TIC
TANTALUM-NIOBIUM
INTERNATIONAL STUDY CENTER
Bulletin N° 176: January 2019

Tantalum and niobium global trade statistics

(see page 8)

Contents

To join the Bulletin mailing list email info@tanb.org

ISSN 1019-2026

Image: Shutterstock / Punch Retouching

President's Letter

Dear Fellow Members,

As we enter the new year, we can hope, and expect, that many of the world events that have raised concerns for our membership's businesses in 2018 will be resolved in 2019. We are hopeful that 2019 will bring a more favorable and stable environment, in which our industries can operate. Regardless of external factors, the T.I.C. encourages its membership to do everything possible, within our organization, and our members' businesses, to build the reputation of the tantalum and niobium industry.

In December 2018 the world's two largest economies widely announced that there would be a halt on new tariffs, in the contentious trade relationship re-negotiation that is occurring between them. This, and the prospect of some ultimate resolution, hopefully this year, will be welcome news for our many members who supply to, or purchase material from the United States and/or China and who have been negatively affected by the tit for tat duties each country has imposed on the other.

On January 8th it was announced that Felix Tshisekedi was the winner of the Democratic Republic of the Congo's (DRC) elections. These results were supported by President Kabila, leading to the prospect of the first peaceful transition of power in the DRC's history. There have been questions raised, and an appeal to the Supreme court, however, at time of writing it appears likely that Mr Tshisekedi will lead a unity government with international recognition. A peaceful transition of power in central Africa's largest and most populous country will be welcome news to all involved, including those that work in our industry, and those that depend on this region as an important source of supply.

The Executive Committee meeting during the 59th General Assembly (photo: T.I.C.)

At the 59th General Assembly several questions were raised about the cost of compliance, and the fairness of these costs, which are borne in part by some of those least able to afford them. The T.I.C. has long supported the most rigorous compliance. We feel our position has been vindicated by the fact that nations subject to the most detailed and rigorous compliance make up the majority of our industry's tantalum supply. Members are reminded of their obligation in our ASM Code of Conduct to implement and comply with the best available due diligence. It is never acceptable to use cost as a pretext to leave a due diligence program, while serious incident reports are unresolved.

Within the T.I.C., many of our members' concerns about holding the event in central Africa seem to have been resolved with the success of the 59th General Assembly. The Kigali event produced record breaking results, as measured by financial metrics and seems to have been universally well received and enjoyed.

As we review the often chaotic world events in 2018, and note much was out of our control, we can assure you that Roland, Emma, and David will work hard on those aspects that are within our Association's prevue in 2019, to promote and progress the industry. We hope that all of our members will agree with the direction the T.I.C. is taking, and together we will build towards progressing our industries' reputation and development in 2019, with a little help from what, I hope, prove to be less tumultuous external factors.

Sincerely yours,

John Crawley, President

Do you speak Chinese, have marketing experience, and seek a new opportunity?

The T.I.C. is hoping to hire an additional member of staff ahead of the T.I.C.'s 60th General Assembly in Hong Kong. The ideal candidate would be able to help promote and expand the T.I.C.'s activities (especially the 60th General Assembly) and better connect with our Chinese members and stakeholders. For more information please contact **director@tanb.org**.

Director's Letter

London, UK

Dear T.I.C. Members,

It was a great pleasure to meet so many of you in person at the 59th General Assembly in Rwanda recently. I'm especially grateful to those of you who took the time to share your thoughts about this Association and what you see as the challenges faced by the tantalum and niobium industries in the coming year.

The event in Rwanda was a great success and has raised the bar for future tantalum-niobium events. Conferences are always team efforts with many partners involved, but particular thanks must go to Emma Wickens, T.I.C. Secretary General, the Meetings Subteam led by Candida Owens, our hosts, the Rwandan Government and the Rwanda Mining Association, and the team at Cronimet Central Africa / Minerals Supply Africa led by Julija Komarovic, especially Yvette Iyadede who provided essential local coordination and more than once raced across town to fix a supply contract on our behalf.

Delegates visiting H&B Mining Company, Rwanda, as part of the 59th General Assembly (photo: T.I.C.)

During our annual general meeting (AGM) in Kigali, members welcomed eight new corporate members and one new associate member (see page 4 for details). Our thanks to our sponsors Cronimet Central Africa (gold), Jiujiang Zhongao Tantalum & Niobium Co. Ltd (silver), and Krome Commodities (Welcome Reception).

This year our light-hearted vote to decide which presentations delegates had found most technical and most entertaining produced a lot of feedback, underlining the high quality of the plenary sessions. Once voting was complete the winning presentations were:

- Most technical: **Technology research on preparation of a new type texture on the tantalum blank**, written by Li Zhao-Bo, Ningxia Orient Tantalum Industry Co. Ltd (OTIC) and presented by his colleague Jiang Bin.
- Most entertaining: **Supply chain stability, corporate social responsibility and the ceramic capacitor (MLCC) shortage: a "perfect storm" for tantalum**, written and presented by Per-Olof Loof, KEMET Electronics Corporation

Their prize will be a copy of "The Elements" by Theodore Gray, a stunning illustrated guide to the periodic table. Members are reminded that the presentations from this General Assembly including the statistics review featured in this journal are available to download in the members' section at www.TaNb.org, under the "MEDIA" tab.

If you are interested in giving a presentation at the 60th General Assembly in October 2019 please contact Emma Wickens at info@tanb.org to receive an abstract submission form before the end of March.

Best wishes,

Roland Chavasse, Director

Fifty-ninth General Assembly and 2018 AGM report

The Fifty-ninth General Assembly, including the 2018 annual general meeting (AGM), was held on October 14th - 17th 2018, at the Marriott Hotel in Kigali, Rwanda. The event was attended by leading tantalum and niobium participants from around the world and was generously sponsored by Cronimet Central Africa (gold), Jiujiang Zhongao Tantalum & Niobium Co. Ltd (silver), and Krome Commodities Ltd (Welcome Reception).

During the AGM on October 15th members passed motions including:

- Minutes from the 2017 AGM
- 8 corporate and 1 associate membership applications
- The budget for 2019 financial year. Note that the annual membership subscription has been frozen until December 2019.

All documents pertaining to the General Assembly and AGM, together with the presentations and photos from the event, are currently available on the members' area of the Association's website or from the T.I.C. office.

Executive Committee elections

During the meeting Mr Conor Broughton (A&M Minerals and Metals Ltd) stepped down from the Executive Committee. In the subsequent elections the other ten committee members were re-elected and Mr Fabiano Costa (Advanced Metallurgical Group N.V. (AMG)) and Ms Silvana Fehling (H.C. Starck Tantalum & Niobium GmbH) were elected. Of these twelve, Mr John Crawley was re-elected President for a second consecutive year. The next AGM and elections will take place on October 14th 2019, during our 60th General Assembly in Hong Kong. The T.I.C. asks that Executive Committee members serve as individuals, not in their corporate roles.

The Executive Committee 2018/19 is (alphabetical by surname):

Fabiano Costa	fcosta@amgmineracao.com.br
John Crawley (President)	jcrawley@rmmc.com.hk
Silvana Fehling	silvana.fehling@hcstarck.com
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

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 a subteam. If you are interested please contact info@tanb.org.

New members

At the AGM eight new corporate members and one new associate member were elected.

Corporate membership of the T.I.C. is open to organisations actively involved in any aspect of the niobium and tantalum industries, from explorers to miners, traders and processors, through to end users and suppliers of goods and services to the industry.

Associate membership is available to organisations that are not commercially involved in our industries, such as academia, associations, government bodies and civil society.

The new corporate members are:

Australian Strategic Materials Ltd (ASM)

Address: 89 Burswood Road, Burswood, WA 6100, Australia
Website: www.alkane.com.au
Delegate: Mr Alister MacDonald
Email: amacdonald@alkane.com.au

Jiujiang Fuxing Tai Trade Co. Ltd

Address: Room 1002, building A, North Area, Lu Feng Xiao Qu, Jiujiang, Jiangxi, China
Website: -
Delegate: Ms Shen Shan (Susan Shen)
Email: jiujiangfuxingtai@163.com

GGV Holding

Address: Christaki Cranou 1, Germasogeia, 4047, Limassol, Cyprus
Website: http://mine.ficom-it.info/
Delegate: Mr Dmitry Skripnik
Email: skrashetrash@gmail.com

RC Inspection Metals B.V.

Address: Gustoweg 66, 3029 AS Rotterdam, The Netherlands
Website: www.rc-inspection.com
Delegate: Mr Ben Bender
Email: info@rc-inspection.com

H.C. Starck Inc. / Fabricated Products

Address: 45 Industrial Place, Newton, MA 02461, United States
Website: www.hcstarck.com
Delegate: Mr Mark Smolinsky
Email: mark.smolinsky@hcstarck.com

SAMWOOD NEO Inc.

Address: 3F, No.3 Hayakawa Bldg., 2-2, Kandatacho, Chiyoda-ku, Tokyo, Japan
Website: -
Delegate: Mr Masakazu Satomi
Email: neo@samwood.co.jp

Halcyon Inc.

Address: Mazaya Business Avenue AA1, Level 41, Jumeirah Lake Towers Embankment, P.O. Box 214745, Dubai
Website: www.halcyonmetals.com
Delegate: Mr David Craik
Email: admin@halcyonmetals.com

United Spectrometer Technologies Pty LTD

Address: 38 Cincaut Street, Blackheath, Cape Town, 7580, South Africa
Website: www.us-tech.co.za
Delegate: Mr Ingo Steinhage
Email: info@ustech.co.za

The new associate member is:

Rwanda Mines, Petroleum and Gas Board (RMB)

Address: KN 4 Ave, Kigali, Rwanda
Website: www.rmb.gov.rw
Delegate: Mr Francis Gatare
Email: fgatare@gov.rw

A selection of photos from the Fifty-ninth General Assembly

The Welcome Reception was sponsored by Krome Commodities Ltd.

