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TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

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Bulletin No.192

CONFERENCE 2024

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The Ekeberg Prize 2024: Winner

65th General Assembly: Technical Programme and Abstracts

SAVE THE DATES

T.I.C.'s 66th General Assembly

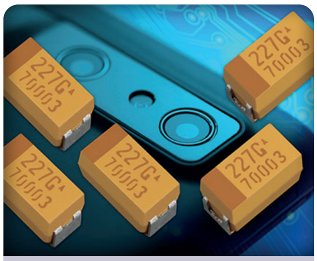
(Conference and AGM) will take place in

Cape Town

September 14th-17th 2025

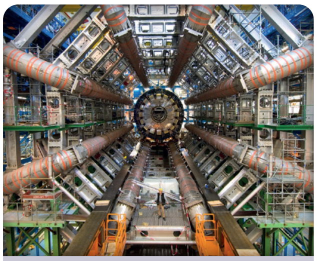
Non-members are welcome to attend this event. The T.I.C. General Assembly attracts global industry leaders. Full details will be made available at www.tanb.org

Our 2025 conference will explore issues such as:



Capacitors

Superalloys



Superconductors

HSLA Steel

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President’s Welcome

Dear Members and Friends:

Welcome to GA65 Tokyo, and the T.I.C. 50th Anniversary bulletin.

This year’s GA65 technical sessions will be equally balanced between tantalum and niobium. We heard our members commenting that the GA technical sessions had become too tantalum centric so hopefully you will find an acceptable balance this year. Also, as this is the 50th anniversary of the T.I.C. we have included retrospective presentations on the evolution of technologies that have been critical to the foundation of the tantalum and niobium related industries.

The winner of this year’s Ekeberg Prize for Innovation in Tantalum will present their winning technology as the day 2 keynote. As we were going to press, the esteemed panel of judges were in the process of reviewing the top entrants and selecting the winner. This year a slight change was made in the process. In past years basic R&D and commercially focused technologies were both included in the nominees; however, this is the first year where we separated the two, with a focus on only R&D for this year. As such, based on instituting an alternate year process, next year’s prize will be based on commercially focused innovations, and so on.

This year we will end the day 2 technical sessions with a panel discussion on innovations necessary to drive the tantalum and niobium industries for the next 5-10 years. A panel of 5 industry leaders will focus on their areas of expertise hopefully lending insight into areas of opportunity, yielding a composite view of the key technologies necessary for future growth.

Given the raw material availability issues that are currently impacting the tantalum supply chain, I expect there will be a considerable number of meetings focused on garnering the necessary raw materials moving forward. These meetings will be even more meaningful if we expect any type of business rebound over the next 6-12 months. While we have worked tirelessly with supply chain to find a solution, there are a numerous issues which are out of or control. And while the T.I.C. Executive Committee has had a number of discussions focused on developing a set of “Enhanced Due Diligence Guidelines”, we are holding off moving forward while the main supply chain mechanisms address the issue as is their mandate. Specifically, the RMI will present their progress on “Enhanced Due Diligence” on the afternoon of day 2.

This year’s GA features the introduction of the “T.I.C. App”. We are excited about this development and hope you will use it to review agenda and speaker details, delegate attendees, set up meetings, and communicate with other delegates. We look forward to your feedback so we can make it more user friendly for next year’s GA in Cape Town, South Africa.

Last but not least, I want to thank all our GA65 sponsors, especially our Platinum Sponsor JX Advanced Metals, for their continued support of the T.I.C. Please extend a heartfelt thanks to all our sponsors when you see them.

In closing, I want to thank you all for your support during my many years as President of the T.I.C. It has been my honor to work with all the T.I.C. members in that capacity. I will hopefully maintain a position on the Excom where I can continue to work on issues important to the T.I.C. and its members. I look forward to seeing you all in Tokyo, experiencing an exciting GA65, and enjoying all that Tokyo has to offer from food to entertainment.

Regards,

Dan

Contents

The Bulletin No. 192
August 2024
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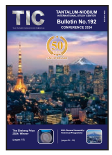
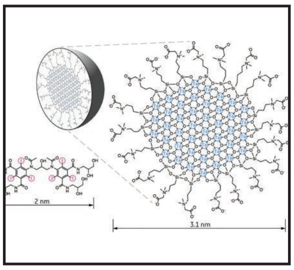


Featured articles:

Ekeberg Prize 2024 Winner



Regular articles:

主席致辞

亲爱的会员和朋友们

欢迎来到东京 GA65 和 T.I.C. 50 周年公报。

今年的 GA65 技术会议将在钽和铌之间保持平衡。我们听到我们的成员评论说，GA 技术会议已变得过于以钽为中心，因此希望今年你们能找到一个可以接受的平衡。此外，由于今年是 T.I.C. 成立 50 周年，我们还加入了对钽和铌相关行业的基础至关重要的技术发展回顾演讲。

今年艾克伯格钽创新奖的获奖者将在第二天的主题演讲中介绍他们的获奖技术。在我们截稿时，备受尊敬的评审团正在审查最优秀的参赛者并选出获奖者。今年的评选过程略有变化。往年，基础研发技术和以商业为重点的技术都包括在被提名者范围内；但今年是第一次将两者分开，今年只关注研发技术。因此，在隔年评选的基础上，明年的奖项将以商业创新为主，以此类推。

今年，在第二天的技术会议结束时，我们将就未来 5-10 年推动钽和铌行业发展所需的创新进行小组讨论。由 5 位行业领导者组成的小组将重点讨论他们的专业领域，希望他们能对机遇领域提出真知灼见，并对未来增长所需的关键技术提出综合看法。

考虑到目前影响钽供应链的原材料供应问题，我预计将会有相当多的会议集中讨论如何获得必要的原材料。如果我们期望在未来 6-12 个月内出现任何类型的业务反弹，那么这些会议将更有意义。虽然我们一直在不懈地与供应链合作寻找解决方案，但仍有许多问题超出了我们的控制范围。虽然 T.I.C. 执行委员会已就制定一套 “强化尽职调查准则 ”进行了多次讨论，但在主要供应链机制按照其职责解决这一问题之前，我们暂缓推进工作。具体而言，马绍尔群岛政府将在第 2 天下午介绍他们在 “强化尽职调查 ”方面取得的进展。

今年的大会特别推出了 “T.I.C.应用程序”。我们对这一发展感到兴奋，希望您能使用它来查看议程和演讲者详情、代表参会、安排会议以及与其他代表交流。我们期待您的反馈意见，以便在明年的南非开普敦大会上使其更加方便易用。

最后但并非最不重要的一点是，我要感谢 GA65 的所有赞助商，尤其是白金赞助商 JX Advanced Metals，感谢他们一直以来对 T.I.C. 的支持。最后，我要感谢大家在我担任 T.I.C. 主席的多年时间里对我的支持。能以主席的身份与 T.I.C. 的所有成员共事是我的荣幸。我希望能继续担任执行委员会的职务，继续致力于解决对 T.I.C. 及其成员非常重要的问题。我期待着在东京见到大家，体验激动人心的 GA65，享受东京从美食到娱乐所提供的一切。

再见、

Dan

Boas-vindas do Presidente

Prezados membros e amigos:

Bem-vindos à GA65 Tóquio e ao boletim do 50º aniversário da T.I.C..

As sessões técnicas da GA65 deste ano serão igualmente equilibradas entre tântalo e nióbio. Ouvimos nossos membros comentarem que as sessões técnicas da GA haviam se tornado muito centradas no tântalo, portanto, esperamos que vocês encontrem um equilíbrio aceitável este ano. Além disso, como este é o 50º aniversário do T.I.C., incluímos apresentações retrospectivas sobre a evolução das tecnologias que foram fundamentais para a fundação dos setores relacionados ao tântalo e ao nióbio.

O vencedor do Prêmio Ekeberg de Inovação em Tântalo deste ano apresentará sua tecnologia vencedora como a palestra do segundo dia. Quando estávamos indo para a imprensa, o estimado painel de juízes estava analisando os principais participantes e selecionando o vencedor. Este ano, houve uma pequena mudança no processo. Nos anos anteriores, as tecnologias básicas de P&D e as tecnologias com foco comercial foram incluídas entre os indicados; no entanto, este é o primeiro ano em que separamos as duas, com foco apenas em P&D. Dessa forma, com base na instituição de um processo de ano alternado, o prêmio do próximo ano será baseado em inovações com foco comercial, e assim por diante.

