TIC
TANTALUM-NIOBIUM
INTERNATIONAL STUDY CENTER
Bulletin N° 173: April 2018

The future of fabrication?

Tantalum and Wire + Arc Additive Manufacturing

(see page 14)

Contents

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President's Letter

Dear Fellow Members,

The tantalum market continues to show strong demand in all segments, at a time when artisanal production appears to have become more difficult. Reassuringly, some years ago, our organization's miners appear to have prudently invested in industrial mining, some of which will be in production this quarter. The T.I.C. has also made investments in its statistics, in promoting artisanal production and in marketing the unique properties of tantalum and niobium. These will show results this quarter, after a significant time.

Last year saw the start of an increase in demand for cobalt which ultimately seems to have affected artisanal supply of tantalum. Artisanal production is heavily dependent on itinerant labor that copper, cobalt and tin mines have in part pulled away from tantalite production in the Democratic Republic of the Congo. While some production sources have declined, we are seeing increased production from two modern lower-labor industrialized mining projects in the Province of Tanganyika, in the Congo. These African industrialization projects coincide with expanded mechanized production from Australia and South America. The long-term desirability of tantalum and niobium depends on our industries' demonstration that we can provide adequate feedstock to meet the increased demand as it occurs.

To further our organization's objectives of promoting increased industrialized supply, the T.I.C. plans to offer workshops to miners during our 59th General Assembly in central Africa later this year. We are also developing resources that will allow the Association to promote mining services and making an outreach effort to attract new members who wish to provide expertise, services and equipment for industrialized mining. Industrializing even a small number of the many artisanally mined deposits will contribute greatly to the desirability of tantalum and niobium as a reliable feedstock for processors and their customers.

The Director (left) and President (right) attending the 2018 Mining Indaba in Cape Town, South Africa, earlier this year. (photo: T.I.C.)

The traditional T.I.C. statistics service has witnessed changes in recent years, including from consolidation within the industry, new data collection technology and the departure of a key member. The reduced number of mandatory reporters in certain categories raised concerns with some members that the results are more transparent than had originally been intended. In the future members continue to be required under our Charter to report statistics, and there will be no change in our longstanding commitment to confidentially by collecting data only through an independent third-party accountant. However, in addition to members' data, going forward the T.I.C. will use publicly available import and export data to augment the quarterly statistics report.

The T.I.C. offers its members unique statistics by providing accurate measures from our complete and diverse membership. We believe more accurate and complete statistics will provide considerable help to our member companies, allowing them to better understand our industry and justify important investment decisions. I extend my thanks for the work done to our Statistics Subteam lead by Alexey Tsorayev and commend the tireless behind-the-scenes work of our Technical Officer, Dave Knudson.

I would also like to thank the Marketing Subteam and particularly the efforts of Dr Dan Persico and our Director, Roland Chavasse, for all the work they have done to assemble the international panel of experts for the A.G. Ekeberg Tantalum Prize. I am excited about the launch of the Prize and believe it will bring much positive attention to the tantalum industry.

Sincerely yours,

John Crawley

President

Director's Letter

Brussels, Belgium

Dear T.I.C. members and stakeholders,

The first quarter of the calendar year is always when the General Assembly machinery steps up a gear and this year has been no different. Presentations and sponsors for our event later this year in Kigali, Rwanda, are falling into place and special early-bird booking rates will be available from late April onwards.

Planning for a conference takes many months and is the culmination of a significant team effort. At this stage in proceedings I believe the 59th General Assembly, our first in central Africa, will be one to remember for all the right reasons.

Talking of Africa, in February T.I.C. President John Crawley and I discovered a great deal about new tantalum and niobium projects across that continent at the Mining Indaba in Cape Town, South Africa. Highlights included meeting with the mining ministries from the DRC, Ethiopia, Zimbabwe, Rwanda, and Malawi to name but a few, and learning of the opportunities for niobium and tantalum in each country.

Gorilla trekking in Volcanoes National Park in eastern Rwanda is popular so must be booked well in advance.

(photo: Jaydene Chapman, The Stocks)

European Union (EU) regulations and the UK

Since the last Bulletin the T.I.C. has written to the UK government ahead of the UK's departure from the EU, to underline the importance of tantalum and niobium to the British economy. Currently the UK implements the EU REACH chemical regulations and it was also signatory to the EU's 2017 conflict-minerals regulation (2017/821) that is due to enter into force on January 1st 2020.

When the UK leaves the EU it will need to duplicate these structures. To that end the T.I.C. strongly recommended that any future UK laws are aligned with the EU as closely as possible and do not duplicate regulation so that, while the UK avoids supply chain disruption and the risk of conflict-affected materials entering the British markets, customers in both territories can continue to work efficiently and effectively.

At the time of writing there are several signs that global trade could be moving towards a period of more protectionist policies. As an international trade association with a world-wide membership and representing two elements with truly globalised supply chains, this is concerning. For the T.I.C.'s part, we will continue our efforts to raise awareness of the benefits of niobium and tantalum without fear or favour in every forum available to us.

Best wishes,

Roland Chavasse, Director

The T.I.C., the Bulletin and your personal data:

To comply with new EU legislation we may ask you to confirm by email that you want to stay on our mailing list.

Our mission with the Bulletin is to provide the global tantalum and niobium community with news, information and updates on our work. We hope you enjoy reading it and you will want to continue receiving it in the future.

The General Data Protection Regulation (GDPR) is a new European regulation that becomes law on May 25th 2018. It affects how personal data is captured, processed, and stored and it is aimed at protecting the personal data of individuals living in the European Union (EU). All EU-based companies must comply, as must non-EU companies that do business in the EU. GDPR affects the T.I.C. since we are registered as an AISBL (international association) in Belgium.

Anders Gustaf Ekeberg Tantalum Prize: The Panel of Experts

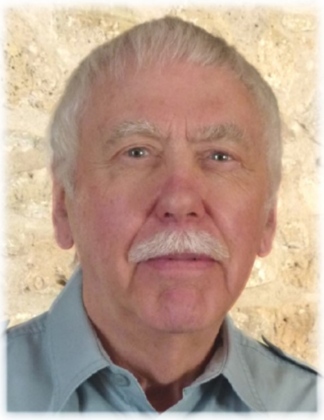
The Anders Gustaf Ekeberg Tantalum Prize (the Prize) is a new annual award established by the T.I.C. to recognise excellence in published tantalum research. The global tantalum community has responded very positively to the Prize and the T.I.C. believes that it has the potential to be a great ambassador for this special element and the cutting-edge research which uses it.

The Prize is named after the discoverer of tantalum and will be awarded to the lead author(s) of the published paper or patent that is judged by an independent panel of experts to have made the greatest contribution to understanding the processing, properties or applications of tantalum.

Since Bulletin #172, the T.I.C. has approached leading tantalum experts around the world and is delighted to be able to announce the members who will form the inaugural panel of experts.

Should you wish to submit or recommend a publication for consideration for the 2018 Award, then please contact info@tanb.org or any member of the Executive Committee (see page 23) by May 31st 2018. The initial Prize is planned to be awarded at the 59th General Assembly in October 2018.

Introducing the 2018 Panel of Experts (alphabetical by surname)



Richard Burt

Kielsinn Inc., Canada

Richard Burt is a former T.I.C. President and widely recognised as a leading expert on tantalum and niobium. After graduation, Richard worked in Central Africa and the UK prior to immigrating to Canada in 1977, where until 1997 he was at Tantalum Mining Corporation of Canada, first as Mill Superintendent then, from 1983 as General Manager. He then moved to Cabot Corporation, as Director of Mineral Development, a world-wide mandate, which included tantalum exploration and development projects in several countries throughout Africa. Since 2002 he has been an independent consultant with an international client list in the tantalum, tin, tungsten and gold industries.

He was on the T.I.C. Executive Committee for many years, including two consecutive terms as President (2009-10 and 2010-11). He has been a Director of various junior mining companies in Canada, UK, Africa and Brazil.

Professor Elizabeth Dickey

North Carolina State University, United States of America

Dr Elizabeth Dickey is a Professor of Materials Science and Engineering at North Carolina State University where she is also the Director of the Center for Dielectrics and Piezoelectrics, a university-industry cooperative research centre with 26 international members. Her research aims to develop processing-structure-property relationships for materials in which the macroscopic physical properties are governed by point defects, grain boundaries or internal interfaces. She is regarded as leader in the application of electron microscopy and spectroscopy techniques to understand the role of material defects on electrical and chemical transport in dielectric materials. She has over 150 peer-reviewed journal publications in these areas and has organized numerous international conferences and symposia. She is a fellow of the American Ceramic Society, has served on the Board of Directors, and was awarded the Fulrath Award by the Society in 2012. She is currently an Editor of the Journal of the American Ceramic Society and serves as a Physical Sciences Director for the Microscopy Society of America.

Dr Magnus Ericsson

Luleå University of Technology, Sweden

Since 2009 Magnus Ericsson is adjunct professor of Mineral Economics at Luleå University of Technology in the mining heart of Sweden. He has for decades been closely involved in developing a global mining database. He has established a reputation for developing among the best overviews of the world's mining industry. Together with his colleagues he has mapped all of the world's deposits, mines and mining companies and monitored their investments and M&A activity. He has over the years been involved in tantalum mining in Namibia and in an advisory capacity regarding social and community matters for a niobium project in Malawi. He is currently setting up a new consultancy called RMG Consulting, based in Stockholm. He is a co-founder and Editor-in-Chief of the scientific journal Mineral economics/Raw Materials Report, now in its 31st year.

He Jilin

China Academy of Engineering, China

Academician He is a specialist in the metallurgy and material properties of the elements tantalum, niobium and beryllium. He graduated from the Science and Technology University of Beijing and has enjoyed a distinguished career. Academician He has published more than 30 papers and been awarded several prizes for national scientific and technological progress. Academician He was elected academician of the Chinese Academy of Engineering in 2001 and has been a Director in Ningxia Orient Tantalum Industry Co., Ltd. since 2006. Previously he served as Chairman of the Board, Vice Chairman of the Board and General Manager at Ningxia. Academician He was a member of the T.I.C. Executive Committee for many years as Ningxia's representative.

Dr Axel Hoppe

Commerce Resources / consultant, Canada / Germany

Dr Axel Hoppe holds a doctorate in chemistry and has worked in the tantalum industry for over 25 years. He has published several papers on the subject and holds various tantalum patents. For over 30 years Dr Hoppe worked at H.C. Starck, then a subsidiary of Bayer. His last position at Starck was Head of Technical Services and Engineering Group. Dr Hoppe was a member of the T.I.C.'s Executive Committee for 10 years (1997–2007), including serving two terms as President (2001-2 and 2006-7). Currently he is Chairman of the Board of Commerce Resources, a Canadian junior mining company, and works as a consultant for rare and refractory metals.