A selection of photos from the Fifty-ninth General Assembly (continued)

Above: The 59th General Assembly was opened by the guest of honour, His Excellency Claver Gatete, Minister of Infrastructure in the Rwandan cabinet (left). Mr Francis Gatare, CEO of Rwanda Mines, Petroleum and Gas Board (RMB) talks to the press after the opening plenary session (right).

Clockwise from top left: Ambassador Ambeyi Ligabo (ICGLR), Ken Brinsden (Pilbara Minerals Ltd), delegates attending presentations, Jean Malic Kalima (Rwanda Mining Association) and Maggie Lee (Asian Metal Ltd).

Right: The prize-giving ceremony for the 2018 Anders Gustaf Ekeberg Tantalum Prize.

The President of the T.I.C., John Crawley, congratulates the winner, Dr Yuri Freeman, of KEMET Electronics, for his book 'Tantalum and Niobium-Based Capacitors'.

Far right: The medal for the Anders Gustaf Ekeberg Tantalum Prize was manufactured by the Kazakhstan Mint from 100% pure tantalum metal supplied by T.I.C. member company Ulba Metallurgical Plant JSC.

Right and below: The superb dancers of Inganzo Ngari enthralled delegates during the Gala Dinner, showing the iconic features of Rwandan traditional folkloric performances.

Below: Following the plenary sessions of the General Assembly many delegates joined a field trip to H&B Mining Company, a cassiterite and tantalite mine located near Kigali. A big “Murakoze” (“Thank you” in Kinyarwanda) to our hosts, Mr Jean Bosco Hakizimana and Minerals Supply Africa for facilitating such a fascinating visit.

All photos are © T.I.C. 2018 and many more are available at www.TaNb.org.

Sponsorship opportunities at the Sixtieth General Assembly

Sponsorship puts your company in front of the global leaders in tantalum and niobium in a targeted and cost-effective way.

A range of opportunities are available on a first-come, first-served basis, so please contact us early to avoid disappointment: director@tanb.org for details.

T.I.C. yearly statistics presentation with augmented trade statistics

Paper written by David Knudson, T.I.C. Technical Officer, and presented by Mr Knudson on October 15th 2018, as part of the Fifty-ninth General Assembly. Additional input and leadership regarding international trade data was provided by the T.I.C. Statistics Subteam chaired by Mr Alexey Tsorayev. The T.I.C. makes no claim as to the accuracy or completeness of these statistics and no liability whatsoever is accepted by the T.I.C. in connection with these statistics.

Introduction

Tantalum and niobium statistics are a core purpose of the T.I.C. and for over forty years the Association has been gathering and sharing statistical data with its members (as mandated by article 3.2 of our Charter). Each quarter, T.I.C. member companies submit their data and, in return, receive an updated report. Annual summaries of this information are shared with non-members at our General Assemblies and in our Bulletin newsletters.

The process has seen several iterations over the years as members' requirements and the markets have developed and changed, but until recently the source data was supplied entirely by members.

Following extensive consultation with T.I.C. member companies throughout 2017 the Statistics Subteam reworked the statistics service, with the key change being that members' data began to be augmented with international trade data to provide a broader and clearer understanding of the market. Initial feedback from members about the improved reports has been very positive and we look forward to improving them further in the future.

This paper provides a comprehensive report on members' data for calendar years 2009 through 2017 and discusses the opportunities that are made possible by incorporating publicly available international trade data to the traditional report. Note that members' data from previous years is available in Bulletin #164 (January 2016).

Miller Roskell Limited
Chartered Certified Accountants

Members' data is collected by Miller Roskell Ltd, a fully independent accountant.

Data sources and interpretation

Historically, members' data was the only source of data used in T.I.C. statistics and it continues to form the foundations of this service. Members' data is collected by an independent third party, Miller Roskell Ltd, a 100% independent chartered certified accountant that has collected members' statistics since 2015. Members' trade data is only seen by Miller Roskell Ltd and members report high confidence that their data is handled confidentially. T.I.C. staff have no access to an individual member's data, only the aggregate totals and international trade data.

The T.I.C. statistics service, based on members' quarterly data, has provided a useful guide to trends in the industry for many years. However, times change and in early 2018 we revealed the results of a long-term plan: using international trade data to augment members' data. This major initiative has been in development since early 2016 and the new report provides members with far greater understanding of international tantalum and niobium markets, and therefore more value.

In 2017 the total number of T.I.C. members reporting in each data category was:

Data Set Groups (2017)	Reporting members	Metric tonnes of
Nb raw materials: mining production and trading receipts	34	Nb_2O_5
Nb product shipments by processors	43	Nb contained
Ta raw materials: mining production and trading receipts	33	Ta_2O_5
Ta receipts by processors	41	Ta_2O_5
Ta product shipments by processors	41	Ta contained

Table 1: 2017 reporting members by category

Augmenting members' data with international trade data

The T.I.C. purchases international trade data from Global Trade Tracker (GTT) and uses it to complete occasional gaps in members' reporting, generate additional charts and as an analytical tool to provide deeper meaning for members.

All physical international trade is recorded according to categories that are defined by the Harmonized System (HS) set out by the World Customs Organization (WCO). Almost all countries in the world participate in this system and use the HS codes to determine their tariff schedules. This system generates a vast quantity of data but with careful and intelligent analysis a great deal of value can be found.

In the global tantalum and niobium market cross-border shipments provide data for analysis (photo: shutterstock)

Additional data sources are used to add additional depth and verify primary data whenever possible. In 2018 the primary data sources for T.I.C. statistics reports were member companies and Global Trade Tracker (GTT), but additional sources of international trade data studied by the Association included, but were not limited to:

* Companies' annual reports, press releases and other publications
* National governments in Australia, Brazil, China, DRC, Ethiopia, Japan, Kazakhstan, Malaysia, Russia, Rwanda and Thailand
* National geological institutes: France (BRGM), Germany (BGR), UK (BGS), USA (USGS)
* International institutions: European Union, UN Comtrade Database, Worldbank, World Trade Organization

Some notes on the use of international trade data to augment T.I.C.'s tantalum and niobium statistics

It is essential to all statistics reports that the data can be defended. This means that the data can be verified as publicly available trade statistics, the method of collection is documented, and second sources are used and cited when possible.

In this report, international trade data may be added to, or replace, T.I.C. members' data, but does not duplicate members' data, several new reporting categories have been generated using only international trade data, and all years are 12-month calendar years unless stated otherwise.

Furthermore, when considering international trade data it is important to appreciate that:

- International trade data only records cross-border shipments. Domestic shipments are not recorded.
- Some HS codes cover several products, adding a further challenge to the data analysis process. For example code 261590 includes ores and concentrates of tantalum, niobium and vanadium.
- While some countries add suffixes to the official standard 6-digit HS codes to provide greater detail of their shipments, the additional suffix digits are not internationally standardised and vary from country to country.
- Customs data may not be easily accessible, or data may be presented in different units such as weight or monetary value.

In many cases informed assumptions have to be made as to being gross weight and the average grade, as well as the historical market price, in order to obtain the net weight contained.

Given these and potentially other issues, care must necessarily be applied in using such data. Nevertheless these additional sources of data constitute a potentially useful source of information.