Este ano, encerraremos as sessões técnicas do segundo dia com um painel de discussão sobre as inovações necessárias para impulsionar os setores de tântalo e nióbio nos próximos 5 a 10 anos. Um painel de cinco líderes do setor se concentrará em suas áreas de especialização, com a esperança de fornecer informações sobre áreas de oportunidade, produzindo uma visão composta das principais tecnologias necessárias para o crescimento futuro.

Considerando os problemas de disponibilidade de matéria-prima que atualmente afetam a cadeia de suprimentos de tântalo, espero que haja um número considerável de reuniões com foco na obtenção das matérias-primas necessárias para o futuro. Essas reuniões serão ainda mais significativas se esperarmos qualquer tipo de recuperação dos negócios nos próximos 6 a 12 meses. Embora tenhamos trabalhado incansavelmente com a cadeia de suprimentos para encontrar uma solução, há vários problemas que estão fora do nosso controle. E, embora o Comitê Executivo do T.I.C. tenha tido várias discussões com foco no desenvolvimento de um conjunto de “Diretrizes aprimoradas de devida diligência”, estamos adiando o avanço enquanto os principais mecanismos da cadeia de suprimentos tratam do assunto, conforme suas atribuições. Especificamente, o RMI apresentará seu progresso sobre “Enhanced Due Diligence” (Diligência devida aprimorada) na tarde do dia 2.

A AG deste ano apresenta a introdução do “T.I.C. App”. Estamos entusiasmados com esse desenvolvimento e esperamos que você o utilize para revisar a agenda e os detalhes dos palestrantes, delegar participantes, marcar reuniões e se comunicar com outros delegados. Aguardamos seus comentários para que possamos torná-lo mais fácil de usar na AG do próximo ano na Cidade do Cabo, África do Sul.

Por último, mas não menos importante, quero agradecer a todos os nossos patrocinadores da GA65, especialmente ao nosso patrocinador Platinum JX Advanced Metals, pelo apoio contínuo ao T.I.C. Por favor, agradeça sinceramente a todos os nossos patrocinadores quando os vir.

Para encerrar, gostaria de agradecer a todos pelo apoio durante os muitos anos em que fui presidente do T.I.C. Foi uma honra trabalhar com todos os membros do T.I.C. nessa função. Espero manter uma posição no Excom, onde poderei continuar a trabalhar em questões importantes para o T.I.C. e seus membros. Espero vê-los em Tóquio, vivenciar um GA65 emocionante e aproveitar tudo o que Tóquio tem a oferecer, desde comida até entretenimento.

Com os melhores cumprimentos,

Dan

社長のあいさつ

会員の皆様、ご友人の皆様：

GA65東京、そしてT.I.C.50周年記念会報へようこそ。

今年のGA65テクニカルセッションは、タンタルとニオブが均等にバランスよく行われる予定です。GA65のテクニカルセッションがタンタル中心になりすぎているとの会員の皆様のご意見をお聞きしましたので、本年はバランスの取れた内容になることを期待しております。また、今年はT.I.C.の50周年ということで、タンタルとニオブ関連産業の基礎に重要な役割を果たしてきた技術の進化に関する回顧的なプレゼンテーションも含まれています。

また、2日目の基調講演では、今年のエーケベルグ賞タンタルイノベーション賞の受賞者が受賞技術を発表する。本誌が取材を開始した時点では、尊敬すべき審査員団が上位入賞者を審査し、受賞者を決定している最中であった。今年はそのプロセスに若干の変更が加えられた。例年は、基礎的な研究開発と商業的に焦点を当てた技術の両方が候補に含まれていたが、今年は研究開発のみに焦点を当て、この2つを分離した最初の年である。そのため、交互に開催することを踏まえ、来年は商業的なイノベーションに焦点を当てた賞とする予定です。

今年は、2日目のテクニカルセッションの最後に、今後5～10年のタンタル・ニオブ産業を牽引するために必要なイノベーションに関するパネルディスカッションを行います。5人の業界リーダーからなるパネルが、それぞれの専門分野に焦点を当て、将来の成長に必要な主要技術に関する総合的な見解を提供する。

現在タンタルのサプライチェーンに影響を及ぼしている原材料の入手可能性の問題を考慮すると、今後必要な原材料を調達することに焦点を当てた会議が相当数開催されると予想される。今後6～12ヶ月の間に何らかの事業回復が見込まれるのであれば、これらの会議はさらに意味のあるものになるだろう。解決策を見つけるためにサプライチェーンと精力的に取り組んできたが、どうにもならない問題が数多くある。T.I.C.執行委員会は「デューデリジェンス・ガイドラインの強化」に焦点を当てた議論を重ねてきましたが、主要なサプライチェーン・メカニズムがその任務としてこの問題に取り組んでいる間、私たちは前進を控えています。具体的には、RMIが2日目の午後に「デューデリジェンスの強化」に関する進捗状況を発表する。

今年のGAでは「T.I.C.アプリ」が導入される。このアプリは、アジェンダやスピーカーの詳細、出席者の確認、ミーティングの設定、他の参加者とのコミュニケーションにご利用いただけます。来年の南アフリカ・ケープタウンでのGAに向け、より使いやすいアプリにできるよう、皆様からのフィードバックをお待ちしております。

最後になりましたが、GA65のスポンサーの皆様、特にプラチナ・スポンサーであるJX Advanced Metalsの皆様には、T.I.C.への変わらぬご支援に感謝申し上げます。

最後に、私がT.I.C.の会長を長年務めている間、皆様からいただいたご支援に感謝いたします。私は、T.I.C.とそのメンバーにとって重要な問題に取り組み続けることができるExcomのポジションを維持したいと思います。東京で皆さんにお会いし、エキサイティングなGA65を体験し、食事からエンターテインメントまで東京が提供するすべてを楽しむことを楽しみにしています。

よろしくお願いします、

Dan

Lettre du Président

Chers membres et amis:

Bienvenue au GA65 de Tokyo et au bulletin du 50e anniversaire du T.I.C.

Cette année, les sessions techniques de l'AG65 seront réparties équitablement entre le tantale et le niobium. Nous avons entendu nos membres dire que les sessions techniques de l'AG étaient devenues trop centrées sur le tantale, nous espérons donc que vous trouverez un équilibre acceptable cette année. En outre, comme il s'agit du 50e anniversaire du T.I.C., nous avons inclus des présentations rétrospectives sur l'évolution des technologies qui ont été essentielles à la fondation des industries liées au tantale et au niobium.

Le lauréat du prix Ekeberg pour l'innovation dans le tantale de cette année présentera sa technologie gagnante lors de l'exposé principal du deuxième jour. À l'heure où nous mettions sous presse, le prestigieux jury était en train d'examiner les meilleurs candidats et de sélectionner le lauréat. Cette année, le processus a été légèrement modifié. Les années précédentes, la R&D de base et les technologies à vocation commerciale étaient toutes deux incluses dans les nominations ; cependant, c'est la première année où nous avons séparé les deux, en nous concentrant uniquement sur la R&D pour cette année. Ainsi, en instituant une année sur deux, le prix de l'année prochaine sera basé sur les innovations à vocation commerciale, et ainsi de suite.

Cette année, nous terminerons les sessions techniques du deuxième jour par un débat sur les innovations nécessaires pour stimuler les industries du tantale et du niobium au cours des 5 à 10 prochaines années. Un panel de 5 leaders de l'industrie se concentrera sur leurs domaines d'expertise, tout en apportant un éclairage sur les domaines d'opportunité, ce qui permettra d'obtenir une vue d'ensemble des technologies clés nécessaires à la croissance future.

Compte tenu des problèmes de disponibilité des matières premières qui affectent actuellement la chaîne d'approvisionnement en tantale, je m'attends à ce qu'il y ait un nombre considérable de réunions axées sur l'obtention des matières premières nécessaires pour aller de l'avant. Ces réunions seront d'autant plus importantes si nous nous attendons à un quelconque rebond de l'activité au cours des 6 à 12 prochains mois. Bien que nous ayons travaillé sans relâche avec la chaîne d'approvisionnement pour trouver une solution, de nombreux problèmes échappent à notre contrôle. Et bien que le comité exécutif du T.I.C. ait eu un certain nombre de discussions axées sur l'élaboration d'un ensemble de « lignes directrices améliorées en matière de diligence raisonnable », nous attendons pour aller de l'avant que les principaux mécanismes de la chaîne d'approvisionnement s'attaquent à la question, comme le prévoit leur mandat. Plus précisément, le RMI présentera ses progrès en matière de « diligence raisonnable renforcée » dans l'après-midi du deuxième jour.