Professor Animesh Jha

University of Leeds, UK

Dr Jha is a materials scientist with a doctorate in metallurgical engineering. He is named on over 20 material patents, including one (#20180044762) that concerns a novel process to refine tantalum-bearing minerals without the use of hydrofluoric acid (HF). He attended the T.I.C.'s 57th General Assembly in Toulouse in 2016. He has worked on a wide range of mineral science and processing applications. His research interests include:

- Processing of rare-earth doped glass, glass ceramics, thin films via pulsed laser deposition, optical fibre engineering for lasers, sensors and amplifiers and materials engineering for optical integration.

(continued)

- Interaction of lasers with biological matter (dental minerals, bone) and rare-earth ion conjugated bio-minerals.
- Fundamentals of chemical kinetics, thermodynamics, and phase transformation, applications of materials fundamentals for processing of rare-earth and critical materials and minerals. Mineral process engineering and flow-sheet development.
- Spectroscopic characterization of glass and minerals, bio-minerals and animal tissues (FTIR, UV-visible, Raman, laser spectroscopy).

Dr Jha is a member of The Metal Society (TMS) in the United States of America and the Royal Society of Chemistry in the UK.

Dr Nedal Nassar

U.S. Geological Survey (USGS), United States of America

Dr Nassar is the Chief of the Materials Flow Analysis Section at the National Minerals Information Center, USGS. Dr Nassar is a leading expert in mineral criticality assessments and materials flow analyses. Employing a systems perspective, Dr Nassar and his team examine the global stocks and flows of non-fuel mineral commodities at each stage of their life cycle in order to gain a more complete understanding of their status above ground. His most recent work on the global stocks and flows of tantalum was published in the journal Resources, Conservation and Recycling, which he presented at T.I.C.'s 58th General Assembly

Dr Nassar received his Ph.D. from Yale University where he worked on the development and application of a methodology for identifying critical minerals. Previously, Dr Nassar worked as a consultant and as a process development engineer in the semiconductors and data storage industries where he was the recipient of three trade secrets for the development of novel new manufacturing processes.

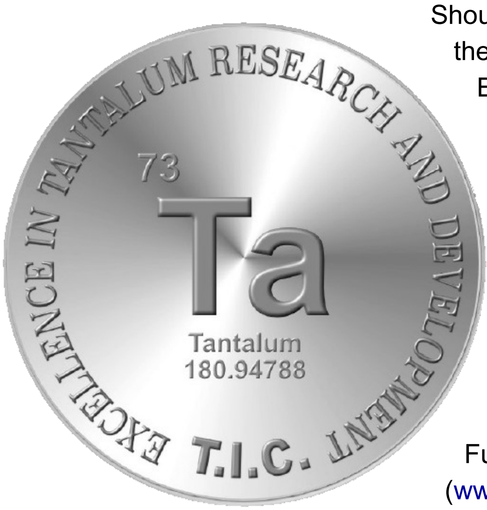
Looking ahead

The Prize is open to any published paper or patent that advances knowledge and understanding of tantalum, its processing or applications.

To be eligible for consideration, the publication must be in English and be made between 24 and 6 months before the award ceremony at the T.I.C.'s annual General Assembly (i.e. to be eligible for the October 2018 Prize a publication must be dated between October 2016 and April 2018).

CALL FOR PUBLICATIONS

(see back cover)



Should you wish to submit or recommend a publication for consideration for the 2018 Award, then please contact info@tanb.org or any member of the Executive Committee **by May 31st 2018.**

Once the call for papers has closed, the T.I.C., acting as secretariat to the Prize, will create a short-list of eligible papers. Then the panel of seven experts, coordinated by Richard Burt as chair, will be asked to decide the winner.

The author of the winning paper will be invited to give a presentation at the Association's 59th General Assembly in October, at which event he or she will receive a medal made from 100% conflict-free tantalum and be recognised by the delegates as an expert in the field.

Further information will be released on the T.I.C. website in due course (www.TaNb.org). The number of panellists and their terms are at the discretion of the T.I.C. Executive Committee. TIC

Photo credits: Mrs Roz Burt, North Carolina State University, Dr M. Ericsson, Zhengzhou University, Commerce Resources Ltd, Leeds University, Dr N. Nassar.

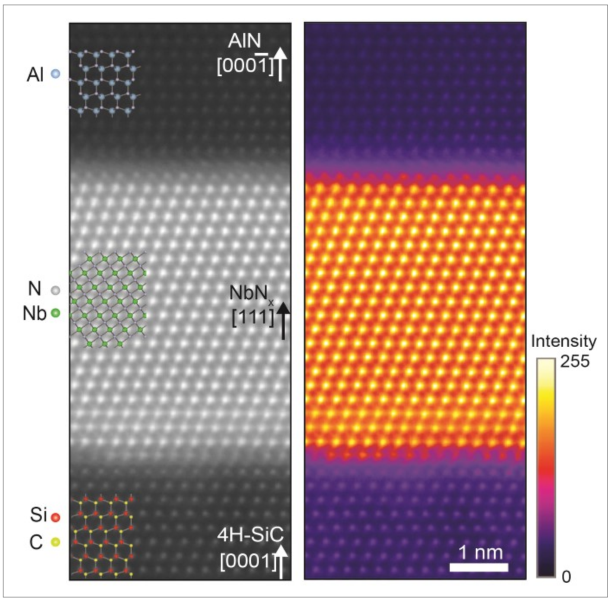
Novel semiconductor-superconductor built on niobium nitride

This is an edited version of "Novel semiconductor-superconductor structure features versatile gallium nitride" by Tom Fleischman in the Cornell Chronicle[1], March 7th 2018.

Silicon has been the semiconductor material of choice for electronics pretty much since the transistor effect was first observed and identified nearly 80 years ago. But a relatively new family of semiconductors – the group III-nitrides, including gallium nitride (GaN), indium nitride and aluminium nitride – offers greater versatility than silicon with capabilities for ultrafast wireless signals, high-voltage switches and high intensity lighting and photonics.

A team led by Professor Debdeep Jena of the electrical and computer engineering (ECE) department at Cornell University (www.ece.cornell.edu) and David Meyer at the US Naval Research Laboratory (www.nrl.navy.mil) has successfully devised a semiconductor-superconductor crystal structure featuring GaN grown directly onto a crystal of niobium nitride (NbN), a proven superconductor material used in quantum communications, astronomy and a host of other applications.

The method for combining the two materials – molecular beam epitaxy (MBE), essentially spray painting of gallium and nitrogen atoms onto the NbN in a vacuum environment – creates an extremely clean interface and is key to the success of the novel structure.



Crystallinity in epitaxial NbNx on SiC
(Picture: Cornell University)

This advance, they say, opens up a range of possibilities that can now combine the macroscopic quantum effects of superconductors with the rich electronic and photonic properties of group III-nitride semiconductors.

"People have tried it with other semiconductors, like silicon and gallium arsenide, but I don't think anything has been as successful as what we've managed to do with GaN," said Jena.

Gallium nitride-based semiconductors have recently made major inroads in the areas of LED lighting, Blu-ray laser diodes, energy and communications. In fact, the 2014 Nobel Prize in physics was given to a trio of Japanese scientists for their invention of energy-efficient blue light-emitting diodes (LEDs) using GaN.

Technological advances – particularly the type of MBE used in this work, which was developed at the US Naval Research Laboratory[2] (patent pending) – has made it possible for scientists to think about semiconductor-superconductor heterostructures such as the one Jena's group has developed.

The specialized nitride MBE system includes an electron beam evaporator source, which "melts" the niobium – which has a melting point of around 2,477 °C (4,491 °F) – but not the crucible it's in. Atoms of niobium are deposited onto a silicon carbide wafer, and the GaN semiconductor layers are then grown on top of that, also by MBE.

"This new source allowed us to overcome the temperature limitations of conventional sources, and bring high-melting-point, refractory transition metals like niobium and tantalum into the picture," Meyer said.

The team demonstrated for the first time the growth and fabrication of a semiconductor transistor switch, the prototypical gain element in electronics, directly on top of a crystalline superconductor layer. This heterostructure is a kind of "best of both worlds," Jena said, offering a method for devising quantum computation and highly secure communications systems. "We think this presents a wonderful opportunity for rapid technology development of next-generation communications and computation systems," Meyer said.

1 - See http://news.cornell.edu/stories/2018/03/novel-semiconductor-superconductor-structure-features-versatile-gallium-nitride for the article describing the paper "GaN/NbN Epitaxial Semiconductor/Superconductor Heterostructures" that was published in Nature at https://www.nature.com/articles/nature25768#f11. Rusen Yan and Guru Khalsa are co-lead authors.

2 - Details of GaN/NbN research at the NRL is found at https://www.nrl.navy.mil/media/news-releases/2017/Nitrides-in-Transition

REACH 10-year review published

REACH is the European Union regulation concerning the Registration, Evaluation, Authorisation and restriction of Chemicals. It came into force on 1st June 2007 and is overseen by the European Chemical Agency (ECHA[1]) in Helsinki, Finland. The REACH Regulation includes the obligation for a review every 5 years to monitor progress in the achievement of its objectives. In March 2018 the European Commission published the delayed second REACH review ("REACH REFIT Evaluation"), following on from the first report published in 2013.

REACH after a decade

To summarize the review in ten words: REACH is effective, but there is still room for improvement.

The report states that after a decade in operation it considers REACH to function well, deliver results and address citizens' concerns about chemical safety. In particular the report commends ECHA for developing the world's largest database on chemicals. It states that "REACH is fully operational and delivering results towards achieving its objectives. Although progress towards the objectives is lagging behind initial expectations, it has steadily improved... REACH is effective but opportunities for further improvement, simplification and burden reduction have been identified, which can be achieved by delivering the actions outlined in the report."

The key improvements that are needed in REACH include making the legislation more efficient and cost-effective, especially for the evaluation, restriction and authorisation processes. The direct costs of REACH are estimated to have been about 45% higher than had been originally forecast, although the Commission is quick to point out that these costs are dwarfed by the potential long-term benefits for human health and the environment and they must take a broad view on the issue.

The final deadline for companies to register all chemicals manufactured, imported or placed on the EU market above one tonne per year is 31st May 2018 .

