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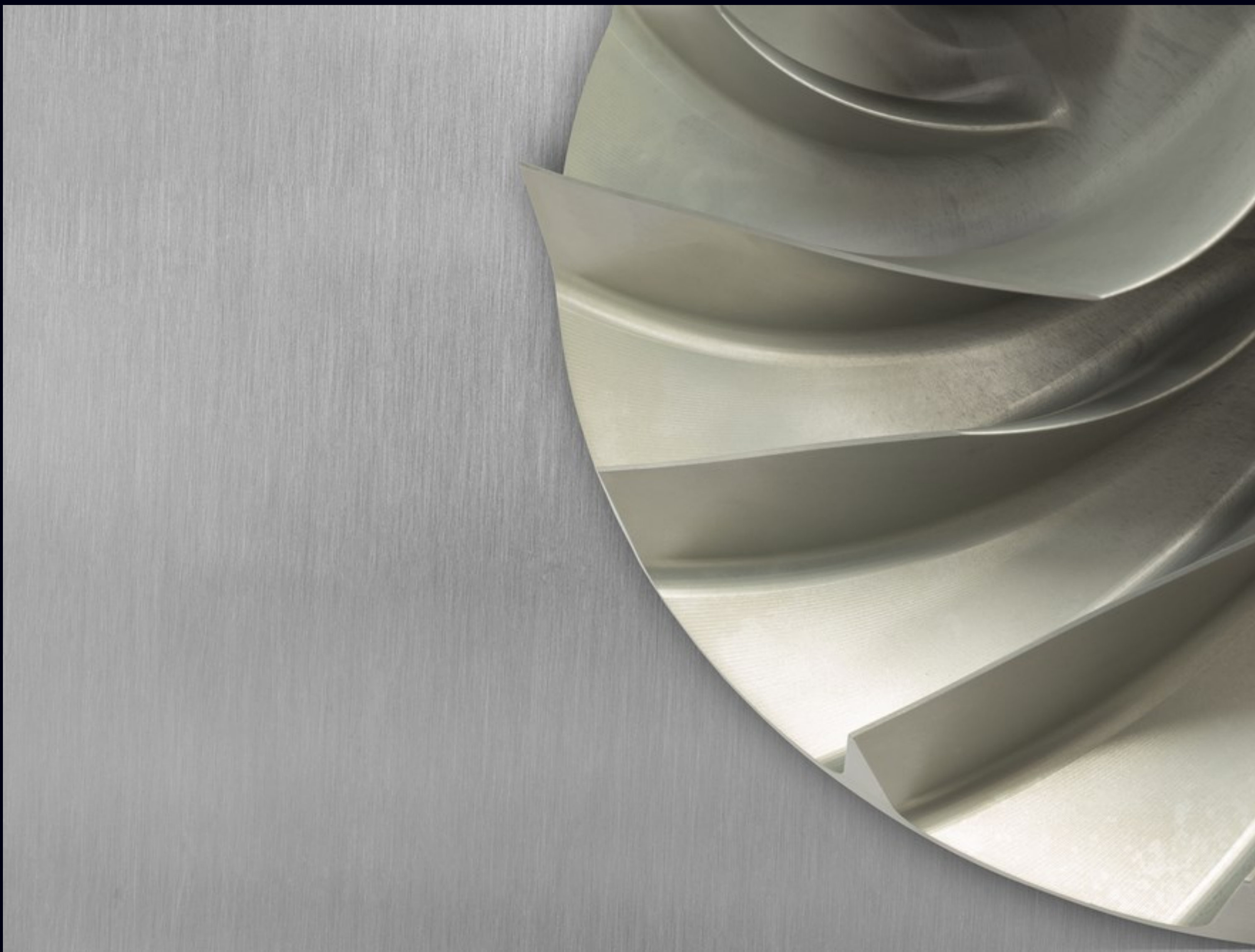
The Crucible

Materials for Defence

Metals conducting electricity with no heat

MMTA visit Vital Materials



Dublin: Chester Beatty Library

How to describe Sir Alfred Chester Beatty (1875-1968)? The young lad whose passion for collecting minerals led him to become one of the world's most successful mining engineers? The man who advised the Guggenheims on the revival of the abandoned Leadville mine in Colorado which led to the foundation of their wealth? The man whose advice led to the development of Bingham Canyon in Utah, the first and largest open cast copper mine in the world? (Still going after 111 years). The man who founded Selection Trust in London in 1916, and assisted the UK War effort? The man whose daughter's estate sold Van Gogh's 'Sunflowers' at auction in 1987 for $39 mln, a price three times higher than any previous painting sold at auction. (He gave his wife £100,000 in 1928 and suggested she concentrate on Impressionists). Or, the man who collected papyri, and Islamic, East Asian manuscripts and prints here displayed in Dublin?

Perhaps metal people, more than others, will be fascinated by the Chester Beatty story and have the chance, while at the MMTA Conference, to take time out to visit the Chester Beatty Library in Dublin Castle (Admission Free). For more information, go to www.clb.ie which is the website for the library and explains some of the objects which date back from 2700 BC to the present day. On the website you will also be able to see some of the subterfuges Beatty needed to employ in his cable exchanges to secure the objects that he wanted; his agent sending coded messages laced with mining terms, one of which reads 'SILVER MINE VERY RICH HAS THREE SHAFTS STOP'.

Who today remembers that the Guggenheims made their fortune from metal, and how many of us even know of Chester Beatty? For metal people there is that fascinating question about how mining or metals have in a number of cases been the foundation for artistic enterprises that have survived long after the metal was mined, bought and sold. I have not been to the Chester Beatty Library, but will certainly be taking time out for this visit during the Dublin Conference.