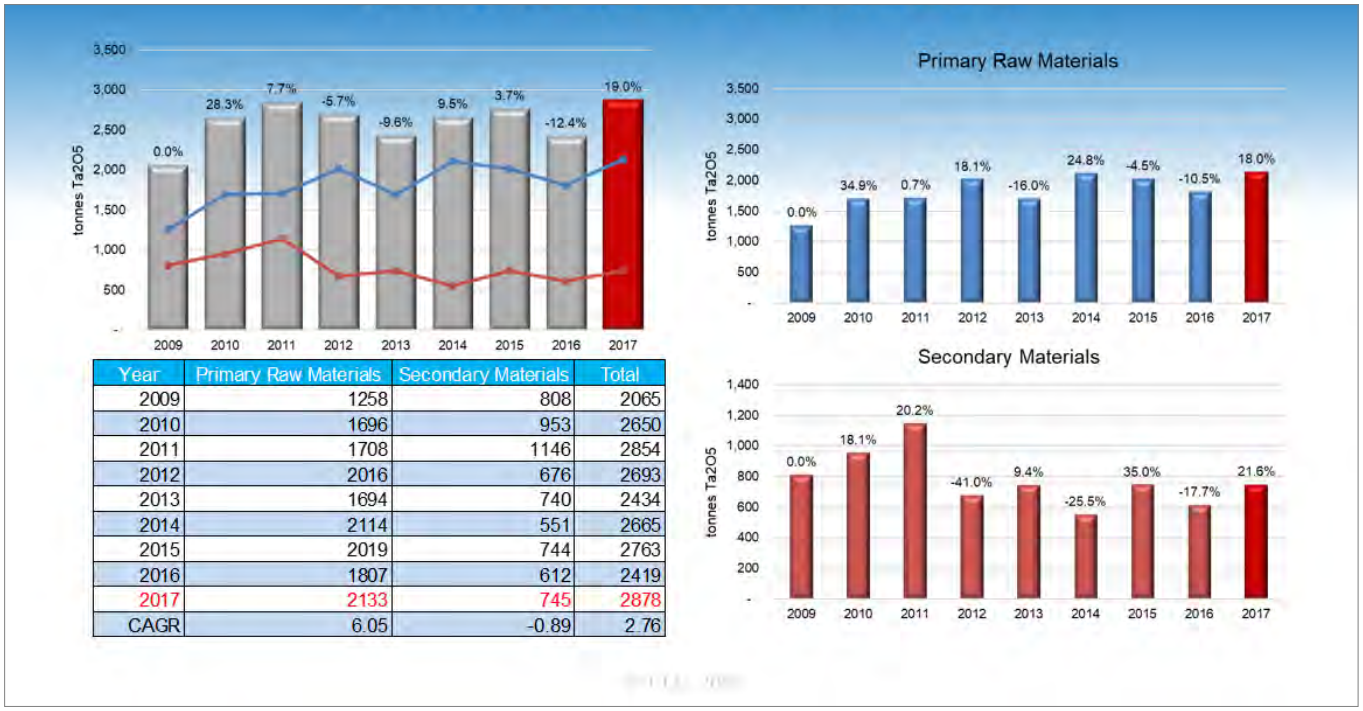
Tantalum: Annual statistics 2009 - 2017

Production of tantalum-bearing raw materials in 2017 was slightly below 2016, making the fourth year in a row of declining production. The significant change from 2016 to 2017 took place in the total tantalum pentoxide (Ta_2O_5) units produced as 'Ta concentrates' by mining and from tin slag. The category of 'other concentrates' registered a 25% increase. However, it is worth noting that this data is contrary to receipts reported by processors (see figure 2) which have seen a significant increase for the same time period.

The compound annual growth rate (CAGR) for the 9-year period in question (determined by the formula ((ending year value/beginning year value)(1/total years)) – 1) of almost 5% indicates a general trend in data in line with growth in global GDP during this period.

Year	Tin Slag	Ta Conc.	Other Conc.	Total
2009	175	226	196	597
2010	342	205	222	769
2011	349	205	163	716
2012	201	359	235	795
2013	211	520	253	983
2014	181	727	332	1240
2015	166	741	240	1148
2016	180	522	245	947
2017	128	475	304	907
CAGR	-3.42	8.62	5.00	4.76

Figure 1: Tantalum raw materials: mining production and trading receipts

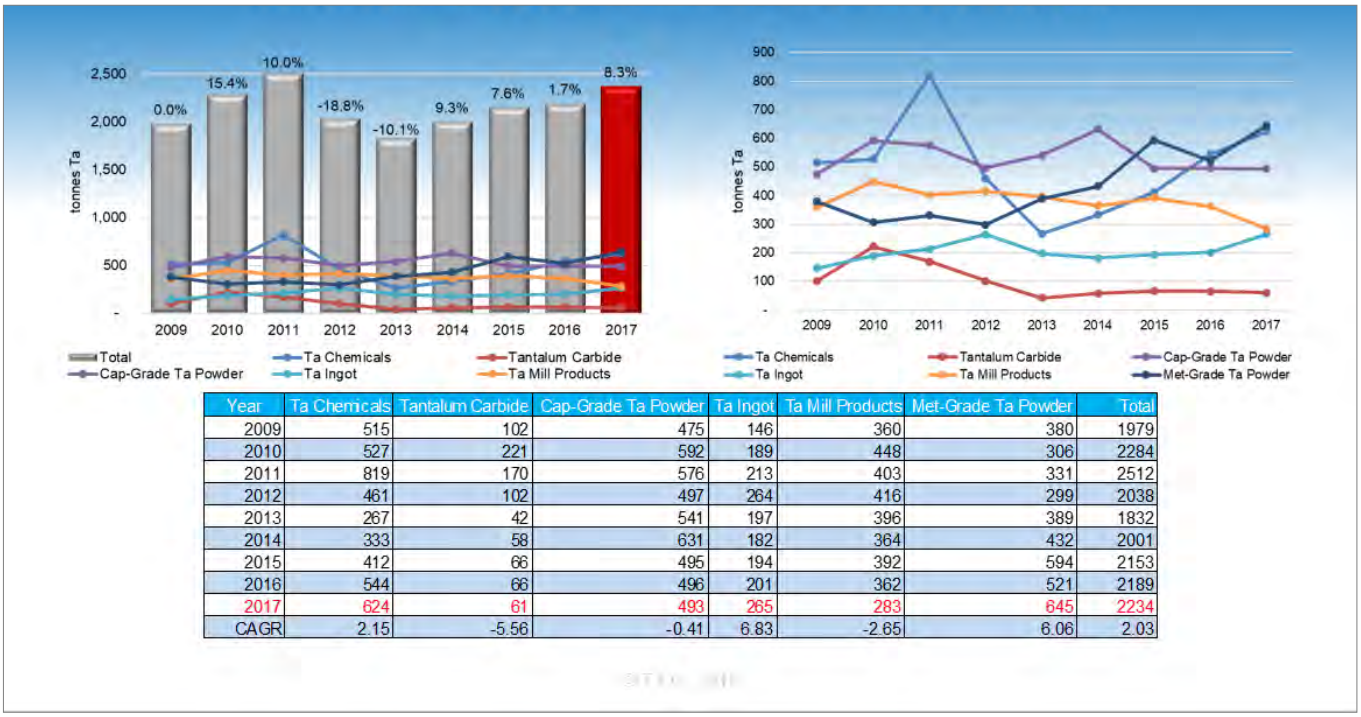


Year	Primary Raw Materials	Secondary Materials	Total
2009	1258	808	2065
2010	1696	953	2650
2011	1708	1146	2854
2012	2016	676	2693
2013	1694	740	2434
2014	2114	551	2665
2015	2019	744	2763
2016	1807	612	2419
2017	2133	745	2878
CAGR	6.05	-0.89	2.76

Figure 2: Tantalum receipts by processors

In 2017 receipts of tantalum pentoxide (Ta_2O_5) by processors enjoyed a total of 19% increase, both in primary and secondary raw materials. The quantities of tantalum receipts reported by processors in 2017 were the highest in the period 2009 - 2017.

While changes to the T.I.C.'s membership have an impact on what members' data is collected, the Association is fortunate in having a broadly stable membership among the processors of tantalum- and niobium-bearing primary and secondary raw materials around the world. The high level of participation from this category of member has contributed significantly to the quality of their statistical data.



Year	Ta Chemicals	Tantalum Carbide	Cap-Grade Ta Powder	Ta Ingot	Ta Mill Products	Met-Grade Ta Powder	Total
2009	515	102	475	146	360	380	1979
2010	527	221	592	189	448	306	2284
2011	819	170	576	213	403	331	2512
2012	461	102	497	264	416	299	2038
2013	267	42	541	197	396	389	1832
2014	333	58	631	182	364	432	2001
2015	412	66	495	194	392	594	2153
2016	544	66	496	201	362	521	2189
2017	624	61	493	265	283	645	2234
CAGR	2.15	-5.56	-0.41	6.83	-2.65	6.06	2.03

Figure 3: Tantalum product shipments by processors (I)

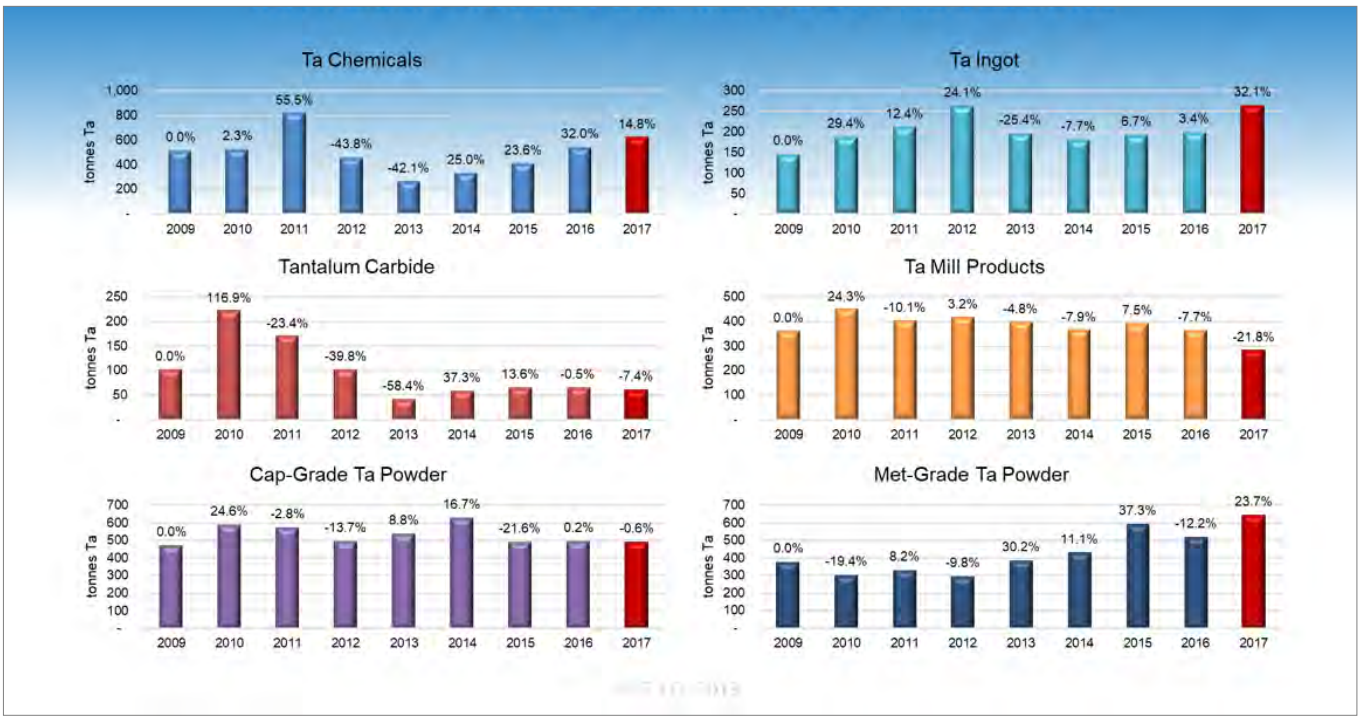


Figure 4: Tantalum product shipments by processors (II)

In 2017 total shipments by processors saw an increase of slightly over 8%. While shipments of ingot, chemicals, and metallurgical-grade ('met-grade') powder recorded growth, capacitor-grade ('cap-grade') powders and carbides remained flat, while mill products registered a drop in shipments of nearly 22%. Overall, the CAGR for the period 2009 - 2017 was 2%, broadly in line with processor receipts during the same period.

