technique and studying alloys of gallium with other metals, such as indium, to investigate other uses at different temperatures.

The results of this research were recently published in the journal *Advanced Materials*.

Source: Max Planck Institute

Update on EU Conflict Minerals Legislation

On 16 March 2017, the European Parliament approved a draft EU regulation to prevent the minerals trade from funding conflict and human rights violations by 558 votes to 17. This regulation will obligate all but the smallest EU importers of tin, tungsten, tantalum, gold to do due diligence checks on their suppliers, and big manufacturers will also have to disclose how they plan to monitor their sources to comply with the rules. The main elements are as follows:

- **Mandatory Checks for Importers** - due diligence checks, in accordance with OECD guidelines, should be mandatory for importers of tin, tungsten, tantalum and gold and their ores from conflict and high-risk areas. Importers shall also keep documentation demonstrating their respective compliance with those obligations, including the results of the independent third-party audits.
- **Small Importer Exemption** - small importers, accounting for 5%, from the mandatory checks. **(Thresholds are set out in the annex of the full document, which you can find by clicking on the link below).**
- Recycled materials are also exempt.
- **Review Clause** - Two years after the date of application of this Regulation and every three years thereafter, the Commission should review the functioning and the effectiveness of this Regulation and the latest impact of the scheme on the ground. It may also have to propose additional

mandatory measures should the application of due diligence by companies prove unsatisfactory.

- **Recognition of Supply Chain Due Diligence Schemes** – Governments, industry associations and groupings of interested organisations having due diligence schemes in place ('scheme owners') **may apply to the Commission to have the supply chain due diligence schemes that are developed and overseen by them recognised by the Commission.** That application shall be supported by adequate evidence and information.
- **Third-Party Audits** – third party audits, which will include information on all of Union importer's activities, processes and systems used to implement supply chain due diligence regarding minerals or metals, including their management system, risk management and disclosure of information. The audit shall also include recommendations to the importer as to how to improve its due diligence practices and must respect the audit principles as laid down in the OECD Due Diligence Guidelines.

- **Disclosure obligations** – Union importers of minerals or metals shall make available to the Member State competent authorities the reports of any third-party audit or evidence of conformity with a supply chain due diligence scheme recognised by the Commission. They shall also make available to their immediate downstream purchasers all information gained and maintained pursuant to their supply chain due diligence with due regard for business confidentiality and other competitive concerns.

Scope – Tin, Tantalum, Tungsten and Gold.

Once the Council has approved the deal, it will be published in the EU Official Journal. Due diligence obligations will apply from 1 January 2021 to allow member states time to appoint competent authorities and importers to become familiar with their obligations.

To read more, please click [here](#). Or visit <http://www.europarl.europa.eu/portal/en> and search for 'conflict minerals'

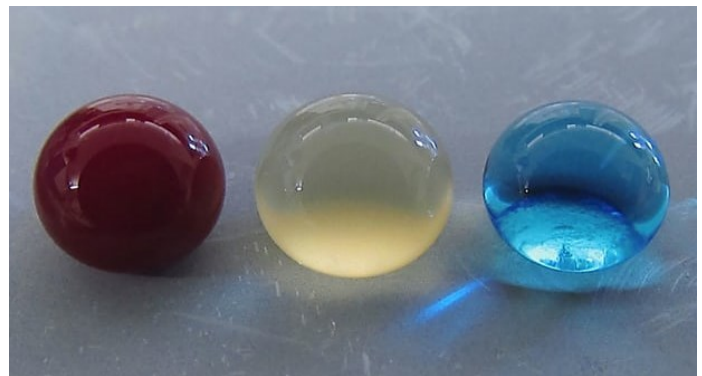
Summary courtesy of the [CRM Alliance](#)

Blood Repellent, life-saving titanium

The human body often rejects foreign objects introduced. This mechanism is designed to protect the body from damage, but is very problematic for medical devices implanted to help a patient. When a medical implant such as a stent or catheter is rejected by the body, blood platelets adhere to the device, forming a clot that encapsulates it. Those clots can lead to heart attacks, embolisms or infections. The current less than ideal solution, is to put patients on blood-thinning medications for the rest of their lives.

Engineers at Colorado State University, Dr Arun Kota and Ketul Popat, have developed blood repellent titanium that could be used to make the implants.

In a previous edition of the Crucible, we talked about super *hydrophobic* materials, making water form droplets on their surface. A blood repellent material is therefore super *haemophobic*.



blood clots forming, and starting the chain of events that leads to more serious medical problems. The surface texture and chemistry of fluorinated nanotubes was found to produce the lowest level contact.

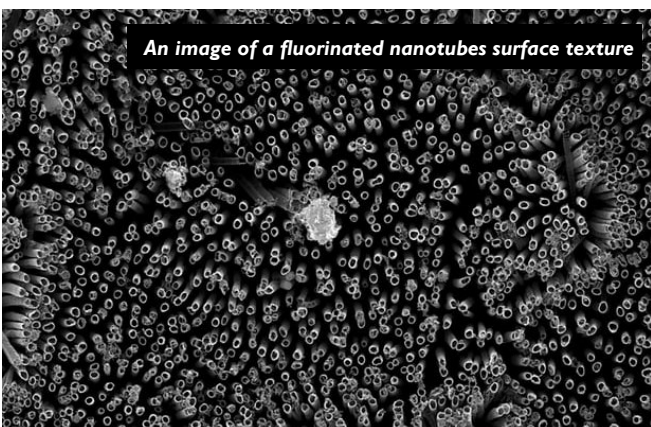
They produced this surface by taking a piece of titanium and growing the nanotubes using anodisation. The super liquid repelling surface is achieved with this type of texture and low-surface-energy fluorination chemistry. The chemistry part of the process used silanisation (covering the surface with a specific type of molecule).

One problem that the scientists need to watch out for is making sure the surface is not too flaky.

So far, tests have been made by simply using blood droplets sitting still on the surface. The next phase of testing will need the blood to flow dynamically over the surface, in order to mimic the flow of blood around the body. This would be followed by testing in an animal model. The scientists predict that it will be at least 4-5 years before we see implants made from this blood repellent material.

A paper on their research was recently published in the journal *Advanced Health Care Materials*.

Source: Colorado State University



An image of a fluorinated nanotubes surface texture

The idea is that the blood does not meet the surface of the titanium and instead comes into contact with a layer of trapped air. As there is very little contact made, there is a greatly decreased chance of

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