A. Lipmann

Why doesn't the Earth's core melt?

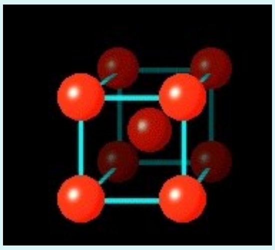
Geologists estimate that the Earth's core is around 5,700 K (5,427° C, 9,800° F), around the same temperature as the surface of the Sun. So, how is it that the core remains a solid ball of iron? Until now, why it didn't melt has been a scientific mystery.

A new piece of research by the KTH Royal Institute of Technology has offered an explanation of the iron's stability in such extreme conditions.

In normal conditions such as those found on the surface of the Earth, iron atoms are in the arrangement of BCC (body centred cubic, see below). It has been assumed that as this is the arrangement of iron at normal temperature and pressure, it was impossible for iron to have the same structure at extreme temperatures and pressures. Under the conditions you find at the centre of the Earth, the crystal architecture of iron was expected to take on the shape of a hexagon, in a state called the hexagonal close-packed (HCP) phase.

By inputting data and using the Swedish supercomputer Triolith, the results indicated that the Earth's core was likely made up of 96 % pure iron, with the remaining 4 % nickel and some light elements. But most importantly, the study found that BCC iron can indeed exist in the core, with its crystal structure remaining stable thanks to the very characteristics that were previously assumed to destabilize it.

The crystal structures can be thought of as being divided into "planes" of atoms – that is, two-dimensional layers of atoms. So, iron atoms in a cubic phase are arranged in two planes of four atoms, making up the eight corners of a cube. These structures are normally fairly unstable, with planes sliding out of shape, but at extreme temperatures, the layers that slide off are reinserted into the mix, occurring reliably enough that it stabilizes the structure.



BCC structure of atoms

This diffusion normally destroys the crystal structure by liquifying it, but in this case, the iron manages to preserve its BCC structure. The researchers liken the planes to cards in a deck.

"The sliding of these planes is a bit like shuffling a deck of cards," says one of the researchers, Anatoly Belonoshko. "Even though the cards are put in different positions, the deck is still a deck. Likewise, the BCC iron retains its cubic structure. The BCC phase goes by the motto: 'What does not kill me makes me stronger.' The instability kills the BCC phase at low temperature, but makes the BCC phase stable at high temperature." The research was published in the journal Nature Geosciences.

Source: KTH Royal Institute of Technology

Mining in Ireland

There is a long history of mining in the beautiful country of Ireland, the location for the MMTA's International Minor Metals Conference this year.

There are records of mining dating back to the Bronze Age (2000 B.C.) when southwest Ireland, including sites at Ross Island, Kerry, Allihies, Cork and later Bunmahon and Waterford, was an important producer of copper and of alluvial gold (loose deposits found in streams), for making artefacts such as coins and jewellery.


A gold Celtic coin

There were iron works dating back to the 16th and 17th centuries, flourishing in the late 18th century due to demand created by the British industrial revolution. During this era, almost every county in Ireland had at least one metal mine. Copper mining also boomed, as did lead-silver extraction from numerous high grade, low tonnage vein deposits.

Mining, as always, was a good way to make, and lose, a fortune. There was a gold rush between 1795 and 1830 at the Gold Mines River (Co. Wicklow), where an estimated 7-9,000 oz of gold was extracted from alluvial gravels. Later 20th and 21st century gold-mining plans in the area were met with significant opposition owing to the expected environmental impact.

Today, Ireland is a major zinc-lead mining province. As of 2007, Ireland produced 38% of Western Europe's zinc and 25% of its lead, from lead and zinc mines including Lisheen Mine, Tipperary, Tara Mine, Meath, and Galmoy Mine, Kilkenny.

Over the last 40 years a string of significant base metal discoveries have been made, including the giant ore deposit at Navan (>70Mt). Zinc-lead ores are also currently exploited from two other underground operations in south-central Ireland: Lisheen and Galmoy. The combined output from these mines, make Ireland the largest zinc producer in Europe and the second largest producer of lead.

As of the beginning of the 21st century, mining companies operating in Ireland included Anglo-American plc, Arcon, New Boliden, Conroy Diamonds and Gold, Hereward Ventures plc, Minco Mining & Metals Corporation, and others.

In addition to metal mining, Ireland has a rich heritage of industrial mineral and coal extraction. Primary raw material industries in Ireland include those involving steel, silver, aluminium, barite, and gypsum mining processing. Heavy industry relying on these materials is based around key port cities such as Dublin, Cork, and Belfast (the latter in Northern Ireland).

New MMTA Member: AVAS Trading

The MMTA is pleased to welcome AVAS Trading as a New Member. AVAS's main traded commodity is Tungsten, with forms ranging from Ores and Concentrates, through Ferro-Tungsten and Chemicals (APT/AMT/YTO/BTO) to pure metal (bars) and Tungsten Carbide Powders. AVAS acts as an exclusive marketing and sales agent for international sales from a major Russian producer. They also trade in Molybdenum, Cobalt and Rhenium.

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AVAS Trading

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The MMTA promotes essential elements that add quality, safety and enjoyment to our lives.