A comparison of processors' tantalum receipts and shipments

By normalizing the processor-members' receipts of tantalum-bearing raw materials we can compare the figures to the quantities they shipped (see figure 5). The total difference during the 9-year period is 154 tonnes, a difference of less than 1%. The data was tested to determine if it is normally distributed and relates; a paired t-test (mean) and F-test (variance) are conducted. Both tests indicated the data is normally distributed. A relationship between the paired samples and the dataset (2009 - 2017) can be considered, thereby allowing for trends to be considered, such as a cyclical pattern of stocking and destocking.

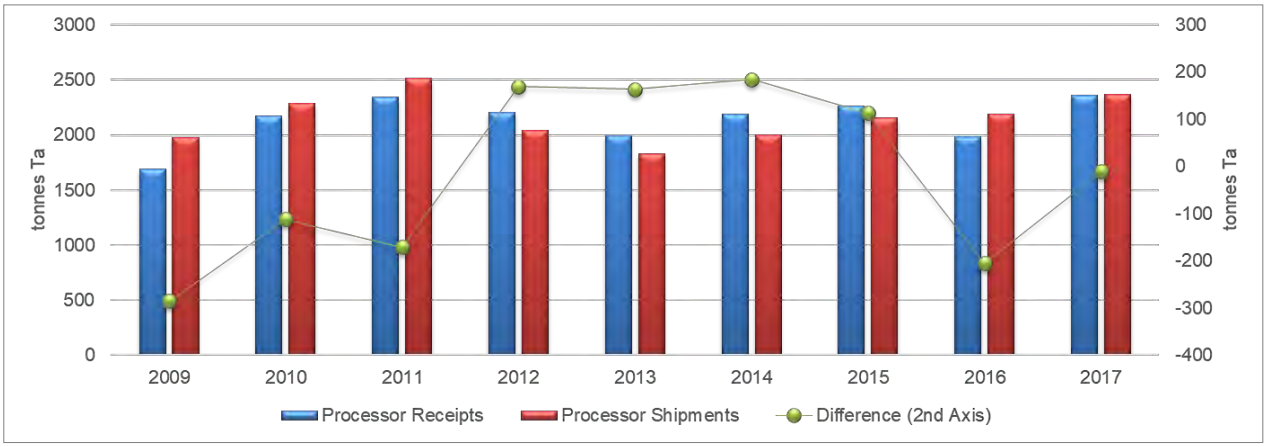


Figure 5: Statistical testing of processors' data

An example of international trade data adding value to members' data

An example of how to report useful data obtained from international trade data is to examine cross-border shipments of tantalum concentrates with >20% Ta_2O_5 content. This grade of tantalum concentrates can be identified by its value per unit volume compared against the value of Ta_2O_5 in ores for the relevant time periods. Using the value an estimation of the Ta_2O_5 percentage can be made. Multiple data sources are used to verify this data.

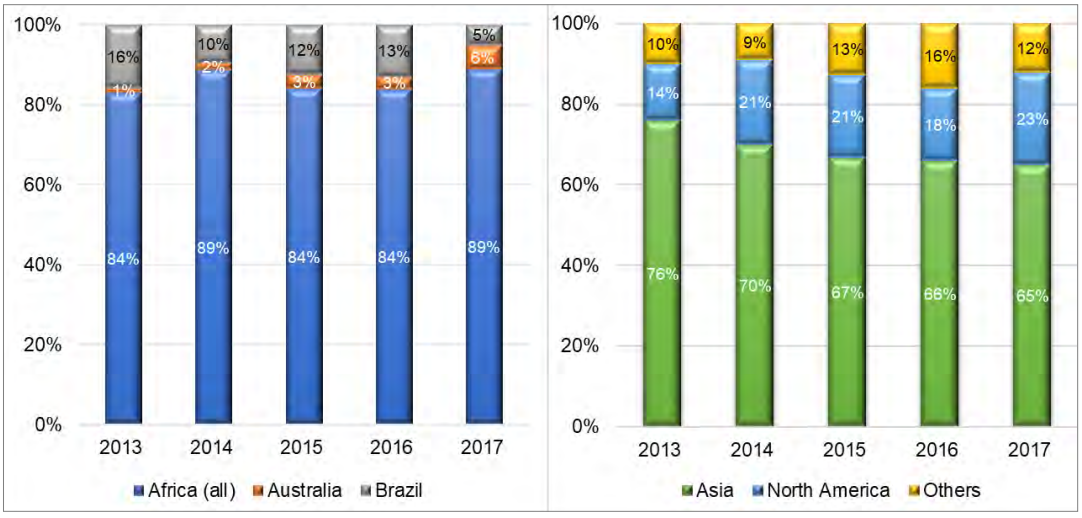


Figure 6: Key exporting (left) and importing (right) regions of tantalum-bearing minerals containing >20% Ta_2O_5

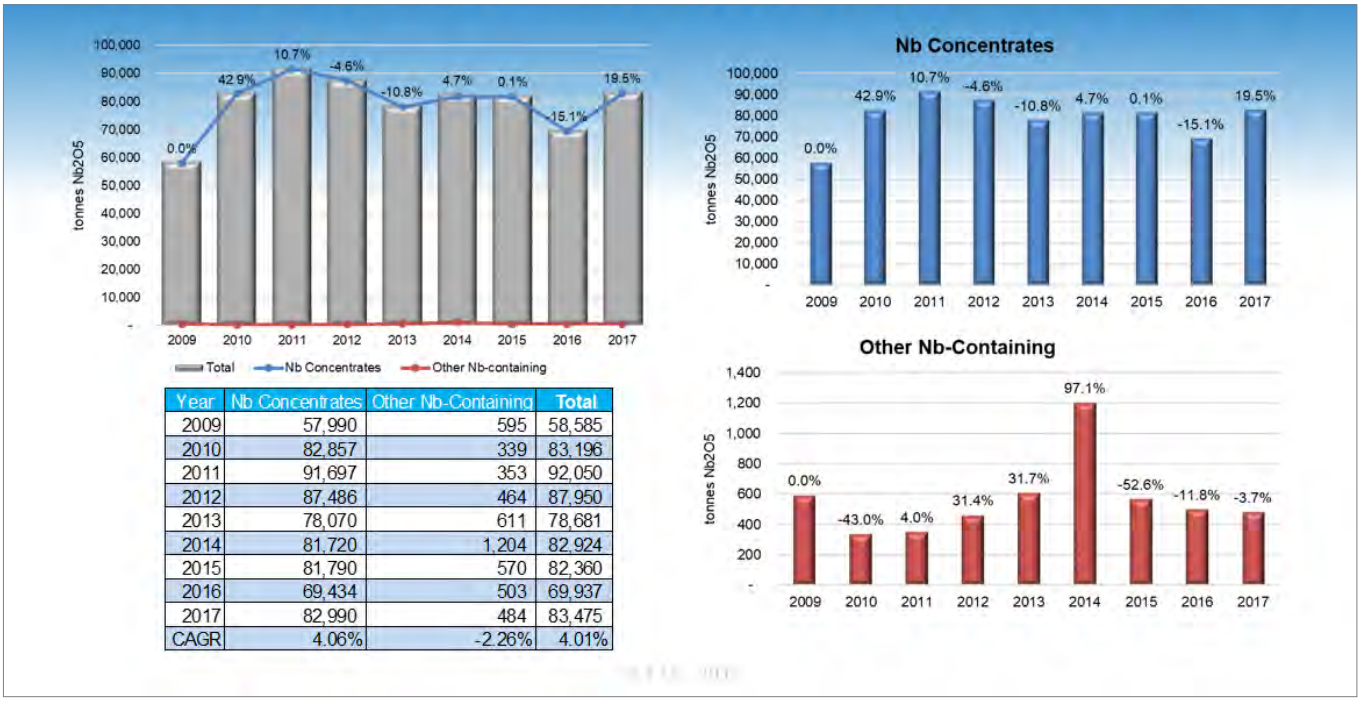
In the export data (figure 6) it appears that since 2013 exports from Africa have dominated supply, accounting for between 84% and 89% of materials as measured using the above method. During this period Brazil has remained steady at 10 to 16% until 2017 when it dropped to 5%.

Since the market didn't expand considerably in 2017 the fall in export is probably due to a widely-reported industrial accident at a major producer. Australia has seen a steady increase in exports over this time period and it will be interesting to see how this particular trend develops in coming years. Meanwhile, in the import data (figure 6) we can see that Asian countries are still the dominant regional player in the market, importing two thirds of the global total, as measured using the above method, although we observe a slight decrease over the period.