L'AG de cette année est marquée par l'introduction de l'« application T.I.C. ». Nous sommes ravis de cette évolution et espérons que vous l'utiliserez pour consulter l'ordre du jour et les détails des intervenants, pour déléguer des participants, pour organiser des réunions et pour communiquer avec d'autres délégués. Nous attendons avec impatience vos commentaires afin de rendre l'application encore plus conviviale pour l'AG de l'année prochaine au Cap, en Afrique du Sud.

Enfin, je tiens à remercier tous les sponsors de l'AG65, en particulier notre sponsor platine JX Advanced Metals, pour leur soutien continu au T.I.C. N'hésitez pas à remercier du fond du cœur tous nos sponsors lorsque vous les verrez.

Pour conclure, je tiens à vous remercier tous pour le soutien que vous m'avez apporté pendant les nombreuses années où j'ai été président du T.I.C. J'ai eu l'honneur de travailler avec tous les membres du T.I.C. à ce titre. J'espère conserver un poste au sein de l'Excom où je pourrai continuer à travailler sur des questions importantes pour le T.I.C. et ses membres. Je me réjouis de vous voir tous à Tokyo, de vivre une AG65 passionnante et de profiter de tout ce que Tokyo a à offrir, de la nourriture aux divertissements.

Je vous prie d'agréer, Madame, Monsieur, l'expression de mes salutations distinguées,

Dan

* correct at time of print

Editor’s notes

Dear Members and Attendees,

It is my great pleasure to welcome you all to the 50th Anniversary General Assembly, GA65. Over the years, we have witnessed many developments, yet the supply chain for tantalum remains as challenging as ever. This ongoing challenge underscores the importance of our gathering and the collaboration it fosters.

This year marks a significant milestone for the T.I.C. with the awarding of the Ekeberg Prize to a medical paper—our first in this field. I am particularly excited for the presentation on Tuesday, which I believe will be both insightful and inspiring.

Organizing this conference on the opposite side of the globe has been no small feat. I would like to extend my heartfelt thanks to JX Advanced Metals for their tireless efforts in making this event a reality.

Given our location in Tokyo, we’ve embraced a Japanese theme throughout the conference. We hope you enjoy the vibrant atmosphere of the Tokyo metropolitan area, the world’s largest city.

We are confident that this year’s conference will provide valuable opportunities for you to conduct business and address your industry concerns. We regret that we reached maximum capacity for Monday’s Gala Dinner and apologize to any members who were unable to attend. To avoid disappointment at next year’s conference in Cape Town, scheduled for 14th to 17th September 2025, we encourage early booking, especially for the Gala Dinner.

Please remember, the T.I.C. staff will be available throughout the conference. Do not hesitate to reach out to us with any concerns or suggestions you may have. This is your conference, and we are here to ensure you gain the maximum benefit from your participation.

Warmest regards,

Ian

Executive Marketing Manager and Technical Officer.

Sign up to attend at -
www.tanb.org/view/65th-general-assembly

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The T.I.C. is an international, non-profit association founded in 1974 under Belgian law that represents around 90 members from over 30 countries involved with all aspects of the tantalum and niobium industry. The T.I.C. is managed by an Executive Committee elected from the membership and representing all segments of the industry. Corporate membership costs EUR 2750 per year and full details of benefits are available at www.TaNb.org

New members

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.

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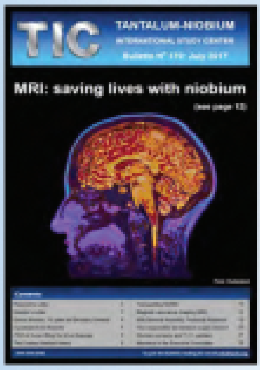

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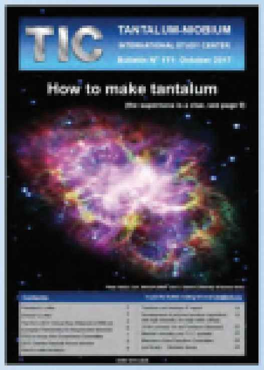


The Anders Gustaf Ekeberg Tantalum Prize: a retrospective

Recognising excellence in tantalum research and innovation

The Anders Gustaf Ekeberg Tantalum Prize ('Ekeberg Prize') is awarded annually by the T.I.C. for excellence in tantalum research and innovation and the new shortlist for the 2024 award shows that the level of interest in element #73 remains as high as ever*.

The Ekeberg Prize was established by the T.I.C. in 2017 to increase awareness of the many unique properties of tantalum products and the applications in which they excel. To date the Ekeberg Prize has been awarded for outstanding work on the subjects of tantalum capacitors (2018, Dr Yuri Freeman), additive manufacturing (2019, Nicolas Soro et al), recycling tantalum by solvent extraction (2020, Prof. Jason Love et al) and cutting of tantalum (2021, Dr Jason M. Davis et al).

Technology-driven innovations will ensure the long-term future of the tantalum market and with so many potential new or embryonic applications in development there is every reason for optimism.

* Although T.I.C. represents and supports both tantalum and niobium equally, the Ekeberg Prize focuses on tantalum, because CBMM's Charles Hatchett Award (www.charles-hatchett.com) already superbly recognises niobium published research.

The judging panel for the Ekeberg Prize

The Ekeberg Prize is judged by an independent Panel of Experts who are selected from around the world to provide an impartial assessment on the technical merit of the shortlisted papers. Members of the current T.I.C. Executive Committee and staff cannot sit on the Panel. This year, we are honoured to have on the Panel the following experts:

Professor Donald Robert Sadoway

Massachusetts Institute of Technology, United States of America

Dr Donald Robert Sadoway is professor emeritus of materials chemistry at the Massachusetts Institute of Technology. He is a noted expert on batteries and has done significant research on how to improve the performance and longevity of portable power sources. In addition, Prof. Sadoway is the Founder and Board Member at Ambri, Boston Metal, Pure Lithium, Avanti Battery, and Sadoway Labs.

Professor Elizabeth Dickey

Carnegie Mellon University, United States of America

Dr Elizabeth Dickey is the Teddy & Wilton Hawkins Distinguished Professor and Department Head of Materials Science & Engineering at Carnegie Mellon University. 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 a 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. She is a fellow of the American Ceramic Society, the Microscopy Society of America, and the American Association for the Advancement of Science (AAAS).

Magnus Ericsson

Luleå University of Technology, Sweden

Magnus Ericsson is adjunct professor of Mineral Economics at Luleå University of Technology in the mining heart of Sweden. He is a founding partner in the independent advisors RMG Consulting. 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. He has 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 the deputy chair of the foundation establishing a museum at the site on Resarö outside Stockholm where tantalum was first isolated. He is a co-founder and Editor-in-Chief of the scientific journal Mineral Economics / Raw Materials Report, now in its 35th year.

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 and his team quantify the global stocks and flows of non-fuel mineral commodities at each stage of their life cycle, analyse trends and examine concerns regarding foreign mineral dependencies, develop supply and demand scenarios, and assess the mineral commodity supply risk to the U.S. economy and national security. He is a member of the U.S. National Science and Technology Council (Executive Office of the President) Critical Minerals Subcommittee. He received his Ph.D. from Yale University where he worked on the development and application of a methodology for identifying critical minerals. In 2019 he was awarded the Presidential Early Career Award for Scientists and Engineers and he also holds an MBA from Cornell University and two master's degrees from Yale University. Previously, he worked as a consultant and as a process development engineer.

Professor Toru H. Okabe

The Institute of Industrial Science, The University of Tokyo.

Dr Okabe's doctorate examined the processing of reactive metals, such as titanium and niobium, and his subsequent career has included postdoctoral research with Professor Donald Sadoway at Massachusetts Institute of Technology (MIT), USA. Dr Okabe specialises in materials science, environmental science, resource circulation engineering and rare metal process engineering. In addition to the research on the innovative production technology, he has worked on new recycling and environmental technology of rare metals, such as niobium, tantalum, scandium, tungsten, rhenium, and precious metals. Dr Okabe is Director General of the Institute of Industrial Science at The University of Tokyo. In 2021 he received an honorary degree from the Norwegian University of Science and Technology for his groundbreaking work on "urban mining".

Tomáš Zedníček Ph.D.

President of the European Passive Components Institute (EPCI).