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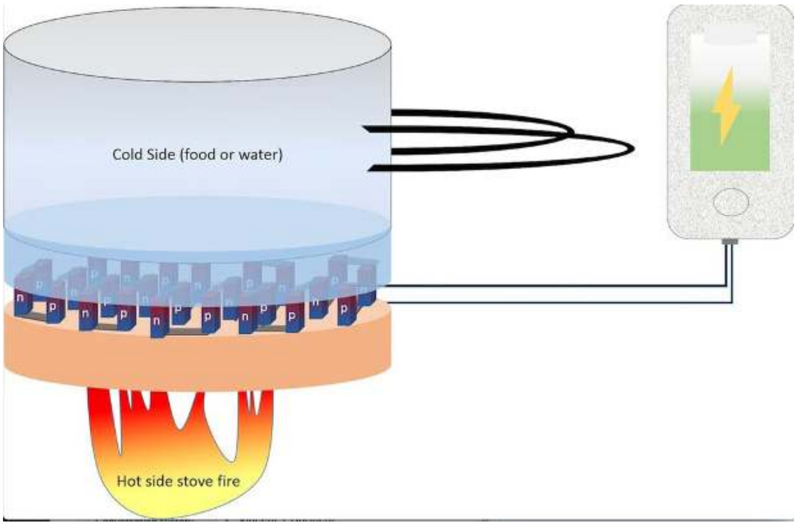
Charging your phone with a cooking pot? New material could make it possible

Devices that generate electricity through the thermoelectric effect – that is, the conversion of differences in temperature to an electric voltage – are showing up in everything from clothing to paint, and they could go a long way towards reclaiming some of the heat lost during energy production. Now researchers at the University of Utah have developed a thermoelectric material that doesn't use the toxic chemicals common in others, but is still efficient and affordable enough for use in everyday products.

Thermoelectric devices work by taking advantage of a temperature difference between two sides of the material. Charge carriers in the material will diffuse from the hot side to the cold side, creating an electric current in the process. The problem is, these devices often rely on elements that are toxic to humans, like cadmium telluride and mercury, or are relatively expensive and inefficient, like some small wearable generators.



Instead, the University of Utah team's new material is made using a combination of calcium, cobalt and terbium, making for a safe and inexpensive alternative.

"There are no toxic chemicals involved," says Ashutosh Tiwari, lead researcher on the project. "It's very efficient and can be used for a lot of day-to-day applications."

The team has plenty of suggestions for what the new material could be used for. Implanted medical monitors could be powered by jewelry that generates electricity by the difference in temperature between body heat and cool air. Cars and planes could power themselves by harnessing the difference between the warm interior and the cold exterior. Pots and pans (or devices like the JikoPower Spark) made from the stuff could generate enough power while cooking to charge a phone, which could be especially useful in developing countries. Or, like other materials, it could be built into power plants to reclaim some of the energy that's typically lost as heat.

"In power plants, about 60 percent of energy is wasted," says Shrikant Saini, first author of the study. "With this, you could reuse some of that 60 percent.

According to the team, the first applications for the new thermoelectric material will be in cars and biosensors, and to get it started, they have applied for a patent.

The research was published in the journal Scientific Reports.

Source: University of Utah

Sleepy Phones...

There were 1.306 billion mobile phone users in China in 2015*, which covers around 95 in every100 people, but only around 10% of phones in China are recycled.

Last year alone, there were 560 million new phones entering the market, meaning that a lot of people received a new phone without getting rid of their old one. What's going on?

On further investigation, it turns out that around 65% of consumers say they have at least one phone sitting at home in a drawer, where they tend to sit for around 2 years. These 'sleeper' phones are a trend around the world.

Valuable materials are trapped in these phones while they're snoozing, not being used and not being recycled (or refurbished for a second life). There are several reasons why people may hang on to their old phones, wanting a 'back-up' phone, not knowing where to send them to be recycled or just lack of awareness of the issue.

Maybe the reserves are being established for a future urban mine?

*Figure from China's Ministry of Industry and Information Technology

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Materials for Defence

Defence spending has been big news recently. President Trump announced that he wanted to increase US defence funding to record levels, and the UK announced in last year's budget that it would be increasing spending for the first time in 6 years. The UK plans to continue this trend by increasing defence spending by 0.5% above inflation every year until 2021 and continuing to meet NATO's target to spend 2% of GDP on defence for the rest of the decade.

Defence spending covers an incredibly diverse range of programmes, but new equipment and hardware, as well as replacing old models, requires access to raw materials from secure, long-term sources. Further research and innovation in such an important sector can also not be constrained by availability of materials.

The EU published a report in 2016 looking at raw material supply for the European defence industry. After an assessment of the most representative applications of the European defence industry, it was revealed that 47 different processed and semi-finished materials (i.e. alloys, composites, compounds) are important for the manufacture of defence application systems.

The report defined these materials as 'important', which in this case is used to denote materials with unique properties, necessary to fulfil the stringent requirements of defence applications. A further assessment of the composition of these 47 important processed and semi-finished materials revealed that 39 raw materials are necessary for their production. An analysis of import dependency showed that the EU is almost 100 % import dependent on 19 of these 39 raw materials (beryllium, boron, dysprosium, germanium, gold, indium, magnesium, molybdenum, neodymium, niobium, praseodymium and other REEs, samarium, tantalum, thorium, titanium, vanadium, zirconium and yttrium) and is more than 50 % reliant on imports for over three-quarters of them. China is the major producer for one-third of the raw materials identified in defence applications. Let's hope war with major raw material producers is off the cards !

The defence sector's materials supply chain is a complex multi-level network of material suppliers, manufacturers, distributors and retailers. But an efficient supply chain ensures the timely delivery at competitive prices of all intermediate and final products to the original equipment manufacturers (OEMs). The supply chain involves various stages, such as the supply of raw materials, metal refining and processing (e.g. alloying or composite production) and conversion into semi-finished and finished products. A strong and sustainable materials supply chain is essential for the overall growth and competitiveness of the European defence industry.

The USA keeps a strategic stockpile of metals and other materials to mitigate raw material supply risks, and the EU takes the approach of trying to establish European raw material supply chains of these 'critical raw materials' with funding activities.