The chart also shows that North America is increasing its imports of concentrates, but in other countries a small decrease has been registered.

Niobium: Annual statistics 2009 - 2017

Niobium has seen a CAGR of 4% in the period 2009 to 2017, partly reflecting a dip in demand caused by the global economic slowdown in 2009, and partly due to the continued increase in demand for niobium in many applications (see figure 7). Of particular note is the year-on-year increase in production of niobium-bearing concentrates from 2016 to 2017, which stood at nearly 20%. As in previous years the proportion of niobium-bearing materials other than concentrates has played a very small role in the supply of units to market.

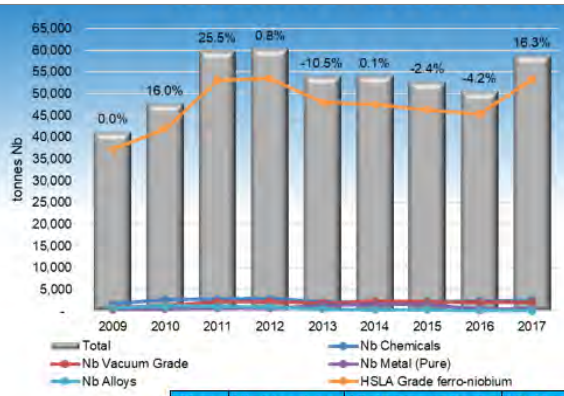


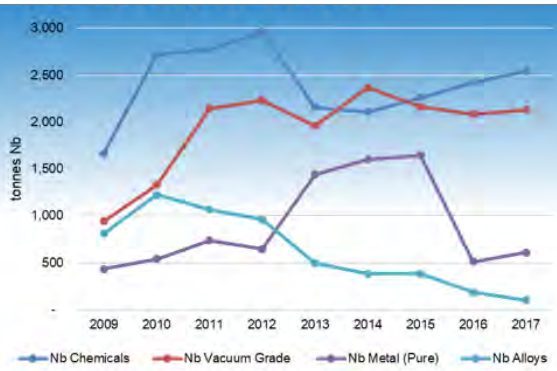
Year	Nb Concentrates	Other Nb-Containing	Total
2009	57,990	595	58,585
2010	82,857	339	83,196
2011	91,697	353	92,050
2012	87,486	464	87,950
2013	78,070	611	78,681
2014	81,720	1,204	82,924
2015	81,790	570	82,360
2016	69,434	503	69,937
2017	82,990	484	83,475
CAGR	4.06%	-2.26%	4.01%

Figure 7: Niobium raw materials: mining production and trading receipts

As in previous years, the vast majority of niobium units went into ferro-niobium destined for high-strength, low-alloy (HSLA) steel (see figures 8 and 9).

Niobium products realized a significant increase obtaining their highest shipped rate by weight since 2014. All categories of niobium (chemicals, vacuum grade, pure metal, and HSLA) enjoyed increased volumes, except for alloys. The latter category fell nearly 47%, but is so small that it can be easily distorted if a member misses reporting its activity in a quarter.





Year	Nb Chemicals	Nb Vacuum Grade	Nb Metal (Pure)	Nb Alloys	HSLA Grade Ferro-Niobium	Total
2009	1,665	942	433	811	37,253	41,104
2010	2,720	1,331	539	1,225	41,877	47,692
2011	2,772	2,144	738	1,067	53,125	59,847
2012	2,964	2,233	644	961	53,516	60,318
2013	2,159	1,962	1,442	496	47,932	53,991
2014	2,108	2,366	1,603	383	47,566	54,026
2015	2,261	2,163	1,645	382	46,275	52,725
2016	2,421	2,084	509	185	45,292	50,491
2017	2,541	2,131	610	99	53,332	58,712
CAGR	4.81%	9.49%	3.87%	-20.86%	4.07%	4.04%

Figure 8: Niobium product shipments by processors (I)

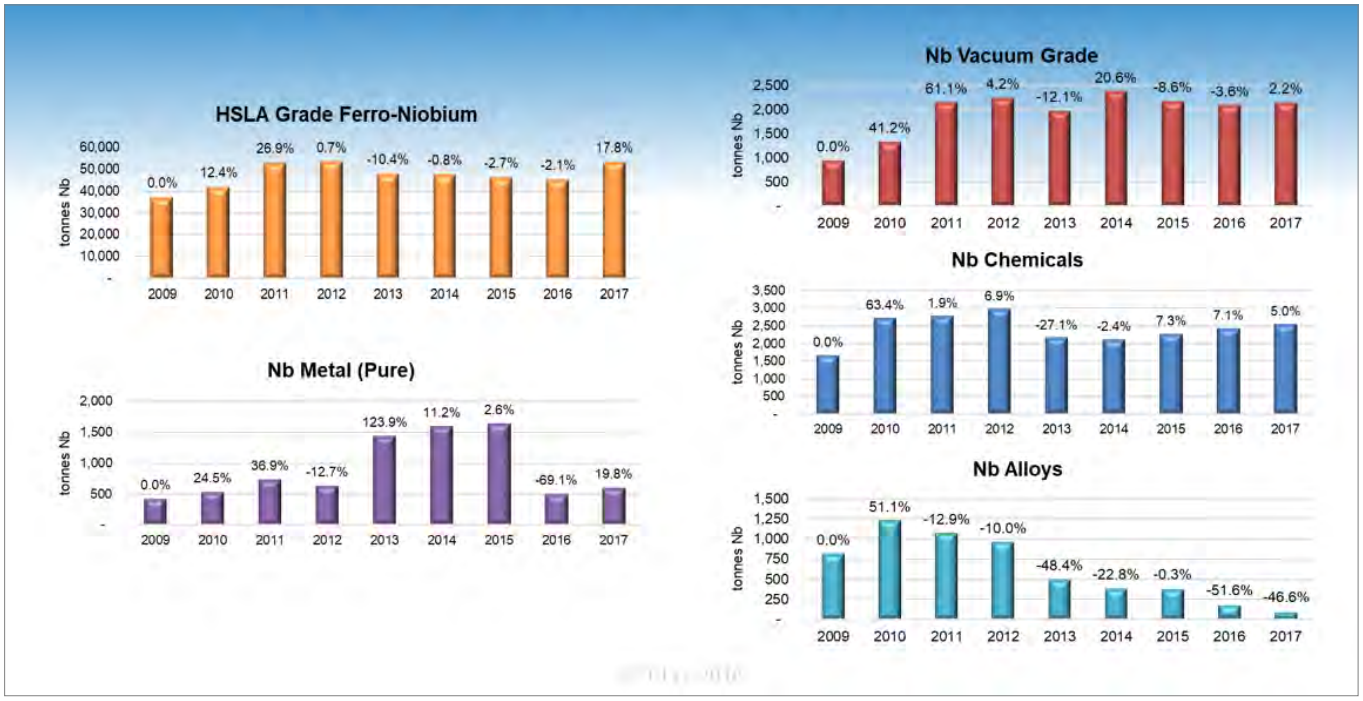


Figure 9: Niobium product shipments by processors (II)

Closing remarks

From the T.I.C.'s statistical analysis the tantalum and niobium markets both appear to be enjoying a period of growth in supply, albeit in the single-figure percentages. The supply of tantalum has been stable for the last decade and continuity of supply from a wide range of sources is one of the core strengths of the market. In niobium the picture also shows every characteristic of strong and stable supply.

Regarding the Association's quarterly statistics service for its members, the initial feedback we have received regarding the addition of international trade data to members' data has been overwhelmingly positive. The new statistics service is a work in progress and new information and analysis will be added to each report as our expertise develops further. As always, the T.I.C. seeks members' feedback and will endeavour to include as many of your suggestions as possible to create the best statistics service for tantalum and niobium that we can.

Tantalum capacitors: current trends and potential future

Paper written by Dr Tomas Zednicek of the European Passive Components Institute (EPCI). All views and opinions in this article are those of the authors and not the T.I.C.

Contact the author: tom@passive-components.eu

www.passive-components.eu

European Passive Components Institute

Introduction

It is well understood that tantalum capacitors offer excellent stability in harsh conditions, high energy and power volumetric efficiency and low parametric shift with lifetime, but are these features securing its position in new electronic designs compared against rival technologies such as multi-layer ceramic capacitors (MLCC) class II capacitors and aluminium hybrid polymer capacitors? This paper summarises recent trends in the electronics industry and discusses tantalum capacitors' potential in future electronic systems.

1. Market trends

We live in a fascinating time of human history as society transitions into a new digital age. This move is enabled by the fast development of electronics and computer segments which bring completely new levels of networking and services to all aspects of our lives (see figure 1).

Figure 1: Computing sector paradigm changes and current digital services growth
(Pictures: EPCI using Wikipedia and Depositphoto)

Completely new levels of digital based services and networking are enabled by new electronic hardware and technologies with high computing, data transfer or storage capabilities. Platforms such as the internet of things (IoT), Industrial internet of things (IIoT) / Industry 4.0, 5G phone networks and similar are creating an exponential increase of global data traffic and mobile data that the electronic hardware and infrastructure must support.