Dr Zedníček's doctorate examined tantalum capacitors and was awarded in 2000 from the Technical University of Brno in the Czech Republic. Prior to establishing EPCI in 2014, he worked for over 21 years at a major tantalum capacitor manufacturer, including 15 years as the worldwide technical marketing manager. He has authored over 60 technical papers and a US/international patent on tantalum and niobium capacitors. He regularly presented at the CARTS passive component conference and other leading events. Since 2017 he has organized the PCNS bi-annual passive components symposium hosted by a European University. Dr Zedníček is a regular contributor to the Bulletin.

How the winner of the Ekeberg Prize 2024 will be announced

The winning publication will be announced in August 2024. The lead author will be invited to give a paper at the 65th General Assembly, to be held in Tokyo, Japan, in September 2024. During the General Assembly there will be an award ceremony at which the lead author will be recognized by the tantalum industry and receive his/her Ekeberg Prize medal, made by the Kazakhstan Mint from pure tantalum metal (pictured on page 8). The T.I.C.'s General Assembly is open to both members and non-members; full details about the event, including speakers and how to book tickets are available at www.tanb.org/view/65th-general-assembly.

Previous winners

Since the Ekeberg Prize was launched there have been six winning publications, understanding differences in metal–imido bonding towards improving Ta/Nb separations, examining cutting of tantalum, recycling tantalum by solvent extraction, additive manufacturing and tantalum capacitors.

In 2023 the Ekeberg Prize was awarded to the paper on 'Tailoring Nb-based alloys for Additive Manufacturing: From powder production to parameter optimization', Dr Axel Hoppe gave his reason for the vote as AM is a key technology for reducing cost and opens new markets for Ta/Nb demonstrating practical outcomes and readiness for mass production.

The 2022 winning publication The 2022 Anders Gustaf Ekeberg Tantalum Prize ('Ekeberg Prize') was awarded to a US team led by Professor Eric J. Schelter , for its paper "Tantalum, easy as Pi: understanding differences in metal–imido bonding towards improving Ta/Nb separations" published in the Chemical Science, Royal Society of Chemistry. (Reprinted in the T.I.C. Bulletin number 189, published in October 2022 and available at www.TaNb.org).

In 2021 the Anders Gustaf Ekeberg Tantalum Prize ('Ekeberg Prize') was awarded to a US-Japanese team led by Dr Jason M. Davis of the Center for Materials Processing and Tribology at Purdue University, IN, USA, for its paper "Cutting of tantalum: Why it is so difficult and what can be done about it" published in the journal International Journal of Machine Tools and Manufacture and also available in Bulletin issue 187, October 2021.

In 2020 the Ekeberg Prize was awarded to a team from Edinburgh University, UK, lead by Prof. Jason Love, for "Tantalum recycling by solvent extraction: chloride is better than fluoride" published in Metals. The paper examined the difficulties of recycling tantalum and discussed their work showing how Ta(V) halides, such as $TaCl_5$ and TaF_5, can potentially be accessed from tantalum metal upon acid halide leaching, and can then be recovered by solvent extraction using a simple primary amide reagent. They concluded that extraction of the fluorides was poor (up to 45%), excellent extraction under chloride conditions is found (>99%) and presents an alternative route to Ta recycling.

In 2019 the winning publication was by a team from The University of Queensland, Australia, for "Evaluation of the mechanical compatibility of additively manufactured porous Ti–25Ta alloy for load-bearing implant applications". The authors were Nicolas Soro, Hooyar Attar, Martin Veidt and Matthew Dargusch from the University of Queensland, Australia, and Erin Brodie and Andrey Molotnikov from Monash University, Australia.

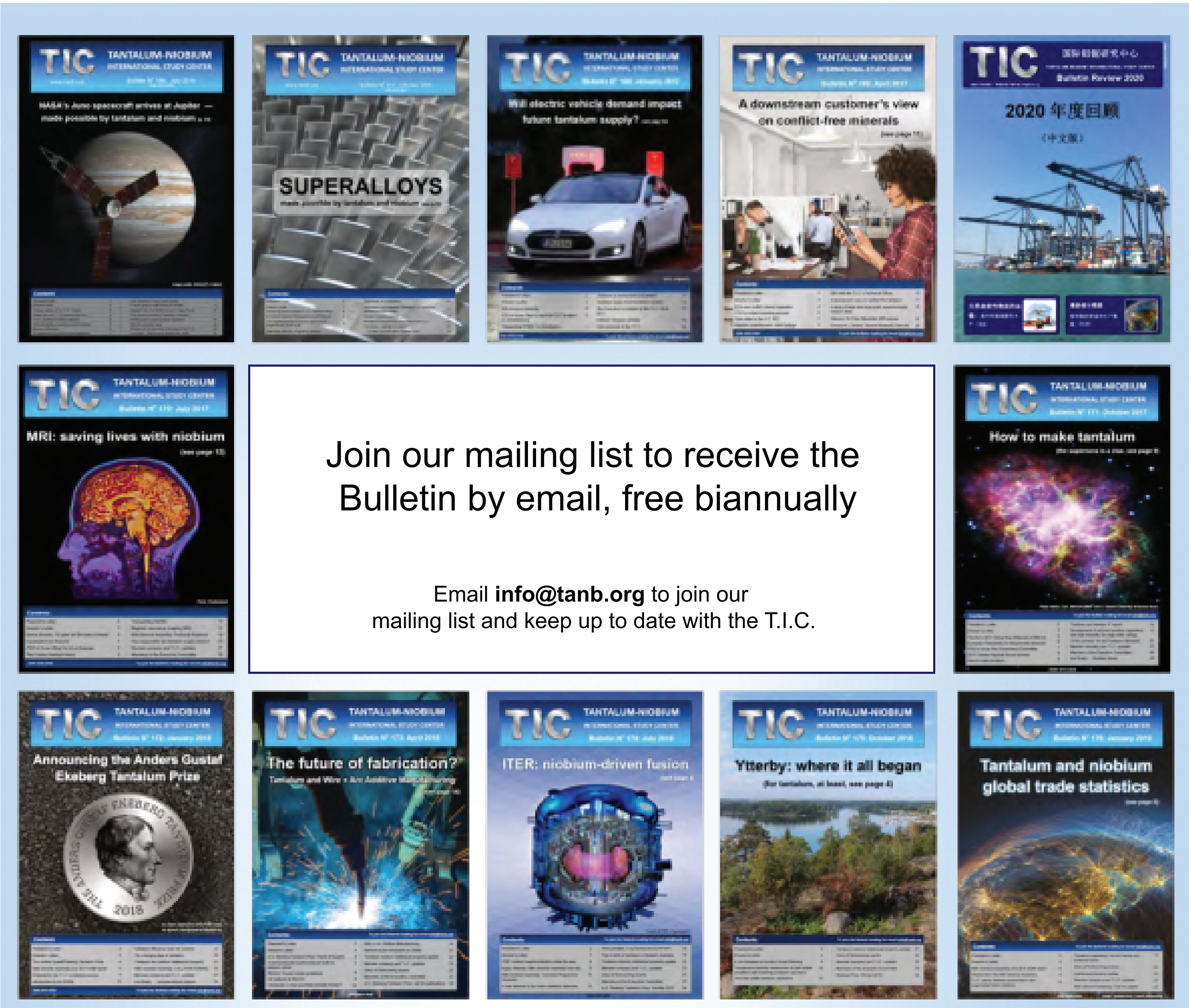
The paper examined how additive manufacturing using Ti–25Ta alloy has enabled the optimisation of the mechanical properties of metallic biomaterials. The mechanical properties were found to be suitable for bone replacement applications, showing significantly reduced elastic moduli and superior mechanical compatibility compared to the conventionally used biomedical Ti–6Al–4V alloy, making the Ti–25Ta alloy a promising candidate for a new generation of load-bearing implants.

In 2018, the inaugural Ekeberg Prize was won by Dr Yuri Freeman of KEMET Electronics, for his book “Tantalum and Niobium-Based Capacitors”.

Dr Freeman has devoted most of his career to the development of Ta-based capacitors and made significant contributions, technological breakthroughs and performance improvements in these devices.

Dr Freeman is the Director of Advanced Research in the Tantalum (Ta) business unit and a member of the Advanced Technology Group at KEMET Electronics. He has published more than 30 papers and received 26 patents in the field of physics and technology of Ta and Nb-based capacitors.