From the EU's Report on Raw Materials in the European Defence Industry 2016

Sixteen of the 39 raw materials used in defence applications are included in the EU's critical raw materials list 2014. (This is likely to increase in the new list to be published in Summer 2017) As regards those defence sectors that mainly use these 16 raw materials, it can be inferred that the defence industry's aeronautics and electronics sectors are the most vulnerable to potential interruptions in the supply of materials.

-The demand for raw materials in the manufacture of defence applications is relatively low. Moreover, the lead system integrators and top-tier contractors in the defence industry do not usually purchase raw materials as such, but rather semi-finished and finished products made of high-performance materials such as special alloys, composite materials, etc.

-Given the very high level of performance and special properties of these materials which cannot be matched by readily available substitutes, their potential supply risk is much higher compared to that of the constituent raw materials (e.g. minerals and metals).

-The EU is a large manufacturer of alloys and special steels, but should improve its production capacities for speciality composite materials and their precursors, since high-quality composites are finding an increasing number of applications in military components.

-The report suggests a number of actions for developing specific future initiatives directed at better understanding and improving the security of supply of raw and processed/semi-finished materials used in the European defence industry.

-The analysis was hampered by the limited information on the types of materials and their use in defence applications which, in general, are bound by confidentiality; therefore it is important that the knowledge base for the materials used in the European defence sector is improved. This can be achieved by promoting information sharing between all relevant stakeholders, the European Defence Agency and the European Commission.

-Undertake additional studies to evaluate each stage of the complex materials supply chain within the European defence industry. These studies should also assess the materials supply risk at application level or within a specific value stream.

-Better exploit the dual-use potential of materials by SMEs and large companies. Promote R&D programmes for the development of high-tech and advanced materials that can address the need of both defence and civil communities.

-The European defence industry needs to strengthen the downstream segment of its materials supply chain and, in particular, materials processing know-how and materials transformation capabilities.

Tamara Alliot, MMTA

The case of Beryllium

The U.S. Department of Defense (DoD) stated that beryllium is "essential for important defense systems and unique in the function it performs."

Military systems depend heavily on electronics for navigation, target acquisition and firing. In critical situations and equipment, stiff, lightweight beryllium components ensure precise operation under extreme conditions.

In military fighter jets, pure beryllium saves weight critical to speed and maneuverability, while also ensuring razor-sharp targeting and strike capabilities. Copper beryllium is used for electrical connectors, fasteners and structural components in fixed-wing aircraft and fighters.

Beryllium is also used in optical systems of military helicopters, unmanned aerial systems, battle tanks on the move and airborne equipment used to detect and destroy improvised explosive devices (IED) and tactical mines.

Source: Materion Corp

Bone inspired steel

Bone has been the inspiration for a new type of steel that could make buildings safer.

Microcracks are common in steel. When the metal is scratched, the scratches can spread and propagate, which can eventually cause failure of the part.

Researchers at Kyushu University in Japan used the structure of bone to inspire a new crack-resistant design.

The bones in the skeleton are not all solid. The outside cortical bone is solid bone with only a few small canals but the insides of the bone contain trabecular bone which is similar to scaffolding or a honey-comb structure. The spaces between the bone are filled with fluid bone marrow cells, which make the blood, and some fat cells.

This structure makes bone resistant to cracks.

The researchers mimicked the multi-layered structure of bone by changing the nanostructure of two types of steel. Under stress testing, the new materials showed better resistance to cracks than conventional steel.

The cracks stopped spreading, as it took a lot more energy for them to find a suitable path through the material.

LETTER FROM NORTH AMERICA

Dear Members

It's the end of March, and there's still some snow on the ground here in NYC – both in the streets and in Central Park. But it doesn't look as if we've any more coming anytime soon. But, these days, who knows.

Last month I wrote a little about Dodd-Frank and conflict minerals. And said I'd keep my eyes open for any further developments. As I mentioned, companies still need to comply with the SEC's conflict minerals reporting rule. And disclosures for the 2016 reporting period remain due on May 31.

According to reports here, however, "[a] recent draft Presidential Memorandum indicates that the White House may seek to temporarily waive the requirements of the conflict minerals rule"[1] and evinces the reasons why. But, as has been the case before with "leaked" and/or official material from the administration, since it appears to raise more questions than it answers, it's probably not worth pondering on for too long. In addition, nobody seems to know when a/the "final" version might be forthcoming. Suffice it to say, there's a draft one "out there".

Of more import, however, may be the fact that, on March 15, "the parties to the legal challenge of the SEC's conflict minerals rule requested that the U.S. District Court of the District of Columbia enter a final judgment in accordance with the decisions of the U.S. Court of Appeals for the District of Columbia Circuit."[2] The request essentially means that, now, absent any prior action by either Congress or the administration, "any further changes to the conflict minerals requirements would be left to the discretion of the SEC."[3] So, once again, we're left to wait and see!

A final bit of intelligence on the Afghanistan front: my friend Ted recently sent me the link to an excellent piece in the publication CTC Sentinel (out of the U.S. Military Academy at West Point – just up the Hudson) entitled "The Taliban Stones Commission and the Insurgent Windfall from Illegal Mining." Whilst the whole article is fascinating, I was particularly struck by the following: "The Taliban exploit mining sites in at least 14 of Afghanistan's 34 provinces and now earn as much as $200 to $300 million annually, the second-largest revenue stream after narcotics."[4] I thought that really put everything in perspective: it's a huge amount!

Looking around on the net as I was the other day, I saw one event that I should love to attend, but, sadly, cannot. It's the first ever "Metals & Minerals for the Environment Symposium" up at MIT on May 11-12. It looks great. It is described as: "The first convening of sustainability leaders in the metals and minerals sector at MIT." It would be great to hear from any members who are actually able to go to it. Amongst other things, it includes tours of MIT's labs!