1.1 Major impacts to the electronic hardware requirements[1,2,3]:

a. wide increase of data to be processed on board
b. move from radio frequency (RF) to optical links (infrastructure)
c. move from systems on printed circuit board (PCB) to system-on-chip
d. higher density & integrated solutions
e. digital, power, RF/optical signal interface to be managed within the same PCB/block, often with downsizing requirements
f. increase of dissipated power & operating temperature
g. miniaturization – smaller and lower profile designs while maintaining/improving system performance
h. cost and lead time reductions

1.2 Consequences for board design architecture changes[1,2,3]:

a. a move towards wide-gap semiconductor technologies (gallium nitride (GaN) or silicon carbide (SiC)) for higher speed, higher frequencies at smaller dimensions (see Bulletin #175)
b. due to the high number of different functions and interface types, more and more different supply voltages will have to be managed separately
c. multiplication of point-of-load and low-drop-out regulators
d. increase of electromagnetic compatibility constraints; protect very small digital control and data signals in increasingly noisy electrical environments
e. lower voltages and higher current DC-DC (direct current) converters

1.3 Consequences for passive components[1,2,3]:

a. low voltage, high capacitance, small size and low equivalent series resistance (ESR) decoupling capacitors (especially MLCC class II)
b. large capacitance, low voltage and low ESR bulk capacitors
c. downsizing, embedding
d. thin film technology requirements
e. 2D/3D printed components
f. high current inductors
g. overload protection by shunt resistors is mandatory
h. electromagnetic interference (EMI) management
i. introduction of 0402 RF inductors
j. introduction of chip ferrite beads for power applications

2. Tantalum capacitors versus MLCC class II capacitors

Tantalum capacitors have been the leader in capacitance volumetric efficiency in the voltage range ~ 3.3-50V for a number of decades due to the combination of unique properties of tantalum pentoxide (Ta_2O_5) dielectric and high surface achieved by tantalum powder sintering technology. The unique features of the Ta_2O_5 insulating layer include relatively high permittivity (~27) for a stable dielectric and high electrical field strength (= relatively high breakdown voltage). Table 1 summarises the key features and benefits for various applications and circuit designs.

Key feature	Functionality	Circuit benefit	Applications	Limitations
High stability of electrical parameters	Stability of parameters in harsh environment	Wide operating temperature; Stable performance at various working conditions (VAC, VDC, frequency)	High reliability, defence, industrial, and aerospace applications	ESR, high current surge, maximum voltage
Long-term reliability	Long-term reliable operation			
High volumetric efficiency	High energy density in small size and low profile	Small size SMPS output filtering; battery back-up	Smartphones, SSDs, handheld devices	Cost
		Battery back-up; high energy bank / local storage	Implantable medical / wearable devices	

Table 1: Tantalum capacitor key features and their importance (Source: EPCI)

2.1 MLCC class II - the closest rival capacitor technology

The closest capacitor rival technology in mass volume to chip tantalum capacitors is MLCC class II capacitors based on $BaTiO_3$ dielectric material. The material belongs to ferro-electric materials that provide very high permittivity in the range of 2,000 to >30,000 that provides high capacitance in a desk type non-polar electrostatic capacitor.

The downside of the $BaTiO_3$ is its sensitivity to environment conditions such as temperature, VAC, VDC, its time stability and piezo effect. Detailed comparison of tantalum versus MLCC capacitors can be found on the EPCI web site[4,5,6,7]. The key MLCC advantage is its design flexibility and miniaturisation while keeping its cost advantages. MLCC technology is dominating the overall capacitor volume and value share. 0201 has become the highest mass volume case size in 2018 and the smallest discrete capacitor in size 008004 has been also released.

2.2 Supply chain and availability

The MLCC capacitor market is currently going through a tight supply time period. During this time, attention is paid towards alternative tantalum capacitors[4,5,6]. The level of possible functional replacement of tantalum to MLCC capacitors has been estimated about 15 to 20% per feedback from customers.

2.3 Cost matters

In a stable market, the technology-based cost of a 1206 case MLCC class II and an A case (1206 equivalent) tantalum capacitor can be very close (depending on capacitance and voltage value).

The 1206 case size is a cost down sweet-spot case size for a standard tantalum capacitor. This is not the case of tantalum/NbO capacitors, where smaller case sizes below 1206 size are more expensive. MLCC capacitors are manufactured in process sheets that are cut into individual capacitors. Therefore, within certain limits and specific product exceptions cost is reduced by manufacturing more, smaller units per sheet. Tantalum capacitors are manufactured "in-row units", so sizes may be more expensive. Other tantalum case sizes are also available (e.g. 0402 and 0201), but are considered niche.

3. Tantalum capacitor potential to answer market needs

The ability of tantalum capacitors to answer the latest market trends and potential future requirements can be summarised in Table 1.

High Volumetric Efficiency Advantage

3.1 Smartphones and miniature hand-held devices

Tantalum capacitors were widely used in mobile phones from the early 1990s to the late 2010s. However, the need for miniaturisation of the board, advances in semiconductor and circuit architectures practically eliminated the need for higher capacitance and tantalum capacitors, and current designs prefer smaller MLCC capacitors.

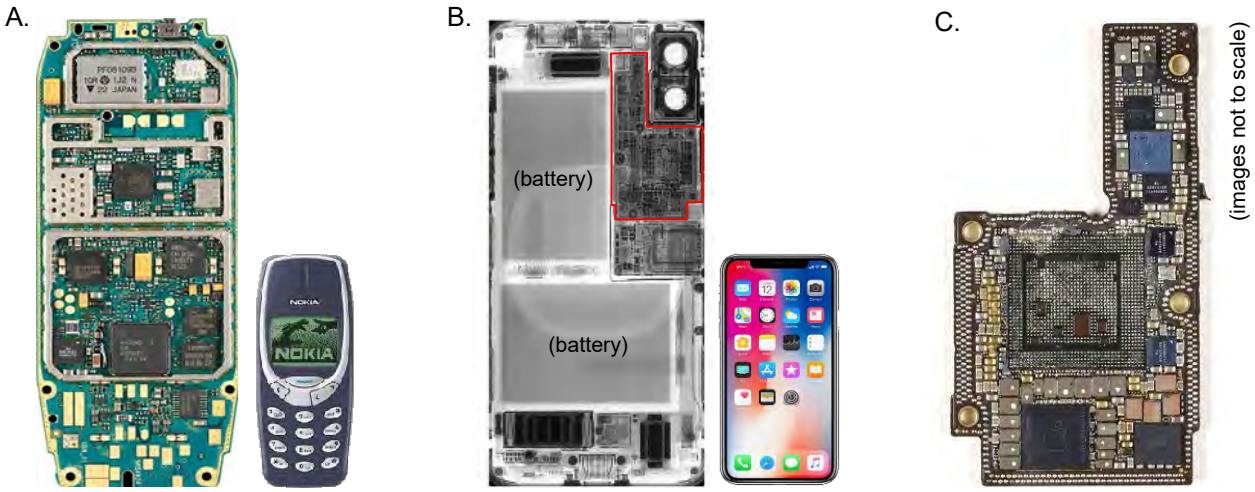


Figure 2: Comparison between A) a 2000 Nokia “3310” and B) a 2017 iPhone “X” showing location of the main PCB board (red) and its detail view (C) with A11 processor removed (photos Nokia (A), iFixIt (B and C)).

The level of miniaturisation in mobile phones is clearly demonstrated in figure 2. The Nokia iconic 3310 mobile phone went on sale in 2000 and sold 126 million units worldwide. It was one of the most successful phones ever and used six tantalum capacitors.

In a 2017 Apple iPhone X smartphone three quarters of the internal space is occupied by batteries and a 20-layer PCB integrates all its functions. There are about 1100 MLCCs on board (no tantalum), including some even embedded underneath the A11 processor.

3.2 Solid state drives (SSD), enterprise SSDs, and servers

High-energy and high volumetric efficiency in a low-profile design are often needed by SSDs and servers as an energy backup in case of sudden power supply interruption. Tantalum capacitors are bringing key value with maximum volumetric efficiency above 500mJ per cc in a single component within just 1.2mm maximum height design. MLCC class II are excellent in miniaturisation towards small case sizes, however tantalum excels in design tasks for high energy content in larger and low profiles.

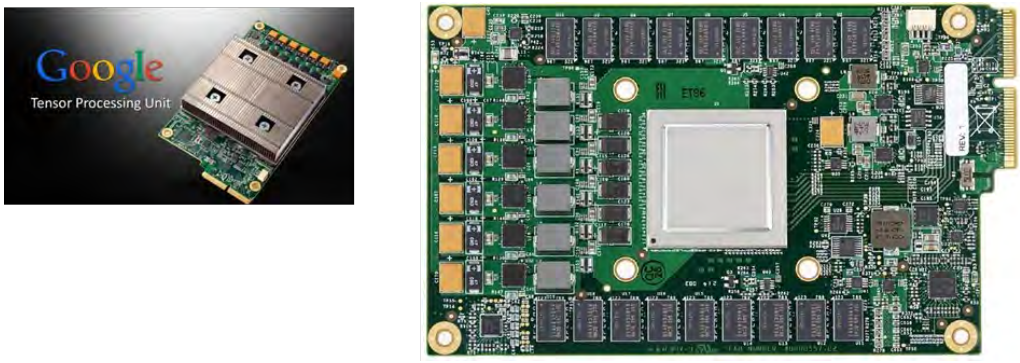


Figure 3: Google Tensor Processing Units (TPU) with tantalum capacitors on board (yellow parts) (photos: Google)

Supercapacitors could be considered as tantalum capacitor alternatives in SSDs energy back up applications. They provide even higher energy density however they are lower in power density (they cannot deliver the required current fast enough within the defined case size dimensions). Tantalum capacitor manufacturers have prepared specific series to match with SSDs' specific requirements and they pose an important market potential[8,9].