The judges’ decision to choose the book by Dr Yuri Freeman reflected the general lack of basic books about tantalum and tantalum capacitors in education, as well as it being “a very good scientific overview, providing basic insight into the manufacturing process of Ta-based electrolytic capacitors”.



The Ekeberg Prize 2024: shortlisted abstracts

Recognising excellence in tantalum research and innovation

The Anders Gustaf Ekeberg Tantalum Prize ('Ekeberg Prize') is awarded annually by the T.I.C. for excellence in tantalum research and innovation. The winner will be announced in September and the lead author will receive the award during the T.I.C.'s 65th General Assembly, scheduled to be held in Tokyo, Japan, on September 8th to 11th 2024. Full details of the Ekeberg Prize winning publication and how to attend the 65th General Assembly are published on www.tanb.org

The following publications are shortlisted for the Ekeberg Prize 2024:

Kink bands promote exceptional fracture resistance in a NbTaTiHf refractory medium-entropy alloy

Authors: David H. Cook [a], Punit Kumar [a], Calvin H Belcher [b], Pedro Borges [a], Wending Wang [a], Flynn Walsh [a], Zehao Li [c], Arun Devaraj [c], Mingwei Zhang [a], Mark Asta [a], Andrew M. Minor [a], Enrique J. Lavernia [b], Diran Apelian [b], Robert O. Ritchie [a],

Organisation: [a] Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.
[b] Department of Materials Science and Engineering, University of California, Irvine, CA, USA.
[c] Physical and Computational Sciences Directorate, Pacific Northwest National Laboratory, Richland, WA, USA

Full article at: www.science.org/doi/10.1126/science.adn2428 for more information.

Abstract -

Single-phase body-centred cubic (bcc) refractory medium- or high-entropy alloys can retain compressive strength at elevated temperatures but suffer from extremely low tensile ductility and fracture toughness. We examined the strength and fracture toughness of a bcc refractory alloy, NbTaTiHf, from 77 to 1473 kelvin. This alloy's behaviour differed from that of comparable systems by having fracture toughness over 253 MPa·m1/2, which we attribute to a dynamic competition between screw and edge dislocations in controlling the plasticity at a crack tip. Whereas the glide and intersection of screw and mixed dislocations promotes strain hardening controlling uniform deformation, the coordinated slip of <111> edge dislocations with {110} and {112} glide planes prolongs nonuniform strain through formation of kink bands. These bands suppress strain hardening by reorienting microscale bands of the crystal along directions of higher resolved shear stress and continually nucleate to accommodate localized strain and distribute damage away from a crack tip.

The clinical translation of a tantalum oxide nanoparticle-based contrast agent for improved diagnostic CT imaging capabilities and patient safety through extensive non-GLP and GLP preclinical development, safety tests, and efficacy tests

Authors: [a] Peter J. Bonitatibus Jr., PhD, [b] Benjamin M. Yeh, MD, [b] Yuxin Sun, MS,

Organisation: [a] Rensselaer Polytechnic Institute – Chemistry, USA, [b] University of California, San Francisco - Radiology, USA

Full article at:

Abstract -

Despite the need for ionizing radiation exposure, the clinical value of CT is such that over 40 million contrast-enhanced scans are performed annually in the United States, and it is the imaging modality of choice for numerous disease diagnosis. Unfortunately, only one class of clinical CT contrast agent is available, namely small-molecule tri-iodinated derivatized benzene-ring agents (Figure 1). These agents all show, (1) reduced CT signal when imaged in thicker anatomy such as the torso, particularly in the obese patient population; (2) poor evaluation of vasculature due to short intravascular half-life from so-called 'washout' or the rapid nonspecific redistribution from blood plasma to interstitial fluid; (3) similar appearance to vascular calcifications or metal implants such as stents; and (4) cross reactivity, such that patients intolerant to one iodine agent are intolerant to the entire class. No substantively new intravenous CT contrast agent has been introduced in over 40 years. Elemental tantalum and its oxide are biologically safe and have long been used in medical implants. From an X-ray physics standpoint, tantalum gives substantially higher attenuation than iodine at the X-ray tube voltages (kVp) of 100 kVp and higher typically used to scan most patients, particularly the obese patient population. Contrast-enhanced CT stands to be revolutionized through further development (clinical trials) of this team's tantalum nanoparticle-based intravascular contrast agent (Figure 1) that provides unprecedented vascular delineation in comparison to clinical iodine-based agents regardless of patient body habitus, e.g, mouse, rat, rabbit, or swine. 1,3,7 This is due, in part, to innovative structural engineering and chemical manipulation and of tantalum nanoparticle core-size and coating that has been demonstrated to control the agent's biological retention, blood pool distribution, and pharmacokinetics. 7,8 The team's tantalum oxide nanoparticle so-called 'TaCZ' is coated with a carboxybetaine zwitterionic (CZ) shell that is stable to an exceptionally wide range of pH and autoclave conditions. 7 The innovative CZ shell imparts water solubility and features distributed charges but is overall charge neutral, thereby avoiding potential cytotoxicity concerns associated with cationic coatings. This zwitterionic character gives low viscosity and osmolality, promotes rapid renal clearance, and negligible organ retention.

Simulation study on the damage behaviour of tantalum target plates under high-velocity projectile impact

Authors: [a]Yuntian Wang, [a]Min Yang, [b]Danping Hu, [a]Qiujie Wei, [a]Ying Zhang and [c]Yuzhu Guo

Organisation: [a]School of Urban Construction, Chengdu Polytechnic, Chengdu 610065, China
[b]LVTC School of Intelligent Construction, Luzhou Vocational and Technical College, Luzhou, 646000, China
[c]School of Civil Engineering, Changsha University of Science &Technology, Changsha 410114, China

Full article at: https://iopscience.iop.org/article/10.1088/1742-6596/2730/1/012062 for more information.

Abstract -

This study aims to explore the damage behaviour of tantalum target plates under high-velocity projectile impact, addressing the threats of damage in the aerospace field due to debris and other factors. With the advent of low-cost space launches and large satellite projects, spacecraft such as space stations are facing increasingly severe collision risks. The research utilizes numerical simulation techniques, based on ANSYS/AUTODYN software and the Smoothed Particle Hydrodynamics (SPH) method, to simulate the impact process of projectiles of different velocities (1 ~ 10 km/s) and materials (aluminium and steel) on tantalum target plates. The results are intended to provide theoretical support for the design of spacecraft protection structures and contribute data support for establishing a millimetre-level space debris impact database.

Dislocation–grain boundary interactions in Ta: numerical, molecular dynamics, and machine learning approaches

Authors: [a,b] A. Kedharnath, [a,b] Rajeev Kapoor, [a,b] Apu Sarkar

Organisation: a Mechanical Metallurgy Division, Bhabha Atomic Research Centre, Mumbai 400085, India
b Division of Engineering Sciences, Homi Bhabha National Institute, Anushaktinagar, Mumbai 400094, India

Full article at:

Abstract -

The motivation of this work was to find the appropriate molecular dynamics (MD) and slip transmission parameters of dislocation–grain boundary (GB) interaction in tantalum that correlate with the stress required for the grain boundary to deform. GBs were modelled using [112], [110], and [111] as rotation axes and rotation angle between 0° and 90°. Dislocation on either {110} or {112} slip planes was simulated to interact with various GB configurations. Drop in shear stress, drop in potential energy, critical distance between dislocation and GB, and critical shear stress for dislocation absorption by the GB were the parameters calculated from MD simulations of dislocation–GB interactions. Machine learning models Extreme Gradient Boosting and Shapley Additive Explanations (SHAP) were used to find the correlation between the various parameters and yield stress of the GB configurations. Machine learning results showed that the MD parameters— critical distance between the dislocation and GB, drop in shear stress; and slip transmission parameter—m′ have a stronger correlation with yield stress. The SHAP results sorted the prominent slip plane and rotation axis affecting the yield stress. The configurations with dislocation on {112} slip plane, and configurations with [111] rotation axis were difficult to deform (higher yield stress of GB) than {110} slip plane and [112] and [110] rotation axes configurations.