Finally, congratulations are due to IBM for winning this year's Compound Semiconductor Industry Innovation Award in Zürich earlier this month. The IBM team was able to demonstrate "an Indium gallium arsenide (InGaAs)/Silicon-germanium (SiGe) CMOS technology on Silicon (Si) substrate using processes suitable for high-volume manufacturing on 300 mm wafers."[5] According to Dr. Lukas Czornomaz, one IBM's lead scientists involved in the research: "'This novel technology is expected to enable 25% better performance with the same power consumption, or to double the battery life of mobile devices while maintaining their performance.'"[6]

Now that's really interesting.

On that high note, I remain, with best wishes from New York

Yours

Tom Butcher, March 27th, 2017

Tom Butcher is an Associate Director at Van Eck Associates Corporation ("VanEck"). The views and opinions expressed herein are the personal views of Tom Butcher are not presented by or associated with VanEck or its affiliated entities.

[1] The National Law Review: SEC Conflict Minerals Rule Faces New Scrutiny Ahead of May Filing Deadline, http://www.natlawreview.com/article/sec-conflict-minerals-rule-faces-new-scrutiny-ahead-may-filing-deadline (March 22, 2017)

[2] Ibid.

[3] Ibid.

[4] CTC Sentinel: The Taliban Stones Commission and the Insurgent Windfall from Illegal Mining, https://www.ctc.usma.edu/posts/the-taliban-stones-commission-and-the-insurgent-windfall-from-illegal-mining (March 2017)

[5] IBM Research: IBM Researchers Take Home Innovation Prize for Semiconductor Research, https://www.ibm.com/blogs/research/2017/03/ibm-researchers-take-home-innovation-prize-semiconductor-research/

[6] Ibid.

Metal that conducts electricity

(...without heating up!)

There's a known rule-breaker among materials, and a new discovery by an international team of scientists adds more evidence to back up the metal's nonconformist reputation. According to a new study led by scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and at the University of California, Berkeley, electrons in vanadium dioxide can conduct electricity without conducting heat.

The findings, published in the Jan. 27th issue of the journal Science, could lead to a wide range of applications, such as thermoelectric systems that convert waste heat from engines and appliances into electricity.

For most metals, the relationship between electrical and thermal conductivity is governed by the Wiedemann-Franz Law. Simply put, the law states that good conductors of electricity are also good conductors of heat. That is not the case for metallic vanadium dioxide, a material already noted for its unusual ability to switch from an insulator to a metal when it reaches just 67 degrees Celsius, or 152 degrees Fahrenheit.

"This was a totally unexpected finding," said study principal investigator Junqiao Wu, a physicist at Berkeley Lab's Materials Sciences Division and a UC Berkeley professor of materials science and engineering. "It shows a drastic breakdown of a textbook law that has been known to be robust for conventional conductors. This discovery is of fundamental importance for understanding the basic electronic behaviour of novel conductors."

In the course of studying vanadium dioxide's properties, Wu and his research team partnered with Olivier Delaire at DOE's Oak Ridge National Laboratory and an associate professor at Duke University. Using results from simulations and X-ray scattering experiments, the researchers were able to tease out the proportion of thermal conductivity attributable to the vibration of the material's crystal lattice, called phonons, and to the movement of electrons.

Vanadium dioxide (VO_2) nanobeams synthesized by Berkeley researchers show exotic electrical and thermal properties. In this false-color scanning electron microscopy image, thermal conductivity was measured by transporting heat from the suspended heat source pad to the sensing pad. The pads are bridged by a VO_2 nanobeam. To their surprise, they found that the thermal conductivity attributed to the electrons is ten times smaller than what would be expected from the Wiedemann-Franz Law.

"The electrons were moving in unison with each other, much like a fluid, instead of as individual particles like in normal metals," said Wu. "For electrons, heat is a random motion. Normal metals transport heat efficiently because there are so many different possible microscopic configurations that the individual electrons can jump between. In contrast, the coordinated, marching-band-like motion of electrons in vanadium dioxide is detrimental to heat transfer as there are fewer configurations available for the electrons to hop randomly between."

Notably, the amount of electricity and heat that vanadium dioxide can conduct is tunable by mixing it with other materials. When the researchers doped single crystal vanadium dioxide samples with the metal tungsten, they lowered the phase transition temperature at which vanadium dioxide becomes metallic. At the same time, the electrons in the metallic phase became better heat conductors. This enabled the researchers to control the amount of heat that vanadium dioxide can dissipate by switching its phase from insulator to metal and vice versa, at tunable temperatures.

Such materials can be used to help scavenge or dissipate the heat in engines, or be developed into a window coating that improves the efficient use of energy in buildings, the researchers said.

"This material could be used to help stabilize temperature," said study co-lead author Fan Yang, a postdoctoral researcher at Berkeley Lab's Molecular Foundry, a DOE Office of Science User Facility where some of the research was done. "By tuning its thermal conductivity, the material can efficiently and automatically dissipate heat in the hot summer because it will have high thermal conductivity, but prevent heat loss in the cold winter because of its low thermal conductivity at lower temperatures."

Vanadium dioxide has the added benefit of being transparent below about 30 degrees Celsius (86 degrees Fahrenheit), and absorptive of infrared light above 60 degrees Celsius (140 degrees Fahrenheit).

Yang noted that there are more questions that need to be answered before vanadium dioxide can be commercialized, but said that this study highlights the potential of a material with "exotic electrical and thermal properties."

While there are a handful of other materials besides vanadium dioxide that can conduct electricity better than heat, those occur at temperatures hundreds of degrees below zero, making it challenging to develop into real-world applications, the scientists said.