The report sets out 16 actions to be addressed and implemented in order to improve REACH:

1. Encourage updating of registration dossiers
2. Improve evaluation procedures
3. Improve the workability and quality of extended safety data sheets
4. Track substances of concern in the supply chain
5. Promote substitution of substances of very high concern (SVHC)
6. Simplify the authorisation process
7. Consider options to further develop and use socio-economic information for possible regulatory measures

1 - www.echa.europa.eu

8. Improve restriction procedures - in particular ECHA is required to clarify the information needed for public consultations and continue its efforts to identify suitable cases for restricting CMR substances in consumer articles
9. Further enhance EU member state involvement in the restriction procedure
10. Better frame the application of the precautionary principle
11. Assess the interplay between restriction and authorisation to achieve a comparable risk reduction more efficiently
12. Clarify the interfaces between REACH, occupational safety and health (OSH) legislation and waste legislation.
13. Enhance enforcement of REACH
14. Support compliance by small and medium-sized enterprises (SMEs)
15. Assess all possible options for reducing the cost of operating ECHA
16. Review the registration requirements for low tonnage substances and polymers

Although the costs of REACH to industry were considerable and should not be down-played, the forecasts that REACH would destroy the European chemicals industry have fortunately not been realised.

(photos: Shutterstock)

Next steps

Following publication of the report, the Commission will discuss the outcomes and follow-up actions of the second REACH review with the European Parliament, Member States and stakeholders at a public conference, planned for June 2018 (no details had been released at time of print). The full report is available at https://ec.europa.eu/docsroom/documents/28201 and its fulsome appendices at https://ec.europa.eu/docsroom/documents/28202. TIC

UK footnote to REACH

The United Kingdom (UK) is currently negotiating to leave the European Union (EU), a very complex procedure that the UK government hopes to have completed by March 2019. One aspect of this process will be to incorporate copies of many EU regulations into UK law in a Great Repeal Bill, to ensure a smooth transition.

Such a bill would include both the EU's 2017 conflict-minerals regulation (2017/821), which explicitly covers tantalum, and the 2006 REACH regulation which covers all metals and chemicals.

REACH allows the UK chemical industry to access the EU single market and vice versa. By leaving the EU and the European Economic Area (EEA), without any regulatory replacement of REACH, the UK chemical industry would automatically find itself behind a regulatory barrier, cut off from its biggest trading partner. Although non-EU companies have no obligations under REACH, chemicals and metals imported for sale to EU customers are bound by it, and several non-EU countries in Europe choose to align closely with REACH.

In early March UK Prime Minister Theresa May said that the UK would seek "associate membership" of ECHA and several other critical EU agencies. Certainly, staying within REACH would be favorable to creating a separate UK REACH system; in effect an expensive duplication of ECHA's expertise and database of safety information on over 17,000 unique chemical substances.

To that end we strongly advise the UK government that any future UK policy is aligned with the EU as closely as possible when it comes to the REACH regulation and Conflict Mineral Legislation so that the UK and its trading partners avoid supply chain disruption and unnecessary costs.

At time of print the future relationship between the UK and REACH remains undecided. TIC

Venezuela: a new columbite-tantalite frontier?

As a non-political organisation the T.I.C. wishes to understand all and any developments that may impact the global tantalum-niobium industry. At the recent Mining Indaba in Cape Town (www.miningindaba.com) we talked with Vice Minister Franklin Ramírez and his colleagues from the Ministry of People's Power for Ecological Mining Development to learn more about Venezuela's plans to develop its mining sector. This report is for information only.

"Coltan Country", the Parguaza River, Bolivar State, Venezuela (Photo: Shutterstock)

Venezuela has vast proven oil and gas reserves and for most of the twentieth century it was a major oil exporter and leading member of the Organization of the Petroleum Exporting Countries (OPEC). However, as with the United Arab Emirates and Saudi Arabia, Venezuela is said to be conscious of the need to diversify its economy away from a dependency on oil revenues and so has started paying more attention to its other natural resources, including tantalite-columbite ('coltan') minerals. In Venezuela economic diversification has been made all the more urgent by falling oil production at the state-owned producer Petróleos de Venezuela S.A. (PDVSA) over the last decade, combined with high domestic inflation[1] of the Venezuelan bolívar.

In 2016 the Venezuelan government under President Nicolás Maduro made three major policy changes to the mining sector:

1. In January it launched the Bolivarian Economic Agenda which includes a 'Mining Engine' with the explicit goal of realising the economic potential of its mineral resources.
2. In February it created the Arco Minero del Orinoco (AMO) (in English the Orinoco Mining Belt or Arc) in Bolivar State as a National Strategic Development Zone for mining. This territory is said to represent 12% of all of Venezuela's government-owned land and will be the focus for new mining activity. Note that within each of the four areas exist many legally-protected environmental and indigenous territories.
3. In June governance of mining was taken away from the oil ministry and installed at the newly formed Ministry of People's Power for Ecological Mining Development (MPPDME, in Spanish[2]).

The new mining opportunities are open to private, public and mixed companies, as well as the participation of small-scale mining.

Under the new policy, all exploitation of mineral resources must be done to the highest standards of environmental harmony and human rights, which is appropriate for a territory with incredible biodiversity and many protected indigenous populations.

The chestnut-mandibled toucan is one of many rare creatures in the Venezuelan rainforest
(Photo: Shutterstock)

1 - The International Monetary Fund (IMF) estimates inflation of the Venezuelan bolívar at 254% in 2016 and over 653% in 2017, www.imf.org.

The Arco Minero del Orinoco (AMO)

The Arco Minero del Orinoco is located south of the Orinoco River, in the northern part of the state of Bolivar. It has a total area of 111,844 km^2, organized internally in four areas for the purpose of development and administrative organization.

However, it is said that only 5% of the AMO will experience exploration and exploitation activities, and just 1.5% will experience mining activity once the exploration stage is completed. Of the four areas, columbite-tantalite minerals are mostly concentrated in Area 1, the most westerly of the four, close to the border with Colombia, but have also been found in Area 3 and Area 4.

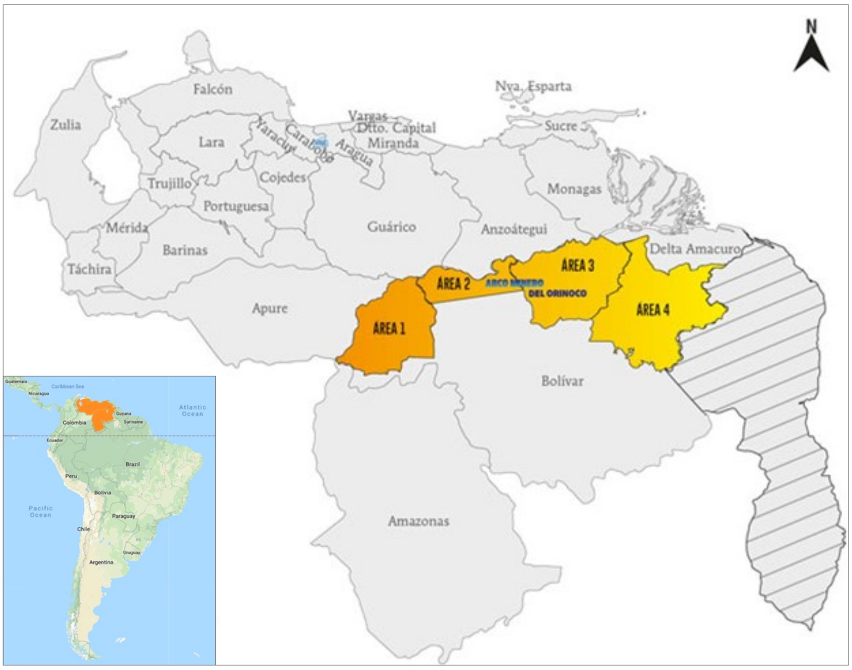


Figure 1: A map of Venezuela showing the four new mining areas in the Arco Minero del Orinoco; inset: South America showing Venezuela (orange) (Images: MPPDME, Google Maps)

Tantalum and niobium in Venezuela

Niobium, tantalum and tin minerals in Venezuela constitute the classic columbite-tantalite (coltan) (columbite-tantalita, in Spanish) mineralizations associated with granitic and pegmatitic complexes. The northeast zone of the Amazonas state and the southwestern region of the municipality of Cedeño, Bolívar state, constitute one of the most interesting metallogenic areas of niobium and tantalum in the country.

Currently, there is no determination of the reserves of columbite and tantalite (coltan), but previous studies carried out by the National Institute of Geology and Mining (Ingeomin) have defined the following deposits of columbite-tantalite with the objective of carrying out prospecting and exploration activities for their subsequent certification of reserves:

- Aguamena- Boquerones-Villacoa sector,
- Cerro Impacto,
- Guaniamo,
- Cuao River sector,
- Cerro Delgado Chalbaud (Black River).

Tantalite-containing mineral samples from Venezuela (Photo: MPPDME)

2 - El Ministerio del Poder Popular de Desarrollo Minero Ecológico (MPPDME), www.desarrollominero.gob.ve.

A note from the T.I.C. archives regarding Venezuelan columbite-tantalite

In Bulletins #52 (November 1987)[3] and #67 (September 1991)[4] Dr Simon E. Rodriguez, then of the Geological Survey of Venezuela (forerunner to Ingeomin), wrote about a large granitic formation located in the western-most part of Bolivar State, that had shown an important Ta-Sn-Nb mineralization in numerous large complex pegmatites. The geomorphology of this area is characterized by large plains, consisting of savannas and smooth hills. Pegmatites had been found in some hills and in addition secondary eluvial deposits located near the pegmatite bodies showed high concentrations of Ta-Sn-Nb minerals. Initial tests on the ore of the Parguaza Ta-Sn-Nb district produced a concentrate with a Ta_20_5 content ranging between 25 and 42 per cent. It is worth noting that Dr Rodriguez's map (see below) and OMB Area 1 show a very close approximation.

In 2010/11 these pegmatites were explored again[5], this time by a team of geologists from Venezuela's Central and Oriente Universities and state-owned mining group CVG Bauxilum. Of their 39 samples 8 were confirmed to contain columbite and tantalite minerals, including struverite, ferrowodginite, titan-wodginite, and ferrocolumbite. Minerals containing rare earths, titanium and tin were also recorded.