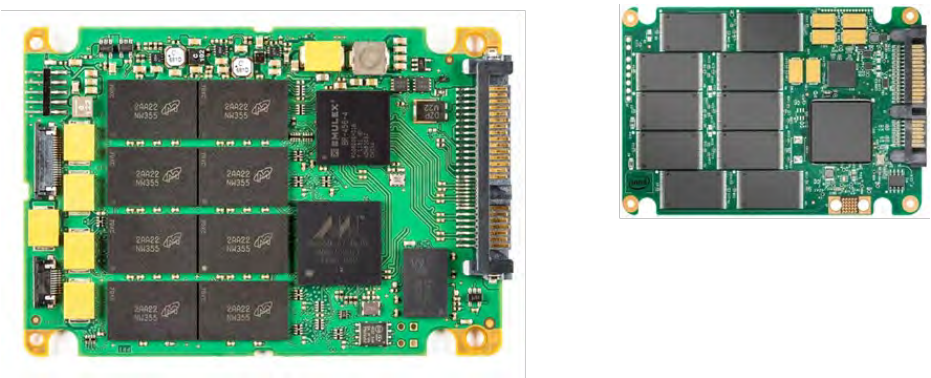


Figure 4: Enterprise SSD boards with low profile tantalum capacitors on board (photos: Micron (left) and Intel (right))

Stable Electrical Parameters and Long Life Time

3.3 Automotive

Tantalum capacitors with stable performance at wide operating temperatures, harsh environment and long term reliability are the choice in many automotive applications, including under the hood, the dashboard, in-cabin, entertainment systems, and telematics.

The highest competition for tantalum capacitors has been aluminium electrolytic capacitors mainly due to cost down reasons. Inferior life and vibration characteristics limited their wider usage.

However, with continuous advancement in aluminium capacitors, new series with higher vibration resistance or hybrid polymer types that improve their reflow assembly robustness and life time stability are replacing tantalum capacitors in some current designs[10].

Figure 5: An ECU with tantalum capacitors on board (in red circle) (photos: Bosch (left), Subaru WRC (right))

Tantalum capacitors will continue to be used in automotive applications, mainly in the most demanding applications at continuous higher temperature operating conditions as electronic control units (ECUs) and gearbox electronics close to the engine. The development of V2X (vehicle to everything) supported by 5G and IoT-capable hardware and networks is also needed and well utilised by the automotive industry IoV (Internet of Vehicles). This has been one of the key current and future developments[16].

3.4. Telecom and networking infrastructure hardware

Telecom base stations, switchers and other internet networking hardware have been using tantalum capacitors due to their long-life stability and reliability in various applications, including for DC/DC converter filtering and coupling/decoupling. The hardware has a typical life-time of 12-15 years that mostly excludes conventional aluminium electrolytic capacitors from bulk capacitance applications.

The need for higher speed, high power in a small unit is a main driver to adopt the new generation of gallium nitride (GaN) and silicon carbide (SiC) power supplies. Lower capacitance, low ESR and higher resonance frequency requirements may change output capacitor requirements towards MLCC. However, the proper set of the working point by GaN gate drive is of key importance for the overall amplifier temperature stability and linearity. Thus many new GaN boards are using tantalum capacitors for gate drive voltage stabilisation[11].

Figure 6: Example of a networking hardware board with tantalum capacitors (photos: Cisco)

3.5. Industrial applications

Industrial applications cover a wide range of applications and requirements including manufacturing machines, oil drilling, security, and power energy generation/ transportation/ regeneration/ storage. Industrial applications may present some of the most demanding operating conditions – even tighter than automotive – considering that most of its life a car is in “off” state in a garage, while industrial equipment has to work constantly, for a long time, at elevated temperature and often in systems demanding a low failure rate.

Tantalum capacitors are the valuable capacitor technology for industrial applications that need continuous operation at elevated temperatures or low profile designs such as embedded controllers, for example in industrial robots as part of Industry 4.0 (IIoT). On the other hand tantalum capacitors are replaced by aluminium hybrid capacitors from other non-space critical, standard temperature range devices such as room temperature based solar inverters.

Figure 7: Industrial 4 channel programmable logic controller (PLC) control board (left) and Xilinx industrial controller (right) with tantalum capacitors on board (photos: Amazon (left); Xilinx (right))

3.6 High-reliability, aerospace, defence and medical applications

The high-reliability market has been using tantalum capacitors for many decades and this will continue in the future. High energy wet and hybrid types in addition serve well some specific areas such as defibrillator capacitors or operations inside oil wells at temperatures of 230°C. There may be some reduction in the overall average selling price on the market as the trend is to use more of lower-class high reliability products or commercial-off-the-shelf-plus (COTS+) grades. On the other hand, the market potential such as "new space" in space applications or medical/wearables is bringing new opportunities for tantalum capacitors.

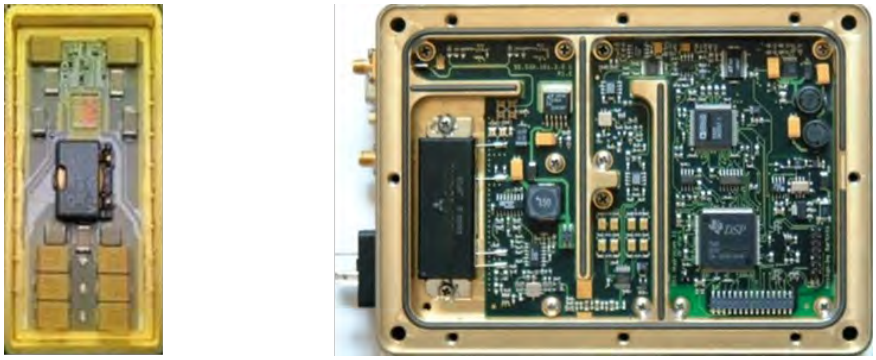


Figure 8: Teledyne high reliability, radiation hardness rated 10A DC-DC POL Module in hermetical package (left) NOA and Meteosat Uplink RF section (right) (photos: Teledyne (left); Bartels Electronics (right))

4. Around and beyond the current technology horizon

Tantalum pentoxide (Ta_2O_5) is a material with unique dielectric properties providing stable characteristics. The following potential applications may benefit from the unique dielectric property characteristics of Ta_2O_5:

- **Nano-scale storage:** On-chip storage in nano-scale can be beneficial for small energy harvesting chips. Some development work announced by the Faculty of Electrical Engineering and Communication with Central European Institute of Technology (CEITEC) at Brno University of Technology (BUT), Czech Republic and Institute of Sensor and Actuator System (ISAS) at TU Wien, Austria[12]
- **High-voltage, high-energy storage:** Electric vehicles and power electricity markets need 400-1000V capacitors. Currently maximum breakdown voltages (BDVs) for tantalum polymer capacitors are around 125V with research on 300V – that is not enough to tackle the bigger market, but is indeed a step forward[13].
- **Thin film tantalum capacitors:** Thin and flat and/or multilayer tantalum structure based on thin film technology to answer needs for either wearable sensors or stacked designs to get lower **capacitance but lower ESR design**. Tantalum paste for printing ultrathin tantalum capacitors of <0.2mm high is already available[14], and one day we may even print tantalum capacitors as part of 3D PCB printers[15].

The trend in supply chain management is that passive component makers are more and more concentrating on development of module solutions rather than development of individual components. This may create a next opportunity for tantalum pentoxide to support both thin-film low-energy and high-energy power thick-film passive component systems in flexible modules answering the needs of a wide range of future applications.

5. Summary and conclusion

Miniaturisation, high speed data communication, processing and storage on one hand and energy generation, transmission and storage on the other hand are the two main drivers for the next generation of electronics. Tantalum capacitors have been on the market for many decades recognised as the stable performance, reliable capacitor technology capable of providing high volumetric efficiency and power density.

Miniaturisation and cost down pressure allowed competing technologies to take over some portion of the tantalum capacitor market:

- MLCC class II ceramic capacitor technology answers best the need for further miniaturisation and high volume production capability to support smartphones and other handhelds.
- Hybrid polymer aluminium capacitors improved robustness and stability replacing tantalum in designs where volumetric efficiency at standard operating temperature conditions is not of a prime concern.

On the other hand, new developments and future trends pose some next opportunities for tantalum capacitors to grow, specifically in the following fields:

- **SSDs, enterprise SSDs, servers, embedded PCs:** These applications need high energy and power density to support energy storage with constraints in dimensions / low profile.
- **Telecommunication and networking infrastructure:** Long term operation with stable electrical parameters at low failure tolerant systems. Exponential global data and mobile data exchange with upcoming 5G standard will require continuous hardware upgrade.
- **Industrial:** Industry 4.0 is a next evolution step to net industrial machines together with communication electronic boards and processing embedded computers. Tantalum capacitors are providing low profile and a reliable solution at elevated temperatures.
- **High reliability:** High reliability electronics are a strong application area for tantalum capacitors with their heritage in aerospace, medical or defence applications.

Tantalum pentoxide with its unique dielectric features is presenting some more opportunities for further development that are currently under evaluation or vision as a next potential for tantalum capacitors to answer the needs of future electronic systems.