Other co-lead authors of the study include Sangwook Lee at Kyungpook National University in South Korea, Kedar Hippalgaonkar at the Institute of Materials Research and Engineering in Singapore, and Jiawang Hong at the Beijing Institute of Technology in China. Lee and Hippalgaonkar started work on this paper as postdoctoral researchers at UC Berkeley. Hong began his work as a postdoctoral researcher at Oak Ridge National Laboratory. The full list of authors is available online.

Source: Berkeley Lab

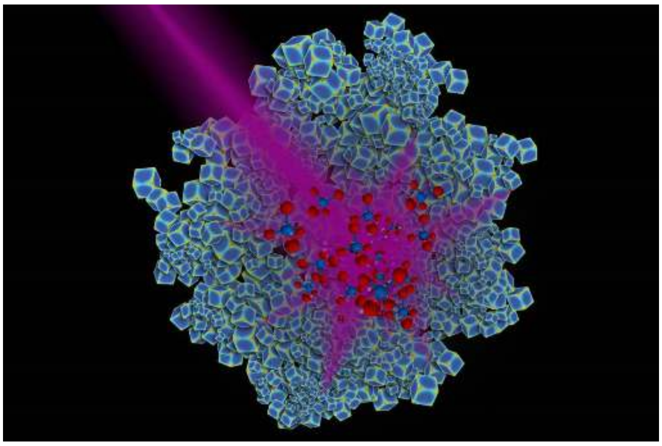
http://newscenter.lbl.gov/2017/01/26/electricity-not-heat-flows-in-vanadium-dioxide/

Light-driven reaction converts carbon-dioxide into fuel

Researchers at Duke University have developed tiny nanoparticles that help convert carbon dioxide into methane using only ultraviolet light as an energy source according to the 23rd February paper published in Nature Communications.

Rhodium nanoparticles are the answer to the long search of for an efficient, light-driven catalyst to power the reaction.

Despite being one of the rarest elements on Earth, rhodium plays a surprisingly important role in our everyday lives. Small amounts of the metal are used to speed up or "catalyze" a number of key industrial processes, including those that make drugs, detergents and nitrogen fertilizer, and they even play a major role breaking down toxic pollutants in the catalytic converters of our cars.



A beam of ultraviolet light hits a swarm of rhodium nanocubes

Rhodium accelerates these reactions with an added boost of energy, which usually comes in the form of heat because it is easily produced and absorbed. However, high temperatures also cause problems, like shortened catalyst lifetimes and the unwanted synthesis of undesired products.

Not only are the rhodium nanoparticles made more efficient when illuminated by light, they have the advantage of strongly favouring the formation of methane rather than an equal mix of methane and undesirable side-products like carbon monoxide. This strong "selectivity" of the light-driven catalysis may also extend to other important chemical reactions, the researchers say.

"The fact that you can use light to influence a specific reaction pathway is very exciting," said Jie Liu, the George B. Geller Professor of Chemistry at Duke University. "This discovery will really advance the understanding of catalysis."

In the past two decades, scientists have explored new and useful ways that light can be used to add energy to bits of metal shrunk down to the nanoscale, a field called *plasmonics*.

"Effectively, plasmonic metal nanoparticles act like little antennas that absorb visible or ultraviolet light very efficiently and can do a number of things like generate strong electric fields," said Henry Everitt, an adjunct professor of physics at Duke and senior research scientist at the Army's Aviation and Missile RD&E Center at Redstone Arsenal, AL. "For the last few years there has been a recognition that this property might be applied to catalysis."

Now the team plans to test whether their light-powered technique might drive other reactions that are currently catalyzed with heated rhodium metal. By tweaking the size of the rhodium nanoparticles, they also hope to develop a version of the catalyst that is powered by sunlight, creating a solar-powered reaction that could be integrated into renewable energy systems.

"Our discovery of the unique way light can efficiently, selectively influence catalysis came as a result of an on-going collaboration between experimentalists and theorists," Liu said. "Professor Weitao Yang's group in the Duke chemistry department provided critical theoretical insights that helped us understand what was happening. This sort of analysis can be applied to many important chemical reactions, and we have only just begun to explore this exciting new approach to catalysis."

Having found a catalyst that can do this important chemistry using ultraviolet light, the team now hopes to develop a version that would run on natural sunlight, a potential boon to alternative energy, which could help reduce the growing levels of carbon dioxide in our atmosphere by converting it into methane, a key building block for many types of fuels.

This research was supported by the National Science Foundation (CHE-1565657) and the Army Research Office (Award W911NF-15-1-0320). Additional support was provided by Duke University's Katherine Goodman Stern Fellowship, the National Defense Science & Engineering Graduate Fellowship (NDSEG) Program and the Center for the Computational Design of Functional Layered Materials, an Energy Frontier Research Center funded by the U.S. Department of Energy (DOE), Office of Science, Basic Energy Sciences (BES), under Award # DE-SC0012575.

Source: Duke University

Review: REACH for the Metals Industry

Several key lessons came out of the recent Metal Events' REACH forum for all those contemplating the fast-approaching 2018 deadline for substances from 1-100 tonnes per annum.

1. IMOA's Sandra Carey outlined the options available—where the substance is already registered, either buy a Letter of Access or co-register. The options if the substance is NOT already registered are:
   - Do it yourself and take the lead as Lead Registrant;
   - Support the Lead Registrant to achieve registration by being an active SIEF member;
   - Contract a REACH registration service provider to do it for you (beware, this is not a hands off option either).

A recipe for disaster is to cross your fingers and hope that someone else will do it all, so you can purchase an LoA at the last moment.