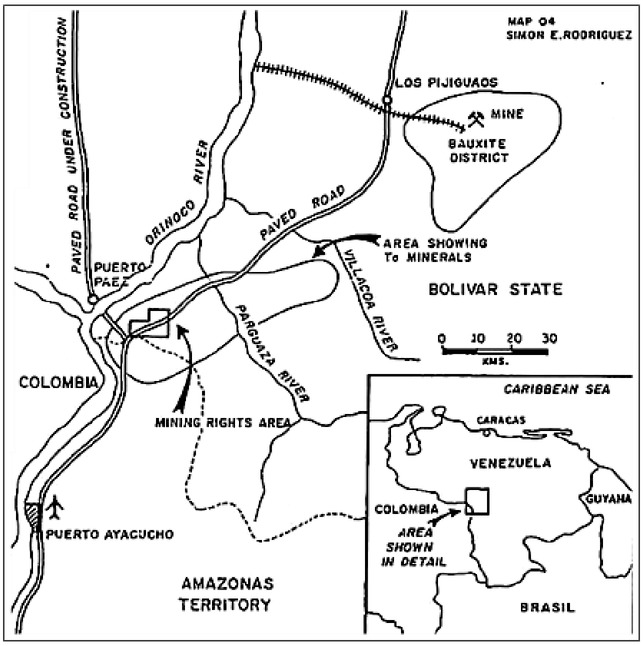


Figure 2: The tantalum district of south western Venezuela, near the confluence of the Paraguaza River with the Orinoco River (credit: Dr Rodriguez)

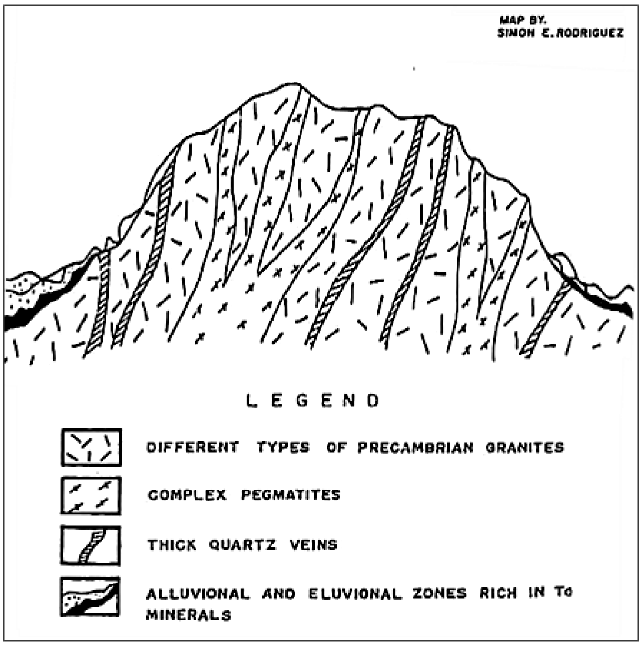


Figure 3: A generalised cross section of mineralized areas in the Parguaza Region (credit: Dr Rodriguez)

Figure 4: Pegmatite rock formations in the Parguaza Mountains, as discussed by Dr Simon E. Rodriguez. According to sources active in Venezuela the Parguaza region is locally known as "Coltan Country". (Photo: Shutterstock)

3 - www.tanb.org/images/Bulletin52.pdf

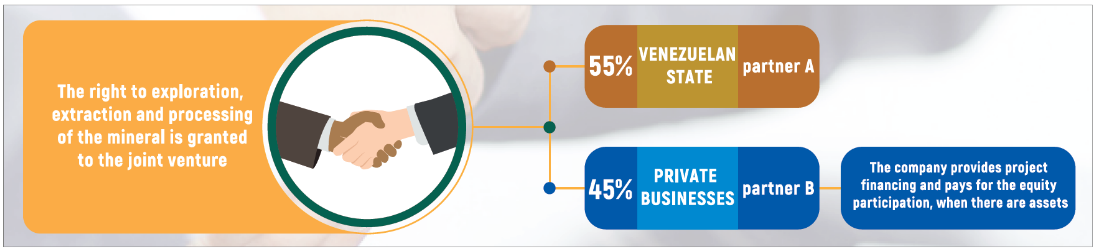
4 - www.tanb.org/images/Bulletin67.pdf, Dr Rodriguez had previously given a paper on this subject at the T.I.C.'s 27th General Assembly

5 - Published (in Spanish) as "Estudio preliminar de los depósitos de tantalita, columbita y casiterita, en el Fundo La Fortuna, al SW del Cerro Boquerones, en el área metalogénica El Burro" by Asdomary Bolívar, Adriana Manrique* y Edixon Salazar, Universidad de Oriente; Sebastián Grande, Universidad Central de Venezuela y Luis Guzmán, Noel Mariño, CVG Bauxilum.

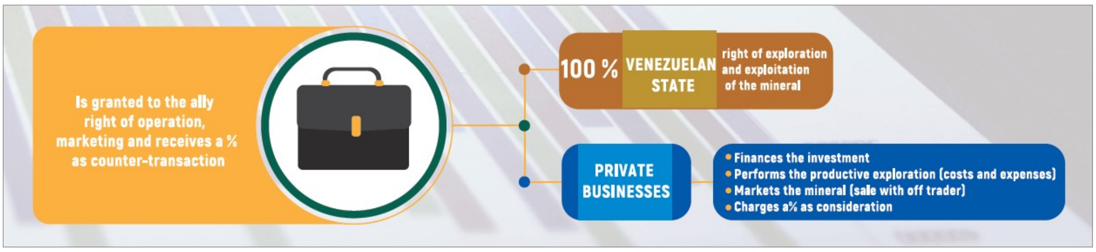
Investment potential

The investment projects in Venezuela may be carried out as either a joint venture or a strategic alliance[6].

Joint ventures are between the government, represented by the Venezuelan Mining Corporation (CVM), and other public or private organizations, national or international. In this arrangement CVM owns at least 55% of the share capital and the investor provides the project finance and equipment in return for the right to explore, extract and process the minerals. Any minerals are exported and sold on the international markets by the investor, on behalf of the joint venture.



Strategic alliances constitute a cooperation mechanism between CVM and public or private organizations, to combine efforts, strengths and abilities, in order to obtain goods, services or works associated with the mining value chain. In a strategic alliance the state retains 100% ownership of the property and the partner organization finances the investment, operates the site and markets the minerals in return for a percentage of the profits obtained.



President Maduro has reported a great deal of interest in the Arco Minero del Orinoco. According to the Venezuelan government, to date some 150 companies from 35 countries have signalled their interest in mining for gold and various minerals. As of February 2018 approximately a dozen applications for coltan mining licenses were being processed and three joint ventures for coltan had been approved and established:

- Empresa Mixta Minera Ecosocialista Parguaza; CVM with Corporación Faoz, C.A.
- Oro Azul, S.A.; CVM with Corporación Venezolana de Minería y Supracal
- Empresa Mixta Minera Metales del Sur; CVM with Energold Minerals, Inc. of Canada

Looking ahead

Although currently there is little effective production of columbite-tantalite, Venezuela undoubtedly has the potential to become a regular producer. It has the attraction of not being covered by the US Dodd-Frank Act (section 1502) and furthermore, government sources state that Venezuelan tantalite has very low radioactivity.

However, it is early days in the Venezuelan mining renaissance and challenges remain, not least relating to the environment and indigenous groups. The OECD's guidance for responsible supply chains has a global scope, as will the EU's conflict-mineral regulation when it comes into force in 2021. It would be amiss in a discussion of Venezuelan mining potential not to mention that the country faces sanctions from the US and EU, and that some Venezuelan opposition politicians and civil society groups suggest illegal mining in Bolivar and Amazonas states is a significant problem for certain minerals.

While the Mining Engine of the Bolivarian Economic Agenda has commendable intentions and great potential, at this stage little is known about mining in a country that until recently has built its entire economy on oil. Responsible mineral buyers and investors know to always proceed with appropriate due diligence. TIC

6 - Further information is available from MPPDME (http://desarrollominero.gob.ve/catalogo-minero-venezolano/)

Wire + Arc Additive Manufacturing: a new way of producing large-scale refractory metal components

Paper written by Professor Stewart Williams, Gianrocco Marinelli, Dr Filomeno Martina and Dr Supriyo Ganguly, Cranfield University, and presented by Gianrocco Marinelli on October 18th 2017, as part of the Fifty-eighth General Assembly in Vancouver, Canada. All views and opinions in this article are those of the authors and not the T.I.C.

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Introduction

Refractory metals have intrinsic low-temperature brittleness, poor weldability and a high susceptibility to oxidation over a large temperature range, properties which can result in limitations in various steps of the manufacturing process. An innovative way of producing refractory metal parts has been developed by using wire feedstock coupled with an electric arc heat source, a process now widely known as Wire + Arc Additive Manufacturing (WAAM).

Although WAAM was effectively first patented in 1925, it is only since the 1990s that this technology has seen significant developments thanks to a much stronger and timely business case. WAAM hardware currently uses standard, off-the-shelf welding equipment: welding power source, torches and wire feeding systems. Motion can be provided either by robotic systems or computer numerical controlled gantries. This report will focus on the technology pioneered at Cranfield University, UK, over the last decade.

Additive Manufacturing Processes Comparison

Additive manufacturing (AM) is a method of construction that promises to reduce part cost by reducing material wastage and time to market. The various technologies for AM (or 3D printing) can be categorised according to the motion system, feedstock and heat source they employ. Feedstocks are typically powder or wire, and heat sources are usually electron beams, lasers or an electric arc.

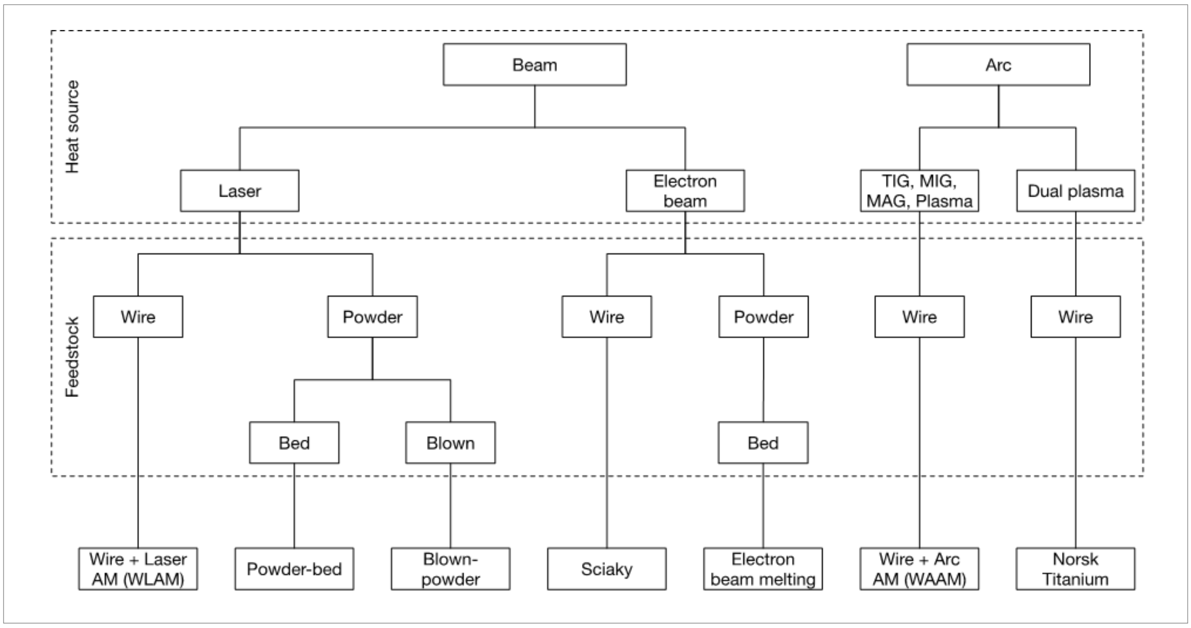


Figure 1: Comparison of additive manufacturing processes (part 1)

When compared to the other established AM processes, WAAM has both advantages and disadvantages. For example, powder-bed and blown-powder processes are net-shape processes and offer the highest complexity and accuracy. However they are comparatively slow, and have limited platform flexibility. High deposition wire-fed processes have a higher build rate than WAAM, but in doing so they sacrifice resolution. The strength of WAAM is in building larger parts with excellent mechanical properties, at good build rates and high platform flexibility, and with relative economy. In conclusion, owing to their intrinsic characteristics, the various processes are naturally suitable for certain applications rather than others, and they should be seen as complementary rather than competing.