Unexpected Periodicity in Cationic Group 5 Initiators for the Ring-Opening Polymerization of Lactones

Authors: [a] Antoine Buchard, [b] Matthew G. Davidson, [b] Gerrit Gobius du Sart, [a] Matthew D. Jones, [a] Gabriele Kociok-Kohn, [a] Srachan N. McCormick, [a] Paul McKeown

Organisation: [a] Institute for Sustainability and Department of Chemistry, University of Bath, Bath BA2 7AY, United Kingdom
[b]TotalEnergies Corbion, Gorinchem 4203 NS, The Netherlands

Full article at:

Abstract -

ε-Caprolactone (ε-CL) adducts of cationic, amine tris(phenolate)-supported niobium(V) and tantalum(V) ethoxides initiate the ring-opening polymerization of lactones. The Ta(V) species prepared and applied catalytically herein exhibits higher activity in the ring-opening polymerization (ROP) of ε-caprolactone than the previously reported, isostructural Nb(V) complex, contradicting literature comparisons of Nb(V)- and Ta(V)-based protocols. Both systems also initiate the ROP of δ-valerolactone and rac-β-butyrolactone, kinetic studies confirming retention of higher activity by the Ta congener. Polymerizations of rac-β-butyrolactone and δ-valerolactone were previously unrealized under Group V- or Ta-mediated conditions, respectively, although the former has afforded only low molecular weight, cyclic poly-3- hydroxybutyrate. Cationic ethoxo−Nb(V) and −Ta(V) δ-valerolactone adducts are also reported, demonstrating the facility of δ-valerolactone as a ligand and the generality of the synthetic method. Both δ-valerolactone-bearing complexes initiate the ROP of ε-caprolactone, δ-valerolactone, and rac-β-butyrolactone. Accordingly, we have elucidated trends in reactivity and investigated the initiation mechanism for such systems, the insertion event being predicated upon intramolecular nucleophilic attack on the coordinated lactone by the adjacent alkoxide moiety. This mechanism enables quantitative, stoichiometric installation of a single monomer residue distinct from the bulk of the polymer chain and permits modification of polymer properties via both manipulation of the molecular architecture and tuning of the polymerization kinetics, and thus dispersity, through hitherto inaccessible independent control of the initiation event.

The Anders Gustaf Ekeberg Tantalum Prize: Winner 2024

Recognising excellence in tantalum research and innovation

The 2024 winning publication of The 2024 Anders Gustaf Ekeberg Tantalum Prize (‘Ekeberg Prize’) was awarded to a US team led by Benjamin M. Yeh, MD , for a paper on “The clinical translation of a tantalum oxide nanoparticle-based contrast agent for improved diagnostic CT imaging capabilities and patient safety through extensive non-GLP and GLP preclinical development, safety tests, and efficacy tests” published in the American Journal of Roentgenology 2023, Oct 25 [published online]. DOI:10.2214/AJR.23.29970.

Ekeberg Prize 2024 Winner

Benjamin M. Yeh, MD is a Professor in the Abdominal Imaging Section in the Department of Radiology at the University of California, San Francisco.

Peter J. Bonitatibus Jr., PhD is an Associate Professor of Chemistry in the Department of Chemistry and Chemical Biology at Rensselaer Polytechnic Institute.

Yuxin Sun, MS is a Research Associate in the Department of Radiology at the University of California, San Francisco (UCSF) and Lab Manager at the Contrast Material and CT Translational Research Laboratory at UCSF.

2024 Ander Gustav Ekeberg Winning Paper

The clinical translation of a tantalum oxide nanoparticle-based contrast agent for improved diagnostic CT imaging capabilities and patient safety through extensive non-GLP and GLP preclinical development, safety tests, and efficacy tests

Authors: Peter J. Bonitatibus Jr., PhD. (Rensselaer Polytechnic Institute - Chemistry), Benjamin M. Yeh, MD (University of California, San Francisco - Radiology), Yuxin Sun, MS (University of California, San Francisco - Radiology)

This team that has been collaborating for more than ten years to advance the clinical translation of a **tantalum** oxide nanoparticle- based contrast agent for improved diagnostic CT imaging capabilities and patient safety through extensive non-GLP and GLP preclinical development, safety tests, and efficacy tests.[1-15]

Despite the need for ionizing radiation exposure, the clinical value of CT is such that over 40 million contrast-enhanced scans are performed annually in the United States and it is the imaging modality of choice for numerous disease diagnosis. Unfortunately, only one class of clinical CT contrast agent is available, namely small-molecule tri-iodinated derivatized benzene-ring agents (**Figure 1**). These agents all show, (1) reduced CT signal when imaged in thicker anatomy such as the torso, particularly in the obese patient population; (2) poor evaluation of vasculature due to short intravascular half-life from so-called 'washout' or the rapid nonspecific redistribution from blood plasma to interstitial fluid; (3) similar appearance to vascular calcifications or metal implants such as stents; and (4) cross reactivity, such that patients intolerant to one iodine agent are intolerant to the entire class. No substantively new intravenous CT contrast agent has been introduced in over 40 years.

Elemental **tantalum** and its oxide are biologically safe and have long been used in medical implants. From an X-ray physics standpoint, **tantalum** gives substantially higher attenuation than iodine at the X-ray tube voltages (kVp) of 100 kVp and higher typically used to scan most patients, particularly the obese patient population. Contrast-enhanced CT stands to be revolutionized through further development (clinical trials) of this team's **tantalum** nanoparticle-based intravascular contrast agent (**Figure 1**) that provides unprecedented vascular delineation in comparison to clinical iodine-based agents regardless of patient body habitus, e.g, mouse, rat, rabbit, or swine.1,3,7 This is due, in part, to **innovative structural engineering and chemical manipulation and of tantalum nanoparticle core-size and coating** that has been demonstrated to control the agent's biological retention, blood pool distribution, and pharmacokinetics.[7,8] The team's tantalum oxide nanoparticle so-called '**TaCZ**' is coated with a carboxybetaine zwitterionic (CZ) shell that is stable to an exceptionally wide range of pH and autoclave conditions.[7] The innovative CZ shell imparts water solubility and features distributed charges but is overall charge neutral, thereby avoiding potential cytotoxicity concerns associated with cationic coatings. This zwitterionic character gives low viscosity and osmolality, promotes rapid renal clearance, and negligible organ retention.

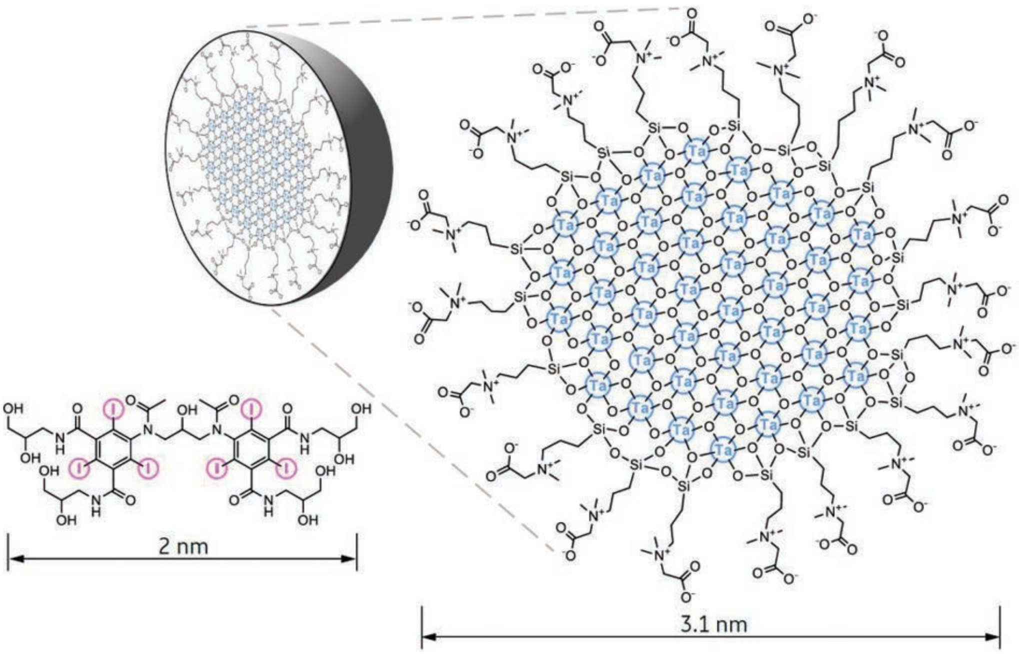


Figure 1. Relative sizes of iodixanol and tantalum agent (TaCZ). Iodine atoms are in magenta; tantalum atoms are in blue. Note that iodixanol is roughly planar, whereas TaCZ is approximately spherical as a nanoparticle.[7-8,10-12]