2. The key message is that this is a long process and can only be achieved with time, money and cooperation. However, there are very useful resources available to help you navigate the process, in particular via the ECHA website.
3. Karin van de Velde of the REACH Orphan Substances Consortium (ROSC) highlighted the size of the task facing ECHA with the 2018 deadline: 25,000 substances, consisting of 60—70,000 dossiers are expected for this final deadline.
4. An estimated 25-40% will be SMEs, who unlike the larger companies predominantly involved in the earlier registrations, do not necessarily have internal expertise or resources readily available to undertake this task.
5. The first key decision is to decide on the benefit of registering a substance versus the cost of registration, and in order to do this, ROSC advocates compiling a REACH inventory, finding out which substances are already registered or being worked on, and what the cost of purchasing a LoA will be. Only once the costs are known, can an informed decision be made as to whether to register the substance or cease importing it in 2018.
6. If it proves to be an orphan substance—ie one that is not registered, and where no one is currently involved in putting together a dossier, ROSC is a consortium created especially to cater for these orphan substances.
7. And finally, the impact of Brexit….. Keven Harlow of NEVEK Consulting illustrated that for the greater than average number of Only Representatives based in the UK, there will be changes ahead: both for the ORs and the non-EU companies currently using their services (UK companies may soon fall into this category). There may well be no REACH obligations for UK-based manufacturers and importers after 2019. What is as yet unknown, is whether the UK will seek alignment with REACH, and if not, what will replace it. This will be an area to watch.

Recycling LEDS

The LED has dominated the lighting market for quite a few years now. Although these bulbs have long life spans, their end-of-life destination still needs to be considered.

In 2012, 50 million LEDs were installed in the USA alone, greatly reducing the cost of energy for consumers, as well as reducing carbon emissions by increased efficiency.

The average lifespan of an LED bulb is 50,000 hours, whereas traditional bulbs have a lifespan of 12,000 hours. It is predicted that LEDs will account for 75% of all US lighting sales by 2030, and globally the use of LEDs should reach 53% by 2019.

There are many materials contained within an LED, making the recycling of the growing pile of spent bulbs rather more complicated than simply removing tungsten filaments as with the previous dominant lighting technology.

The challenge for recyclers is to extract the valuable metals and materials without using dangerous chemicals, which eats into the environmental credentials of LEDs.

Researchers at the Urban Mining Innovation Centre discovered that with a series of steps that target density, magnetism and gravity, materials were able to be isolated and recycled. This process is based on the physical attributes of LEDs creating a 'simple and economical' process. This system was inspired by mining industry practices and the recycling of other electronics.

The researchers have developed a flow sheet that identifies where materials could be extracted after various processes such as crushing and grinding, as well as other straightforward physical processes. Successful tests have been performed recovering copper, lead, zinc, silver, rare earths, gallium and indium so far. This new approach means that higher amounts of materials are recovered than predicted. When the LEDs are ground up the metal content is similar to high quality ores.

The aim is to eventually extract gold in the same way and to expand the system to other types of e-waste, making the eventual recycling easier and safer and without losing valuable and critical materials.

Vital Materials - Investing in the Future

Vital Materials, an MMTA Member since 2004, provides a fascinating example of the development of the Chinese minor metals industry. By following the vertical integration strategy on which it prides itself, Vital is dedicated to developing advanced materials and technologies for fast growing, high tech industries, including amongst others, clean energy, LED, communication, infrared detection, laser, fiber, and health care.

Globally, the company employs 1,600 people and is a market leader in selenium and tellurium materials, gallium, indium, germanium, bismuth and cadmium products.

Vital Material's production	
Metal	**Production*(metric tons)**
Selenium	1,000 – 1,200
Tellurium	300 – 350
Gallium	100 – 120
Germanium	50 – 60
Bismuth	3,000 – 5,000
Cadmium	6,000** – 8,000
Indium	300 – 350
*Metal contained, **including world distribution and trading volumes	

It was on a beautiful, sunny day that the MMTA, along with other delegates of the CNIA Global Minor Metals Forum (China), arrived to visit the Guangzhou headquarters of Vital Materials. Our hosts graciously showed us around several of the factories located on the site, which is a modern and spacious plant in Qingyuan, on the outskirts of the city. One of the first things that stands out on visiting the site is the focus on sustainable solutions. These include customized closed loop recycling, and a commitment that is embedded throughout the company to being a responsible and sustainable materials technology group.

After viewing the range of products displayed in the reception area, along with a model of the complex, we were taken on a guided tour to see some of the products being produced at the site.

The role of minor metals in modern industry is significant, and Vital Materials manufactures over 100 products in the seven categories of materials: selenium, tellurium, indium, gallium, germanium, bismuth and cadmium.

The wide range of products include (but are by no means limited to) semiconductors, such as gallium arsenide - used in the manufacturing of devices such as microwave frequency integrated circuits, light-emitting diodes, laser diodes, solar cells and infrared optical windows, and bismuth telluride which, when alloyed with antimony or selenium, is an efficient thermoelectric material for refrigeration or power generation. Another product, zinc selenide, is very important for infrared optics applications and IR imaging systems. Materials are produced for use in RF and Microwave semiconductor devices, widely used in mobile communication, wireless LAN, and multimedia, as well as evaporation and sputtering coating materials for the solar and optoelectronic industries.

The company has developed dynamically since its founder and President, George Zhu, started producing selenium dioxide along with a small team for Chinese customers in electrolytic manganese back in 1995.

High Purity Materials industrial base He Yun plant

Rare Materials industrial base-Yun long Plant

George Zhu puts the company's growth into context: "We invested over USD300M before 2014, not perfect timing for us, but our positive focus on the future and great excitement due to new products almost quarterly is making us stronger".