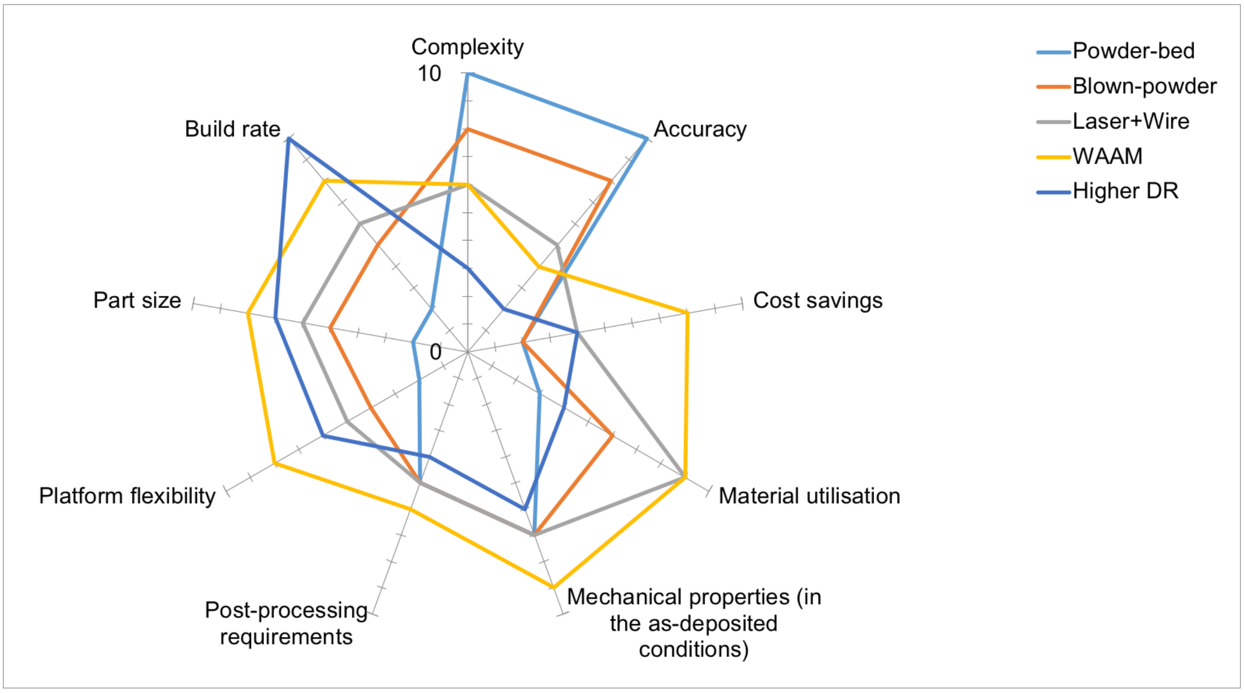


Figure 2: Comparison of additive manufacturing processes (part 2)

<u>Capability of Wire + Arc Additive Manufacturing (WAAM)</u>

Case study: this bowl made for the Aircraft Research Association is a thin-walled revolving structure that was created in approximately 150 minutes from the aluminium alloy Al5087, using coordinated motion of an industrial robot and a rotary stage.

A B C

Figure 3: Case study showing three stages in creating a simple structure manufactured by WAAM; A) after WAAM operation, B) scanning and computer modelling , C) the finished item after machining.

Following the WAAM process the wall thickness is 5mm, but during machining 0.5-1mm is removed from all surfaces to achieve a finish that is comparable to a similar item manufactured using traditional subtractive processes, thus minimising material waste.

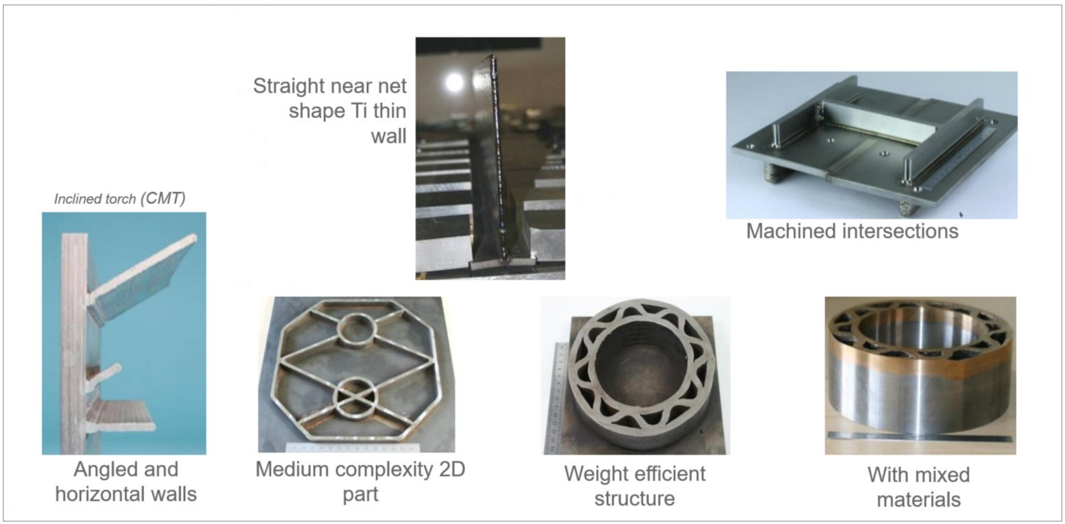


Figure 4: Features of WAAM capabilities

Other possibilities opened up by WAAM include self-supporting high-angled or inclined structures, structures of medium complexity and structures made of more than one material. Typically, WAAM parts are treated by superficial machining processes to achieve the desired surface quality and geometry.

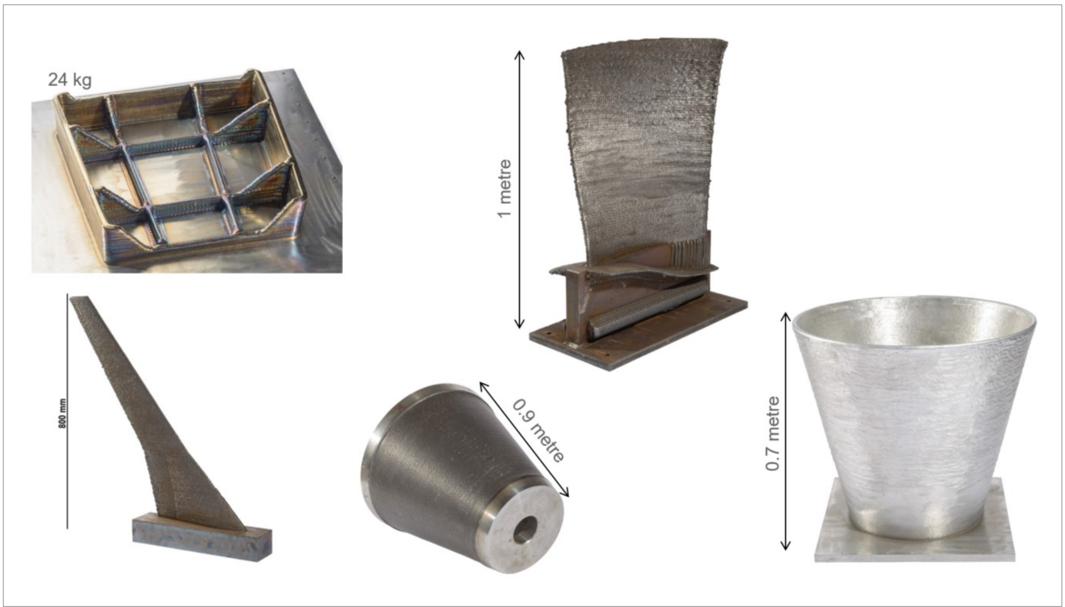


Figure 5: Semi-finished parts manufactured by WAAM

Materials that have been successfully used, tested and characterised by WAAM to date include titanium (grade 2, grade 5, grade 5 + O_2 doping, grade 23, 5553, timetal 407), aluminium (2024, 2319, 4043, 5087, Safra 66, ZL205A), refractory metals (tungsten, molybdenum, tantalum), Invar®, steels (ER70, ER80, ER90, ER120, maraging grade 250, maraging grade 350), stainless (17-4 PH, 316L, 420, + others), Inconel® (625, 718), bronze, copper, and magnesium.

Refractory Metals Deposition

Cranfield is involved in two projects on WAAM of refractory metals. One is AMAZE, funded by the European Commission, and closed in 2017; and the other is an industry-funded project in collaboration with a UK aerospace company. Within AMAZE, Cranfield University was collaborating with the Culham Centre for Fusion Energy to construct a diverter block using AM for the first time. The diverter represents one of the most critical components of the future nuclear fusion reactor, due to the challenges from both the radiation and structural points of view. Cranfield's task was to develop a method to have a plasma-facing tungsten section connected to the molybdenum cooling system, using a tungsten-molybdenum functionally graded structure (FGS) – all built by WAAM. The second project explores the possibility of using unalloyed tantalum and WAAM to manufacture a large component.

There are several challenges associated with the deposition of refractory metal components using AM. In particular, their high melting point and their high density require a phenomenal amount of energy to even be able to melt the material, let alone to obtain a stable weld pool and melt the feedstock material. Furthermore, their high susceptibility to oxidation leads to a pivotal use of a completely inert atmosphere, usually constituted by high-purity argon, during the deposition process. Lastly, the high ductile-to-brittle temperature transition typical of refractory metals such as tungsten and molybdenum leads to a high probability of cracks developing during the deposition, if the heating and cooling thermal cycles are not controlled carefully.