Intravenous dose injection of **TaCZ** in swine, rats, and rabbits showed no obvious toxicity. High dose rat intravenous injection of 5000 mg Ta/kg showed no obvious toxicity (10X intended human intravenous dose). Oral dosing of 500 mg Ta/kg (3X intended human oral dose) shows minimal blood uptake, with no **tantalum** detected after 24 hours in rats. Intraperitoneal dosing of **TaCZ**, simulating leakage from bowel, showed rapid bodily resorption without obvious toxicity. Profoundly, the biological half-life of **TaCZ** agent is on par with that of small molecule iodinated agents. This discovery is extraordinary since blood pool agents generally have a very long half-life, on the order of days. Unlike prior contrast agents that show blood pool distribution, the **TaCZ** agent this team designed, developed, and tested appears to be "just right" in terms of size at ~3 nm and zwitterionic surface coating, i.e., small enough to be filtered rapidly through the renal collecting system, yet large enough to remain in the blood pool without crossing normal vascular endothelial junctions or showing retention in reticuloendothelial tissues. Indeed, ~99% of injected **tantalum** as **TaCZ** was shown to be eliminated after 48 hours of a bolus-injected dose of 500 mgTa/kg in rat, which is equivalent to clinical iodine agent elimination. *No other injectable nanoparticle formulation for CT (from academia or industry) is known to match this* ***team's innovation*** *in terms of* ***TaCZ*** *agent biological safety (clearance) coupled with clinically relevant physicochemical properties of concentrated agent solutions, e.g., viscosity and osmolality.*

Imaging studies with **TaCZ** showed superior opacification than iodine particularly above 100 kVp in phantoms and swine (**Figure 2**).[1,3,7,9] More profoundly, this team's **tantalum agent** features a CT attenuation profile that is visibly different from vascular calcifications unlike today's commercial iodine- based agents. The novel **tantalum** agent is designed to appear as a different "color" than iodine (or barium or gadolinium) agents at dual energy CT (DECT).[15] When given simultaneously with iodine at DECT, the **tantalum** agent gives high-resolution perfectly co-registered CT delineation of intertwined anatomy in a single 5-second information-rich CT scan without added radiation dose (**Figure 3**).[2] Since approximately 10-20% of current clinical CT scanners in America are DECT capable and approximately 40% of scanners are expected to have DECT capability by 2026, introduction of the team's tantalum agent will catalyze a "color" revolution for multi-contrast multi-energy CT imaging, analogous to the introduction of color television to the grayscale world.[5]

We envision vivid clinical CT contrast agents that are different "colors" from each other to give unprecedented detailed multi- color-contrast CT images for greater accuracy and speed of anatomic diagnosis in a general utility setting and for delineation of a broad range of disease. We feel our work with tantalum as a CT imaging agent, particularly in 2023, is progress to unlock powerful diagnostic abilities of multi-energy CT and transform the capability of CT for oncologic imaging.

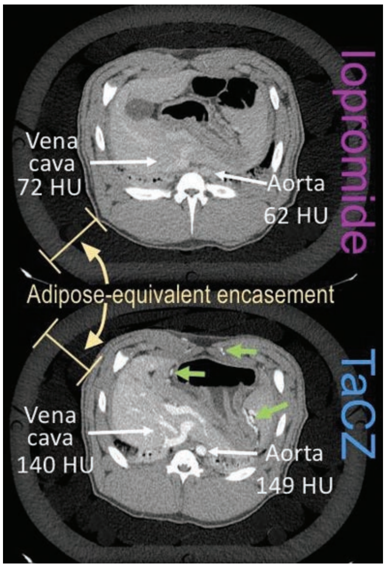


Figure 2. Vascular delineation at CT in swine encased within adipose-equivalent rings to simulate obese patient size, imaged 80 sec after intravenous **500 mg iodine/kg** versus **500 mg Ta/kg** bodyweight. Intravascular iodine signal (iopromide) is faint; tantalum vascular signal (TaCZ) is vivid. Small vessels (green arrows) are revealed only on the TaCZ image.[3]

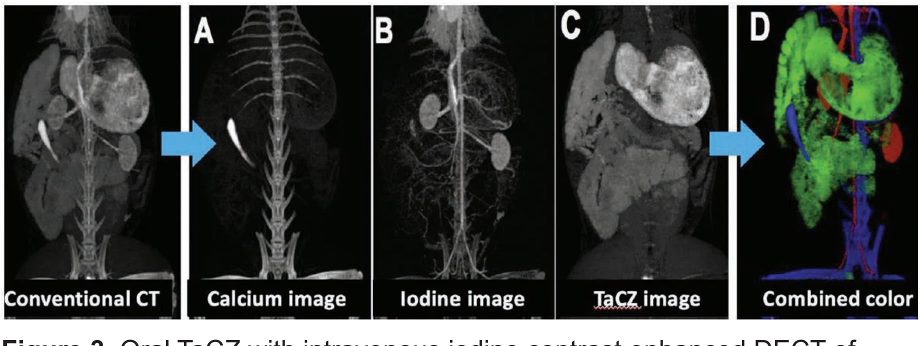


Figure 3. Oral TaCZ with intravenous iodine contrast enhanced DECT of rabbit. (Left) is readily decomposed into individual high resolution (A) calcium bone; (B) iodine vascular; (C) TaCZ bowel images and recombined in (D) color to intuitively clarify anatomic relationships. With TaCZ, any clinical MECT scanner can give similar image reconstructions without need to upgrade either the scanner hardware or software. Based on material X-ray attenuation at low versus high X-ray spectra, dual-energy data can be reconstructed to better evaluate bony, vascular, and bowel anatomy. These individual high-resolution images can then be recombined into 3D composite color image (D), set to show fine inter-relationships of anatomy depicted by each map.[2]

<u>References and Nominee's Key Publications:</u>

1. Heimer MM, **Sun Y**, Grosu SR, Cyran CC, **Bonitatibus PJ**, Okwelogu N, Bales B, Meyer DE, **Yeh BM** ”Novel Intravascular Tantalum Oxide-based CT Contrast Agent Achieves Improved Vascular Contrast Enhancement and Conspicuity Compared to Iopromide in an Animal Multiphase CT Protocol” Investigative Radiology 2023, Under Review.

2. **Yeh BM**, Heimer MM, **Sun Y**, **Bonitatibus PJ** ”Oral CT Contrast Agents: What's New and Why?” American Journal of Roentgenology 2023, Oct 25 [published online]. DOI:10.2214/AJR.23.29970.

3. **Yeh BM**, FitzGerald PF, Colborn RE, Edic PM, Lambert, **Sun Y**, Stillson C, Marino ME, **Bonitatibus PJ** ”An Intravascular Tantalum Oxide-based CT Contrast Agent: Preclinical Evaluation Emulating Overweight and Obese Patient Size” Radiology 2018, 289, 103-110.

4. FitzGerald PF, Colborn RE, Edic PM, Lambert, **Bonitatibus PJ**, **Yeh BM** ”Liquid Tissue Surrogates for X-ray and CT Phantom Studies” Medical Physics 2017, 44, 6251-6260.

5. **Yeh BM**, FitzGerald PF, Edic PM, Lambert JW, Colborn RE, Marino ME, Evans PM, Roberts JC, Wang ZJ, Wong MJ, **Bonitatibus PJ** ”Opportunities for New CT Contrast Agents to Maximize The Diagnostic Potential of Emerging Spectral CT Technologies” Advanced Drug Delivery Reviews 2017, 113, 201-222.

6. Lambert JW, **Yeh BM**, **Sun Y**, FitzGerald PF, Edic PM, Colborn RE, **Bonitatibus PJ** “The Effect of Patient Diameter on the Dual-Energy Ratio of Selected Contrast-Producing Elements” Journal of Computed Assisted Tomography 2017, 41, 505-510.

7. FitzGerald PF, Butts MD, Roberts JC, Colborn RE, Torres AS, Lee BD, **Yeh BM**, **Bonitatibus PJ** ”A Proposed Computed Tomography Contrast Agent Using Carboxybetaine Zwitterionic Tantalum Oxide Nanoparticles: Imaging, Biological, and Physicochemical Performance” Investigative Radiology 2016, 51, 786-796.

8. Crowder JM, Bates N, Roberts JC, Torres AS, **Bonitatibus PJ** ”Determination of Tantalum from Tantalum Oxide Nanoparticle X-ray/CT Contrast Agents in Rat Tissues and Bodily Fluids by ICP- OES” Journal of Analytical Atomic Spectrometry 2016, 31, 1311-1317.