REFERENCES

1. Airbus defence and space roadmap for passive components; ESA SPCD 2018; https://passive-components.eu/airbus-defence-and-space-roadmap-for-passive-components/
2. Thales Alenia space passive components roadmap 2018; ESA SPCD 2018; https://passive-components.eu/thales-alenia-space-passive-components-roadmap-2018/
3. Design trends in automotive passives; Avnet Engineers Insight; https://passive-components.eu/design-trends-in-automotive-passives/
4. MLCC capacitors availability first aid – Tantalum/NbO to MLCC replacement guidelines; EPCI original article; https://passive-components.eu/mlcc-capacitors-availability-first-aid-tantalum-nbo-to-mlcc-capacitors-replacement-guidelines/
5. Kemet polymer to MLCC shortage: When you can't find the cap you need; https://passive-components.eu/kemet-polymer-to-mlcc-shortage-when-you-cant-find-the-cap-you-need/
6. Substituting solid tantalum and tantalum polymer capacitors for SMT MLCCs; Vishay technical note; https://passive-components.eu/substituting-solid-tantalum-and-tantalum-polymer-capacitors-for-smt-mlccs/
7. The basics and benefits of tantalum and ceramic capacitors; AVX technical article; https://passive-components.eu/the-basics-benefits-of-tantalum-ceramic-capacitors/
8. AVX J-Cap series http://www.avx.com/products/polymer/j-cap-series/
9. Kemet T545 series http://www.kemet.com/ProductCatalog%20Documents/KEM_T2060_T545.pdf
10. Panasonic releases new conductive polymer hybrid aluminum electrolytic capacitor ZS series; Panasonic press release; https://passive-components.eu/panasonic-releases-new-conductive-polymer-hybrid-aluminum-electrolytic-capacitor-zs-series/
11. Temperature stability assessment of GaN power amplifiers with matching tantalum capacitors; EPCI original article; https://passive-components.eu/epci-passive-components-tech-insight-temperature-stability-assessment-of-gan-power-amplifiers-with-matching-tantalum-capacitors/. A summary of this article appeared in T.I.C. Bulletin #175 (October 2018).
12. On a chip energy storage capacitors; 1st PCNS 2017; https://passive-components.eu/on-a-chip-energy-storage-capacitors/
13. Pushing tantalum capacitors to the limit: view to 300 V anodisations and beyond; H.C. Starck article; ESA SPCD 2018; https://passive-components.eu/pushing-tantalum-capacitors-to-the-limit-view-to-300-v-anodisations-and-beyond/
14. Tantalum paste technology for the next generation of capacitors; H.C. Starck brochure; https://www.hcstarck-tantalum-niobium.com/products/productinformations/product_information_tantalum_paste.en.html\
15. When are we going to print PCBs on 3D printer ourselves?; EPCI original article; https://passive-components.eu/when-are-we-going-to-print-pcbs-on-3d-printer-ourselves/
16. Autonomous vehicles may not rely on 5G; EDN original article; https://passive-components.eu/autonomous-vehicles-may-not-rely-on-5g/

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

Surface processing method for tantalum spinning head
WO2018157867 (A1) — BEIJING HUAYU CHUANGXIN TA NB SCIENCE & TECHNOLOGY CO LTD [CN], BEIJING HUAYU CHUANGXIN SCIENCE & TRADE CO LTD [CN] — 2018-09-07

Titanium-tantalum alloy and method of forming thereof
US2018258512 (A1) — UNIV NANYANG TECH [SG], AGENCY FOR SCIENCE TECH AND RESEARCH [SG] — 2018-09-13

Tantalum-based alloy that is resistant to aqueous corrosion
US2018274064 (A1) — AIMONE PAUL R [US], HINSHAW EVAN [US] — 2018-09-27

Preparation process of porous tantalum sheet
CN108588810 (A) — HUNAN UNIV OF TECHNOLOGY [CN] — 2018-09-28

Method of tantalum carbide for hard metal and tantalum carbide for hard metal using the same
KR20180107332 (A) — KOREA INSTITUTE OF INDUSTRIAL TECH [KR] — 2018-10-02

Tantalum sputtering target
WO2018179742 (A1) — JX NIPPON MINING & METALS CORP [JP] — 2018-10-04

Thin film tantalum coating for medical implants
US2018325632 (A1) — ZIMMER INC [US] — 2018-11-15

Low profile flat wet electrolytic tantalum capacitor
EP3403269 (A1) — VISHAY SPRAGUE INC [US] — 2018-11-21

Atomic layer etching of tantalum
US2018350624 (A1) — LAM RES CORPORATION [US] — 2018-12-06

Processes for producing tantalum alloys and niobium alloys
EP3416772 (A1) — ATI PROPERTIES LLC [US] — 2018-12-26

NIOBIUM

Grayish white niobium oxynitride powder and method for producing the same
JP2018140896 (A) — MITSUBIHI MAT ELECTRONIC CHEMICALS CO LTD [JP] — 2018-09-13

Bulk nickel-niobium-phosphorus-boron glasses bearing low fractions of chromium and exhibiting high toughness
US2018258516 (A1) — GLASSIMETAL TECH INC [US] — 2018-09-13

Coated article having low-e coating with ir reflecting layer(s) and niobium-doped titanium oxide dielectric…
US2018250917 (A1) — GUARDIAN GLASS LLC [US] — 2018-09-06

System and method of concentrating niobium ore
WO2018184094 (A1) — ALEY CORP [CA] — 2018-10-11

Method for producing nanocrystalline titanium alloys with β and pseudo β structure, that contain niobium...
PL421097 (A1) — POLITECHNIKA POZNANSKA [PL] — 2018-10-08

Processes for producing thicker gage products of niobium microalloyed steel
US2018327882 (A1) — CBMM SA [BR] — 2018-11-15

Pink and violet pigments comprising antimony and/or niobium oxide(s) that display heat stability…
AU2017259957 (A1) — SHEPHERD COLOR CO — 2018-11-15

Method of joining a niobium-titanium alloy by using an active solder
WO2018206982 (A1) — OXFORD INSTRUMENTS NANOTECHNOLOGY TOOLS LTD [GB] — 2018-11-15

BCC materials of titanium, aluminum, niobium, vanadium, and molybdenum, and products made therefrom
WO2018149967 (A1) — ARCONIC INC [US] — 2018-11-29

Niobium-germanium superconducting photon detector
WO2018232332 (A1) — PSIQUANTUM CORP [US] — 2018-12-20

Diary of forthcoming events to be attended by T.I.C. staff *

- Mining Indaba, Cape Town, South Africa, February 4th to 6th 2019
- Argus Metals Week, London, UK, February 26th to 27th 2019
- MIRU (IR Universe), Tokyo, Japan, March 6th 2019
- Corrosion Conference and Expo 2019, Nashville, TN, USA, March 24th to 28th 2019
- MMTA's International Minor Metals Conference, Edinburgh, UK, April 9th to 11th 2019
- OECD's 13th Forum on Responsible Mineral Supply Chains, Paris, France, April 23rd to 25th 2019
- IAEA's 38th TRANSSC meeting in Vienna, Austria, June 26th to 28th 2019
- **T.I.C.'s 60th General Assembly and AGM in Hong Kong, China, October 13th to 16th 2019**
- RMI's Annual Conference in Santa Clara, CA, USA, October 23rd to 25th 2019
- London Metals Week 2018 in London, UK, October 28th to 30th 2019

* correct at time of print

Member company and T.I.C. updates

Successful applications for membership

At the Fifty-ninth General Assembly the following corporate membership applications were approved : Australian Strategic Materials Ltd (ASM), GGV Holding Ltd, H.C. Starck Inc. / Fabricated Products, Halcyon Inc., Jiujiang Fuxing Tai Trade Co. Ltd, RC Inspection Metals B.V., SAMWOOD NEO Inc., and United Spectrometer Technologies Pty Ltd. An associate membership application by Rwanda Mines, Petroleum & Gas Board (RMB) was also approved (see page 5 for details).

Transfers of membership

At the Fifty-ninth General Assembly the following membership transfer was approved:

- **NAC Kazatomprom** to **Ulba Metallurgical Plant JSC**. The delegate has changed to Mr Alexey Tsorayev, who can be contacted on TsorayevAA@ulba.kz. The company address is 102 Abay Avenue, 070005 Ust-Kamenogorsk, Republic of Kazakhstan and the website is www.ulba.kz.

Changes in member contact details

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

- **Roskill Information Services Ltd:** The delegate has changed to Ms Suzanne Shaw. She can be reached on suzanne@roskill.com or by phone on +44 20 8417 0087
- **Thailand Smelting and Refining Co Ltd:** The delegate has changed to Mr Andrew Davies. He can be reached on Andrew.Davies@thaisarco.com.

Resignations

The following corporate members have resigned from the Association since Bulletin #172 was published: Buss & Buss Spezialmetalle GmbH, Commerce Resources Corp., Elite Material Solutions Ltd, Metalysis Ltd, Scandmetal International SA, Standard Resources Corp., TOKIN Corp. and Zimmer Trabecular Metal Technology.

Join our mailing list to receive the Bulletin directly by email

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.

Email **info@tanb.org** to join our mailing list and keep up to date with the T.I.C.

The T.I.C.'s Sixtieth General Assembly: Hong Kong, China

T.I.C.'s 60th General Assembly will take place in

Hong Kong

from Sunday October 13th to Wednesday October 16th 2019.

CALL FOR PAPERS

Papers on relevant tantalum and niobium subjects are sought from members and non-members. Welcome topics include:

- Raw materials
- Supply chain traceability
- Services to the Ta-Nb industry
- Primary processing and refining
- Secondary processing and metallurgy
- Capacitors, superalloys, HSLA steel and other key applications
- Research and development on new applications for tantalum and niobium

GA60 will include the A.G. Ekeberg Tantalum Prize award ceremony 2019

Talks are to be given in English and the general length of presentations is 20-25 minutes. Please submit your proposals for papers for the technical sessions by March 31st 2019. The final program is decided by the Executive Committee. Full papers must be submitted by September 15th 2019.

All questions and requests for abstract submission forms should be sent to Emma Wickens at info@tanb.org.