Development of WAAM for unalloyed tungsten

Cranfield's initial development of WAAM for unalloyed tungsten structures found that the substrate used for the deposition often suffers from severe cracking developed during the repetitive heating and cooling cycles. The substrate was a commercially available tungsten plate manufactured from the traditional powder metallurgical process. The high thermal stresses produced caused the cracks to start from the side of the substrate and develop across the deposited structure, affecting its integrity. The analysis of the fractured surface showed a feature of delamination of the tungsten substrate, possibly parallel to the rolling direction.

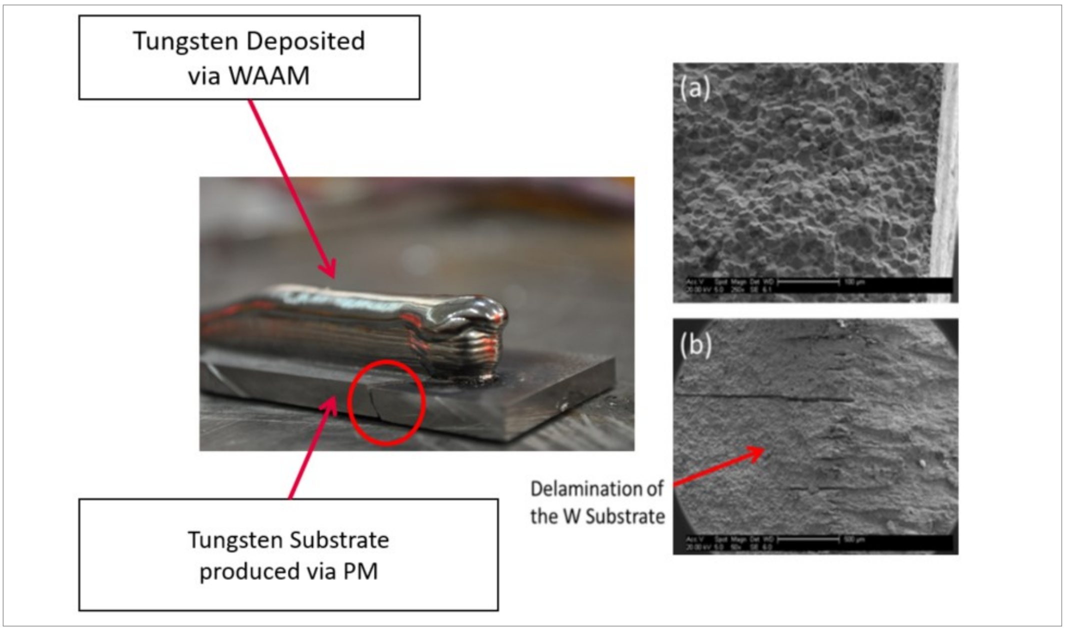
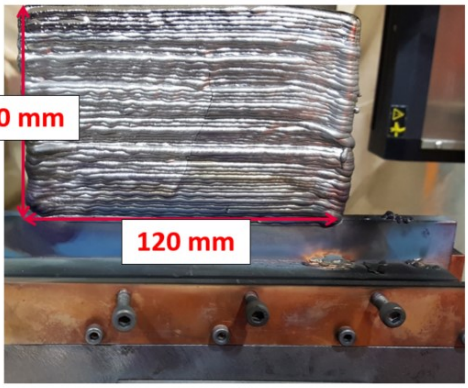


Figure 6: The brittleness of the tungsten substrate was a challenge that was successfully overcome

Cranfield developed a new strategy of deposition employing a substrate rotation of 90° and the deposition on the narrow side of the plate. This gave much fewer constraints to the tungsten structure allowing low-gradient thermal stress through the height of the substrate. The uniform distribution of stresses and the absence of constraining led to the complete absence of cracks within both substrate and deposit. A modulation of the power input led to a constant layers' geometry. Using the new strategy developed, Cranfield achieved the deposition of large-scale components in unalloyed tungsten with a deposition rate of 2.7 kg/h. Remarkable is the full nominal density and the absence of cracks.



Tungsten WAAM Deposition Parameters

Wire feed speed (WFS)	35 mm s^{-1}
Travel speed (TS)	2 mm s^{-1}
Current (I)	350 A
Wire diameter	1 mm

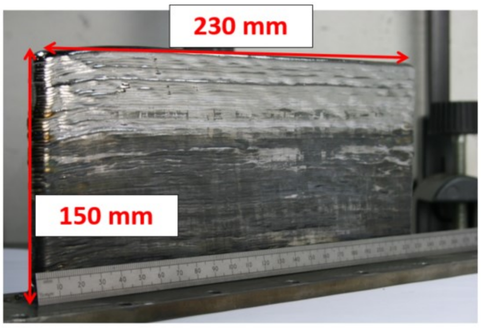
- Sound deposition achieved with ~ **6.1 kJ/mm**
- Deposition rate: **2.7 kg/h**
- First structure ever in unalloyed tungsten using WAAM
- Absence of cracks
- Fully-dense

Figure 7: The first structure ever in unalloyed tungsten using WAAM

Development of WAAM for unalloyed tantalum

Using the experience accumulated during the process study on unalloyed tungsten, the development of the WAAM process for unalloyed tantalum started from some of the fundamental parameters already known. In particular, even if tungsten and tantalum have a close melting point, a lower total heat input was used for tantalum with respect to tungsten mainly due to the low thermal conductivity of tantalum. In other words, the heat dissipates through the tantalum substrate at a lower rate compared to a tungsten substrate so that a higher accumulation of the heat led to a larger melting pool dimension at lower heat input. For this reason, Cranfield was also able to deposit unalloyed tantalum with a higher build rate than tungsten, as high as 4 kg/h.

Tantalum structures can be deposited with high integrity and excellent mechanical properties, superior to those of commercially available tantalum. Two different wires were tested as feedstock ("P" and "H" in figure 10) and WAAM-produced samples demonstrated yield strength and ultimate tensile strength comparable to the commercially available tantalum substrate. For example, a yield strength of around 200 MPa was achieved for the WAAM-deposited material compared to 180 MPa for commercially available unalloyed tantalum, even though the grains in the WAAM were large and had a high aspect ratio.



Tantalum WAAM Deposition Parameters

Wire feed Speed (WFS)	60 mm s^{-1}
Travel Speed (TS)	4 mm s^{-1}
Current (I)	300 A
Wire diameter	1.2 mm

- Sound deposition achieved with **~2.6 kJ/mm**
- Deposition rate: **4 kg/h**
- First structure ever in unalloyed tantalum produced via WAAM
- Fully-dense

Figure 8: A wall of unalloyed tantalum using WAAM, showing columnar grains

However, the WAAM samples had far lower elongation values, largely due to the size and the shape of the grains. This led to the application of a patented technique (in-process cold-work via rolling) to refine the microstructure. After each layer had been deposited it was then rolled under high pressure.

The small defects introduced in the crystalline structure (such as dislocation) store energy, but when the next layer is added the residual heat of the WAAM process triggers recrystallisation in earlier layers and removes those defects[1].

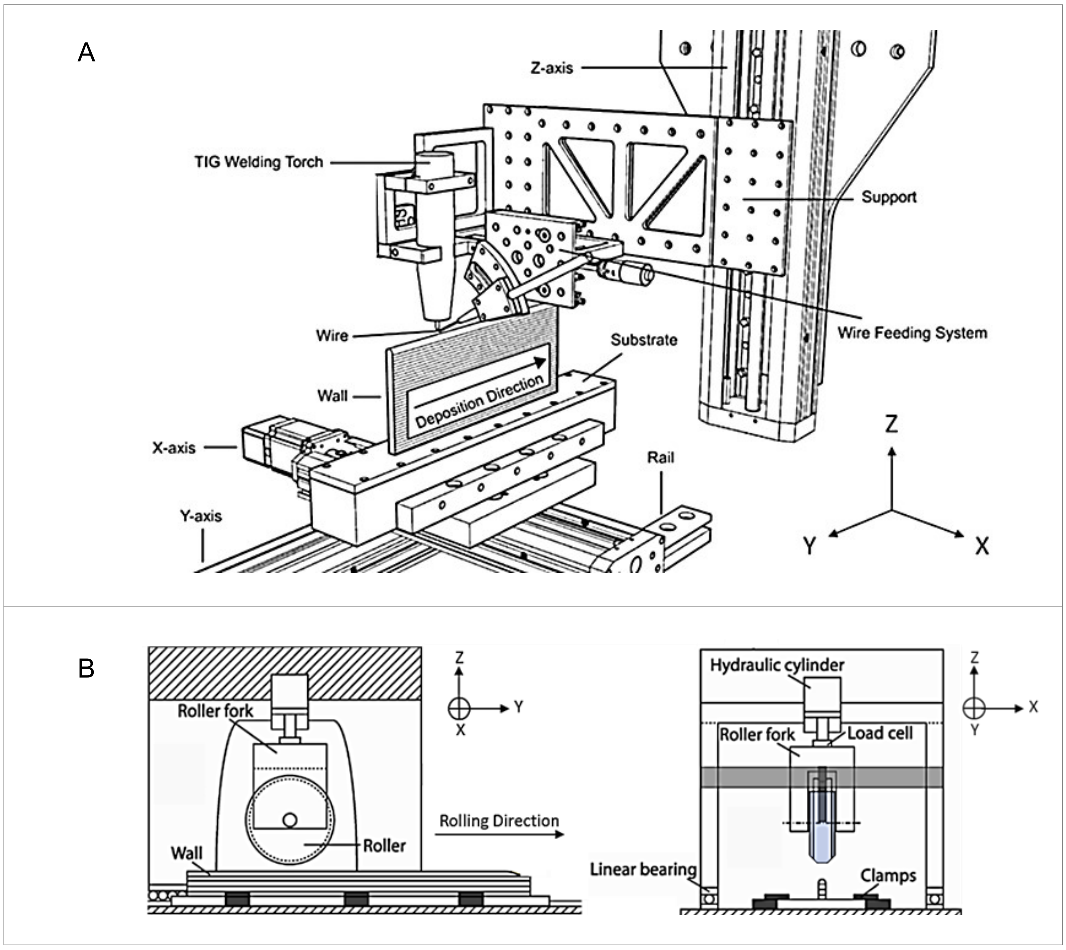


Figure 9: Schematics of A) the WAAM set-up used for the refractories development; and B) the rolling set-up used for the rolling of the unalloyed tantalum