By 2003, with 250 employees, the operation of First Rare Materials Co., Ltd was producing selenium, tellurium and cadmium alloys and chemicals in Heyuan Industrial Park.

Recycling Plant -CleanTech

With the Chinese market growing in all sectors by 2009 - solar, telecoms, semi-conductors, using advanced minor metal products - the company invested USD40M to build a fully integrated minor metals upstream recycling plant, capable of treating 25 different metal streams. By this point, the employee base worldwide had grown to over 800.

Historically, recycling in the industry has been variable, with many minor metals still lost at end of life. However, it is well-known that a large portion of waste generated within the industry contains valuable metal elements. The company highlights its dedication to the development of tailor-made recycling technologies, allowing for the reuse of valuable metal elements by means of re-purification, pointing out that "this will not only generate economic benefits, but also contribute to environmental protection".

In 2011, George decided to invest heavily in downstream advanced products. Raising USD300M, construction of the advanced materials facility as a 52 hectare site in Qingyuan, outside Guangzhou began.

Acquisitions in the USA of Bolton Metal Products (2011), producing specialty alloy and LMPA products, and Phoenix Infrared Corporation (2012) followed, and in 2013, Vital purchased the pigments operation in Tianjin from Capelle, establishing Vital Pigments Co. Ltd in Teda Industrial Park. The company also set up a Joint Venture with Hangzhou Jingjiang Group for the supply of 4N gallium metal units.

Recycling Plant -CleanTech

George reflects that: "2014, 2015 and most 2016 were difficult years for underlying commodity prices. We have worked through these years and with localization and continued growth in China, the future for minor metals within our range of advanced downstream products is exciting".

The growth continued throughout 2014, with the full commissioning of the Advanced Materials Plant at Qingyuan. Production lines include metal organics (TMGa, TMIn), high purity (6N, 7N), GaAs substrates, Ge substrates, InP substrates, thin film materials, infrared and radiation detection. The total worldwide workforce now exceeded 1,000. Vital also signed a Joint Venture with Umicore for the production of ITO Targets, establishing Umicore Vital Thin Film Technologies during 2014. It includes a manufacturing facility in Providence USA. Construction of the second ITO Plant also started in Qingyuan.

Bringing developments up-to-date, in 2016, Vital's worldwide workforce reached over 1,600, and the company commissioned its CleanTech operation in the Xiongxing Industrial Park, for the processing of licensed hazardous waste in China, as well as waste streams from its own operations.

VITAL Specialty Materials

In the words of George Zhu, the future for Vital is bright: "We are recruiting in all areas, both in China and overseas". There are, he says, currently "positions available for Commodity Sales Managers, Advance Product Sales Engineers, Qingyuan R&D Engineers, Recycling & Sourcing Managers and Technical Sales Engineers."

Maria Cox, MMTA

IN BRIEF

Heavy Metal Snails

A special type of small sulfur-rich protein, metallothioneins, have an extraordinary capability for binding heavy metals. An international team of scientists has now discovered that the marine common periwinkle, which is widely considered a delicacy, contains the largest version of the protein found yet, with one additional cadmium-binding domain and a one-third higher detoxification capacity. As they report in the journal Angewandte Chemie, this feature may help the snail survive in heavy-metal-polluted environments.

Snails and slugs are known for their intriguing ability to accumulate and detoxify heavy metals. They are even capable of discriminating between cadmium and copper, as the latter element is an indispensable element in their metabolism, while cadmium is toxic. They detoxify cadmium by binding it to metallothioneins, a class of small proteins rich in the sulfur-containing cysteine amino acid. Oliver Zerbe at the University of Zurich, Switzerland, and Reinhard Dallinger at the University of Innsbruck, Austria, and their colleagues in Barcelona, Spain, investigate the evolution of these proteins as a strategy to adapt the gastropodes to their new habitats—land snails have developed from marine species, and had to find novel strategies to cope with the higher loadings of heavy metals in the soil.

To find out more visit www.phys.org and search for 'sea snail'

Water Repellent Rare Earths

Surfaces that have been coated with rare earth oxides develop water-repelling properties only after contact with air. Even at room temperature, chemical reactions begin with hydrocarbons in the air. In the journal *Scientific Reports*, researchers from the University of Basel, the Swiss Nanoscience Institute and the Paul Scherrer Institute report that it is these reactions that are responsible for the hydrophobic effect.

Additional uses for rare earths were opened up after American researchers reported in 2013 that surfaces that have been coated with rare earth oxides become water-repellent.

Scientists from the University of Basel, the Swiss Nanoscience Institute and the Paul Scherrer Institute have now worked with the company Glas Trösch to examine these hydrophobic properties more closely.

The researchers coated glass pieces with rare earth oxides, nitrides and fluorides and analyzed how well they could be wetted with water. They could not detect any hydrophobic properties when the coating was freshly deposited. It was only chemical reactions with gaseous hydrocarbons found in the ambient air that increased the surfaces' roughness and reduced wetting by water.

The gaseous organic compounds from the ambient air are first adsorbed by the surface and then react with the oxides to form carbonates and hydroxides until the surface is completely covered with these compounds. This process takes place even at room temperature.

"We were surprised that the hydrophobic effect was caused by the surface aging," says Professor Ernst Meyer, from the Department of Physics at the University of Basel, commenting on the results of the project supported by the Commission for Technology and Innovation (CTI). These conclusions are very revealing from a scientific point of view because catalytic processes also frequently take place at room temperature, which makes it important to understand the surface's physical properties.

The examined materials are, however, unsuitable for the industrial production of water-repellent glass surfaces, because the glass requires a sophisticated storage process before it shows the desired hydrophobic characteristics.

Source: University of Basel

Read more at: https://phys.org/news/2017-03-rare-earths-water-repellent-age.html#jCp

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