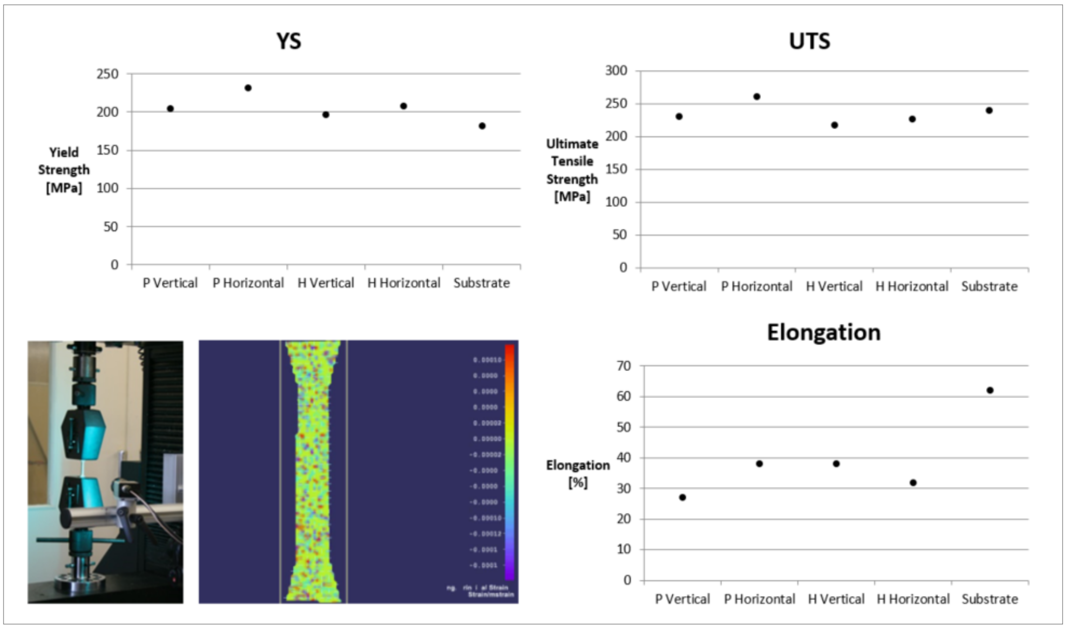


Figure 10: Yield strength, ultimate tensile strength and elongation of WAAM tantalum test sample

1 - A video of this process can be found on the website of Cranfield University at https://waammat.com/about/materials-and-properties

Figure 11 shows an example of a wall of unalloyed tantalum made using WAAM. The lower 15 layers were not rolled and show columnar grains with a ratio of approximately 1:10. From the sixteenth layer onwards cold rolling took place and the recrystallisation process refined the microstructure to produce equiaxed grains with an average size of 650 µm, although some deformation took place on the sides of the wall. This process is not yet fully optimised but shows great potential.

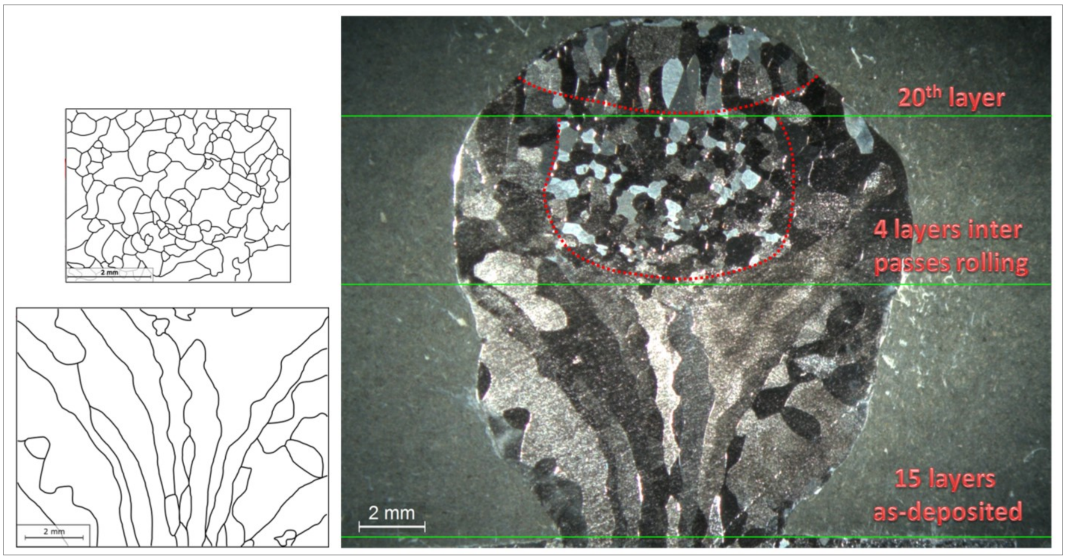


Figure 11: A WAAM structure of unalloyed tantalum showing crystal structure and layers

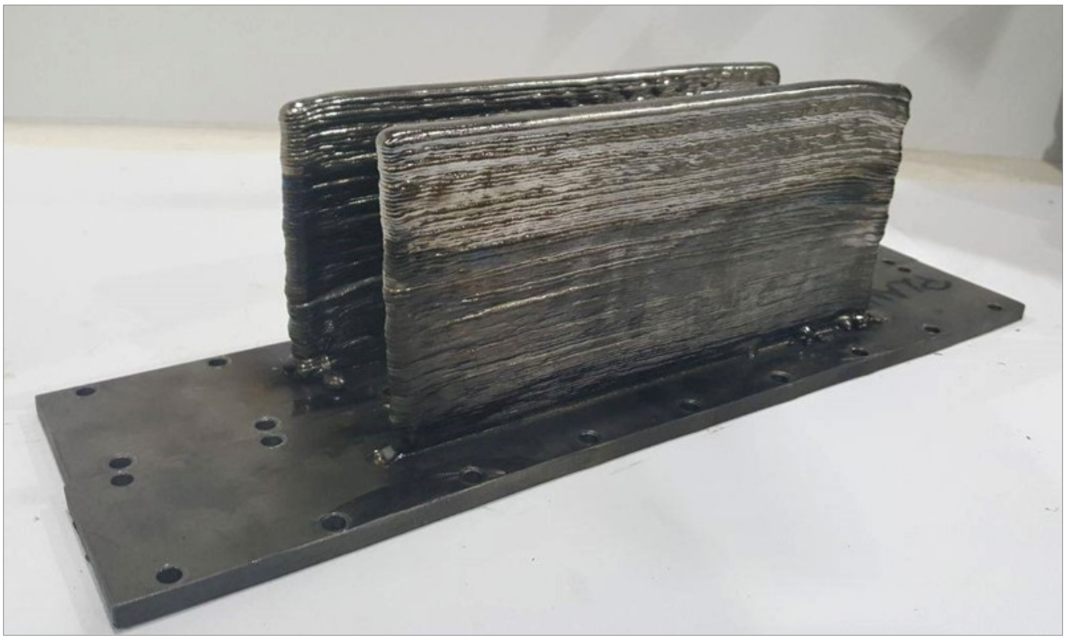


Figure 12: Two WAAM structures of unalloyed tantalum

Functionally graded structure molybdenum to tungsten

Figure 13 shows a multi-metal structure made out of tantalum, molybdenum and tungsten produced using WAAM. The structure has been deposited within the same build starting from an unalloyed tantalum substrate and depositing firstly molybdenum wire and secondly tungsten wire.

A functionally graded structure was obtained with a smooth gradient in both elemental composition and Vickers hardness that proves the feasibility of this approach, as well as the good metallurgical bond between the metals.

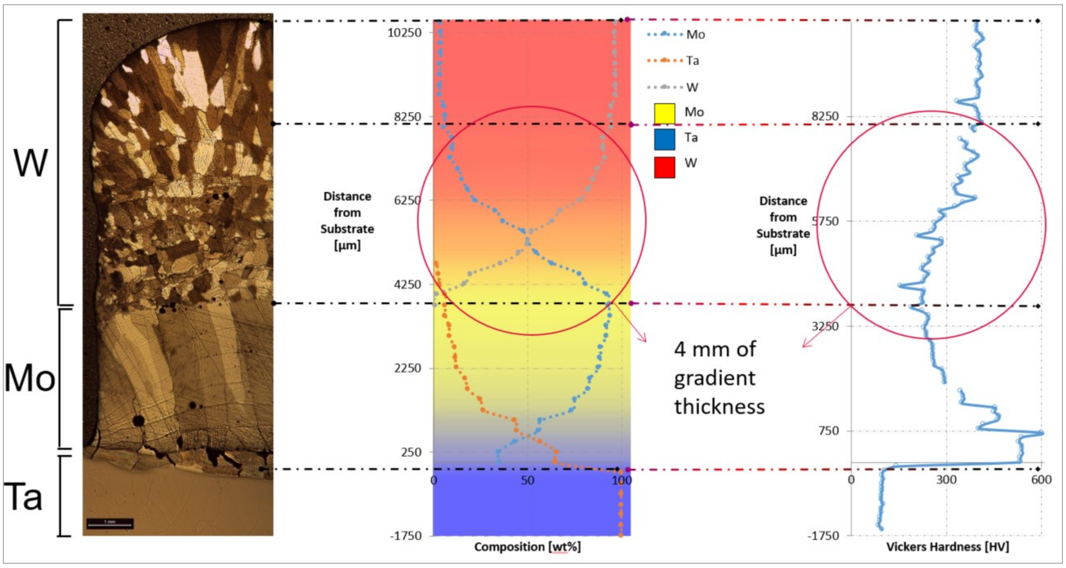


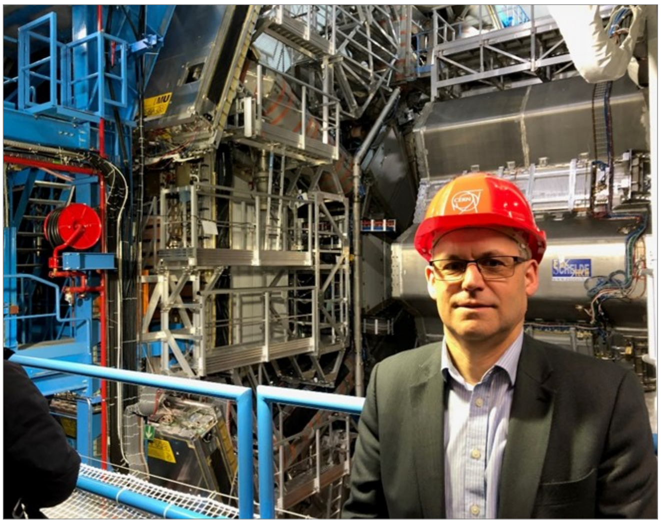
Figure 13: Functionally graded structure molybdenum to tungsten on a tantalum substrate

Conclusion

In the relatively short time this project has been operating it has demonstrated that WAAM is not only able to manufacture solid large-scale structures in refractory metals by fusion, but it is also able to create functionally graded structures is a controlled way too. Despite substrates suffering from high deformation or even cracking, the as-deposited structures are free from internal cracks, and the layer's geometry is stable during the process. Furthermore, WAAM can control the evolution of the microstructure by monitoring the thermal cycles during deposition, and the process is able to improve and manipulate the mechanical properties using in-situ cold work. WAAM has shown the potential to produce refractory metal components with relatively low cost, exploiting the freedom of 3D printing and the opportunity of obtaining engineered properties, offering a solid alternative manufacturing route to powder metallurgy. Initial results suggest WAAM has the potential to achieve significant cost saving in certain applications of refractory metals, similarly to what is proven for other alloy systems based on titanium, aluminium, iron and nickel. For further technical information visit www.waammat.com.

Niobium superconductors behind the science at CERN

On a recent visit to the ATLAS Detector at CERN in Switzerland (www.home.cern), Richard Wrigley, Managing Director at Beta Technology, had the opportunity to learn more about CERN's ATTRACT programme (www.attract-eu.org) and see where niobium's superconducting properties are used in niobium-titanium (NbTi) wires that form the coils of the magnets.



Beta Technology's Richard Wrigley in front of the ATLAS detector at CERN (photo: Beta Technology)

Currently magnetic fields in the Large Hadron Collider (LHC) are able to reach levels of 9-10 Tesla, but there are plans to increase this to above 10 Tesla by using a niobium-tin (Nb_3Sn) compound in the upgraded High Luminosity LHC (HL-LHC).

The ATTRACT programme is to help translate new technologies in the area of high-performance detector and imaging from the CERN activity into commercial opportunities, and is open to researchers and business to collaborate to find new applications for the technology. Beta Technology (www.betatechnology.co.uk) works for industry and universities to translate technology innovations into new products. For many years Beta has supported the niobium development programme of the world's largest niobium producer, CBMM (www.cbmm.com.br), including through the annual Charles Hatchett Award (see Bulletin #170 and #171, www.charles-hatchett.com).

Tantalum and niobium intellectual property update

Historically the T.I.C. reported those patents and papers that were relevant to the tantalum and niobium industries (2000-2007, available in the members' area at www.TaNb.org). Information here is taken from the European Patent Office (www.epo.org) and similar institutions. Patents listed here were chosen because they mention "tantalum" and/or "niobium". Some may be more relevant than others due to the practice by those filing patents of listing potential substitute materials. Note that European patent applications that are published with a search report are 'A1', while those without a search report are 'A2'. When a patent is granted, it is published as a B document. Disclaimer: This document is for general information only and no liability whatsoever is accepted. The T.I.C. makes no claim as to the accuracy or completeness of the information contained here.

Title		
Publication #	Applicant(s)	Publication date

TANTALUM

Title / Publication #	Applicant(s)	Publication date
Method for manufacturing tantalum powder		
KR101794626 (B1)	RESEARCH INSTITUTE OF INDUSTRIAL SCIENCE & TECH [KR]	2017-12-01
Tantalum based alloy that is resistant to aqueous corrosion		
EP3266892 (A1)	STARCK H C INC [US]	2018-01-10
Tantalum sputtering target and production method therefor		
KR20180014869 (A)	JX NIPPON MINING & METALS CORP [JP]	2018-02-09
Electrolytic capacitor and method for improved electrolytic capacitor anodes		
WO2018031943 (A1)	COMPOSITE MATERIALS TECH INC [US]	2018-02-15
Process for producing crystalline tantalum oxide particles		
US2018044199 (A1)	BASF SE [DE]	2018-02-15
Process for manufacturing agglomerated particles of tantalum, mixed tantalum powder and process...		
US2018047516 (A1)	GLOBAL ADVANCED METALS USA INC [US]	2018-02-15
Processes for extracting and recovering tantalum present in an acid aqueous phase by means of an ionic liquid…		
AU2016305269 (A1)	CNRS, UNIV MONTPELLIER, UNIV DE CHAMBERY, ENSCM, TND	2018-02-22
Tantalum sputtering target and method for producing same		
IL237919 (A)	JX NIPPON MINING & METALS CORP [JP]	2018-02-28
Coating for an implant		
WO2018036843 (A1)	LINK WALDEMAR GMBH CO [DE]	2018-03-01
Sintered heat-resistance material		
RU2647051 (C1)	SHCHEPOCHKINA YULIYA ALEKSEEVNA [RU]	2018-03-13
Method for recovering tantalum metal from electrolytic capacitors		
WO2018046786 (A1)	CSIC [ES], WEEE INT RECYCLING S L [ES]	2018-03-15
Method of making a tantalum sputter target and sputter targets made thereby		
US2018080120 (A1)	TOSOH SMD INC [US]	2018-03-22

NIOBIUM

Title / Publication #	Applicant(s)	Publication date
Systems and methods for fabrication of superconducting integrated circuits		
US2018033944 (A1)	D-WAVE SYSTEMS INC [CA]	2018-02-01
Fabrication method of strontium niobium oxynitride film having small carrier density and its use		
US2018030602 (A1)	PANASONIC CORP [JP]	2018-02-01
Method for producing wear-resistant coating for cutting tool		
RU2643740 (C1)	ULYANOVSKY STATE UNIVERSITY [RU]	2018-02-05
Substrate with transparent conductive layer, liquid crystal panel and method for producing substrate…		
WO2018029886 (A1)	ULVAC INC [JP]	2018-02-15
Aluminum-titanium-vanadium-zirconium-niobium alloy composition for high temperature applications		
US2018051361 (A1)	BOEING CO [US]	2018-02-22
Method for production of hot galvanised roll stock for cold die forming		
RU2645622 (C1)	PAO SEVERSTAL [RU]	2018-02-26
Process for producing tantalum or niobium arsenide single crystals		
MD4552 (B1)	INST DE FIZIC APLICAT AL ACADEMIEI DE STIINTE A MOLDOVEI [MD]	2018-02-28
Case-hardenable stainless steel alloy		
US2018073113 (A1)	AB SKF [SE], SKF AEROSPACE FRANCE SAS [FR]	2018-03-15
High strength special steel		
US2018073114 (A1)	HYUNDAI MOTOR CO LTD [KR]	2018-03-15
Superconducting device and method of manufacturing a superconducting device		
AU2016313944 (A1)	ROYAL HOLLOWAY AND BEDFORD NEW COLLEGE	2018-03-22

Member company and T.I.C. updates

Changes in member contact details

Since the last edition of this newsletter the following changes have been made to delegate contact details:

- The delegate at **Better Sourcing Program (BSP)** has changed from Mr Benjamin Clair to Mr Ferdinand Maubrey. He can be contacted on ferdinand@bsp-assurance.com. The mailing address has not changed but the website is now https://bettersourcing.io/.
- **Jiujiang Nonferrous Metals Smelting Corp. Ltd** has changed its name to **Jiujiang Tanbre Co. Ltd**. The delegate has changed from Mr Guo Yongzhong to Mr Cen Duanguo, who can be contacted at cenduanguo@jjtanbre.com.cn.
- The email for the delegate at **KEMET Electronics Corp.**, Dr Daniel Persico, has changed to danielpersico@kemet.com.

Diary of forthcoming events attended by T.I.C. staff

- MMTA's International Minor Metals Conference in Montreal, Canada, April 11th to 13th
- OECD-ICGLR-UN's 12th Forum on Responsible Mineral Supply Chains in Paris, France, April 17th to 19th
- RAPID + TCT in Fort Worth, TX, USA, April 23rd to 26th
- IAEA's 36th TRANSSC meeting in Vienna, Austria, June 4th to 8th
- London Metals Week 2018 in London, UK, October 8th to 10th
- **T.I.C.'s 59th General Assembly in Kigali, Rwanda, October 14th to 17th**
- RMI's Annual Conference in Santa Clara, CA, USA, October 31st to November 1st

Members of the Executive Committee of the T.I.C. 2017-2018

The Executive Committee is drawn from the membership and committee members may be, but need not also be, the delegates to the T.I.C. of member companies. The current Executive Committee was approved by the T.I.C. members at the Fifty-eighth General Assembly and consists of (alphabetical by surname):

Conor Broughton	conor@amgroup.uk.com
John Crawley (President)	jcrawley@rmmc.com.hk
David Gussack	david@exotech.com
Jiang Bin	jiangb_nniec@otic.com.cn
Janny Jiang	jiujiang_jx@yahoo.com
Kokoro Katayama	kokoro@raremetal.co.jp
Raveentiran Krishnan	raveentiran@msmelt.com
Ben Mwangachuchu	bmwangaceo@smb-sarl.com
Candida Owens	owens.candida@cronimet.ch
Daniel Persico	danielpersico@kemet.com
Alexey Tsorayev	tsorayevaa@ulba.kz

Of these eleven, Mr John Crawley was elected President of the T.I.C. until October 2018.

The T.I.C. currently has the following subteams (chaired by): Marketing (Daniel Persico), Meetings (Candida Owens), Statistics (Alexey Tsorayev) and Supply Chain (John Crawley).

We are always looking for enthusiastic T.I.C. members to join the Executive Committee or one of our subteams. If you are interested in doing so and have a couple of hours each month spare, please contact director@tanb.org.

The Anders Gustaf Ekeberg Tantalum Prize

CALL FOR PUBLICATIONS

About the Anders Gustaf Ekeberg Tantalum Prize:

The Prize is named after the discoverer of tantalum and will be awarded to the lead author(s) of the published paper or patent that is judged by an independent panel of experts to have made the greatest contribution to understanding the processing, properties or applications of tantalum. It is open to any published paper or patent that is judged to advance knowledge and understanding of tantalum.

Eligible publications

To be eligible for consideration the publication must be in English and be made between 24 and 6 months before the award ceremony at a T.I.C. General Assembly. Therefore, to be eligible for the October 2018 Prize, a publication must be dated between October 2016 and April 2018.

How publications will be judged

The T.I.C. is secretariat to the Prize and will create a shortlist of eligible publications for consideration by the independent panel of experts (see pages 4 to 6). The panel of experts will vote on the winner.

Suitable subjects may include, but are not limited to:

- Processing of tantalum minerals, synthetic concentrates or other raw materials
- Tantalum used in capacitors or other electronic applications
- Tantalum metallurgy and mill products, including alloys
- The use of tantalum powder in additive manufacturing (3D printing) as pure metal or in an alloy
- Medical (including dental) applications of tantalum
- Recycling of tantalum-bearing scrap
- Innovative new applications for tantalum

How to submit a publication

To submit or recommend a publication for consideration for the 2018 Award, please contact the T.I.C. office at info@tanb.org or any member of the T.I.C. Executive Committee (see page 23) by May 31st 2018. Papers may be submitted by e-mail attachment, or by regular mail.

The prizegiving ceremony

The initial Prize will be awarded at the 59th General Assembly in Kigali, Rwanda, in October 2018. For further information please contact the T.I.C. office. TIC