9. FitzGerald PF, Colborn RE, Edic PM, Lambert JW, Torres AS, **Bonitatibus PJ**, **Yeh BM** ”CT Image Contrast of High-Z Elements: Phantom Imaging Studies and Clinical Implications” Radiology 2016, 278, 723-733.

10. **Bonitatibus PJ**, Torres AS, Kandapallil B, Lee BD, Goddard GD, Colborn RE, Marino ME ”Preclinical Assessment of a Zwitterionic Tantalum Oxide Nanoparticle X-ray Contrast Agent“ ACS Nano 2012, 6, 6650-6658.

11. Torres AS, **Bonitatibus PJ**, Colborn RE, Goddard GD, FitzGerald PF, Lee BD, Marino ME ”Biological Performance of a Size-Fractionated Core-Shell Tantalum Oxide Nanoparticle X-Ray Contrast Agent“ Investigative Radiology 2012, 47, 578-587.

12. **Bonitatibus PJ**, Torres AS, Goddard GD, FitzGerald PF, Kulkarni AM ”Synthesis, Characterization, and Computed Tomography Imaging of a Tantalum Oxide Nanoparticle Imaging Agent“ Chemical Communications 2010, 46, 8956-8958.

13. Heimer MM, **Sun Y**, Okwelogu N, **Bonitatibus PJ**, Meyer DE, Bales B, Houshmand S, **Yeh BM** ”Benchmarking a Novel Intravascular Tantalum Oxide-based CT Contrast Agent in a Multiphase Protocol: Preliminary Results of a Preclinical Study” RöFo 2023, 195(S01), S43. DOI:10.1055/s- 0043-1763058. Also presented at the German X-ray Congress; Wiesbaden, Germany; May 2023.

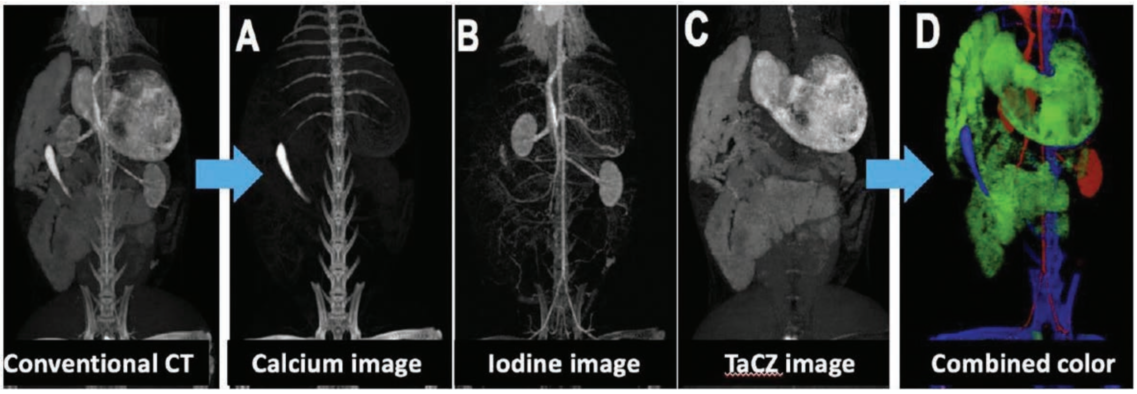
14. Heimer MM, **Sun Y**, Meyer D, Bales B, Okwelogu N, Houshmand S, **Bonitatibus PJ**, **Yeh BM** “Performance of a Novel Intravascular Tantalum Oxide-based CT Contrast for Enhancement and Conspicuity of Thoracic Vasculature in an Animal Model: Total and Relative Contrast Material Advantage” Radiological Society of North America (RSNA); Chicago, IL; November 2023.

15. **Sun Y**, Heimer MM, Yin Z, Bales B, **Bonitatibus PJ**, **Yeh BM** “Evaluation of an Experimental Tantalum Oxide Contrast Material for Material Separation from Iodine and Gadolinium using DECT and PCCT” Radiological Society of North America (RSNA); Chicago, IL; November 2023.

Nominee’s List of 2023 Abstracts - Five (5) abstracts are shown below:

Yeh BM, Heimer MM, **Sun Y**, **Bonitatibus PJ** ”Oral CT Contrast Agents: What’s New and Why?” American Journal of Roentgenology 2023, Oct 25 [published online]. DOI:10.2214/AJR.23.29970.

Current CT oral contrast agents improve the conspicuity and confidence for bowel and peritoneal findings in many clinical scenarios, particularly for outpatient and oncologic abdominopelvic imaging. Yet, existing positive and neutral oral contrast agents may diminish the detectability of certain radiologic findings, frequently in the same scans in which the oral contrast agent improves the detectability of other findings. With ongoing improvements in CT technology, particularly multi-energy CT, opportunities are opening for new types of oral contrast agents to further improve anatomic delineation and disease detection using CT. The CT signal of new dark oral contrast agents and of new high-Z oral [**tantalum**] contrast agents promise to combine the strengths of both positive and neutral oral CT contrast agents by providing distinct CT appearances in comparison with bodily tissues, iodinated intravenous contrast agents, and other classes of new CT contrast agents. High-Z [**Tantalum**] oral contrast agents will unlock previously inaccessible capabilities of multi-energy CT, particularly photon-counting detector CT, for differentiating simultaneously administered intravenous and oral contrast agents; this technique will allow generation of rich 3D, intuitive, perfectly co-registered, high-resolution image sets with individual contrast-agent “colors” that provide compelling clarity for intertwined intra-abdominal anatomy and disease processes.



Heimer MM, **Sun Y**, Meyer D, Bales B, Okwelogu N, Houshmand S, **Bonitatibus PJ**, **Yeh BM** “Performance of a Novel Intravascular Tantalum Oxide-based CT Contrast for Enhancement and Conspicuity of Thoracic Vasculature in an Animal Model: Total and Relative Contrast Material Advantage” Radiological Society of North America (RSNA); Chicago, IL; November 2023.

Purpose: To compare a novel intravenous **tantalum** oxide (TaCZ) nanoparticle CT contrast agent to conventional iodinated (iopromide) CT contrast agent for thoracic artery and vein visualization in a rabbit model.

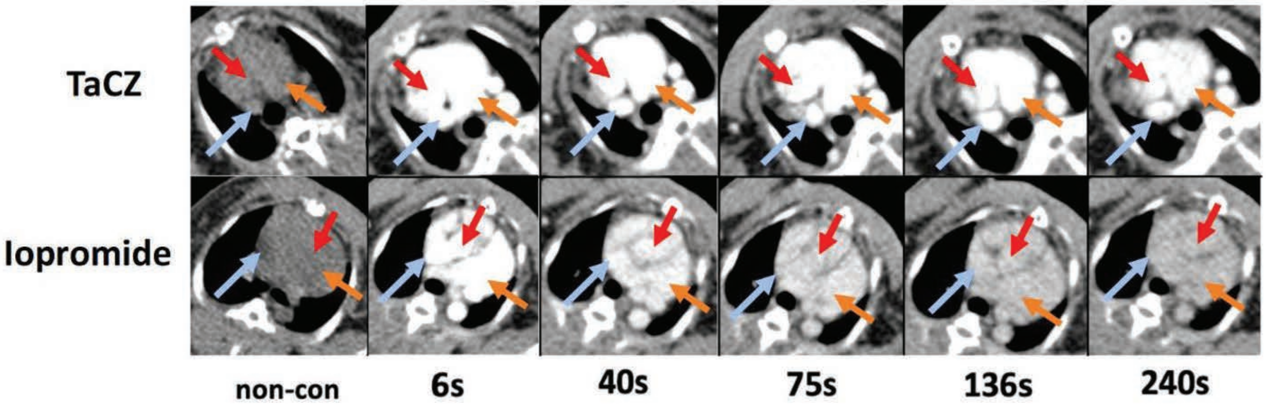
Methods and Materials: Five New Zealand White rabbits were serially placed in a human-torso-sized adipose-equivalent encasement and scanned on a clinical CT system (Philips IQon, Best, Netherlands) before and 6, 40, 75, 136, and 240 sec after intravenous injection of 540 mg element (Ta or I) per kilogram of body weight of TaCZ or iopromide. Animals were scanned twice, once with each contrast agent. Absolute contrast enhancement of the aortic arch, pulmonary trunk, superior vena cava, and subclavian vein was measured in Hounsfield Units (HU) by averaging three regions of interest drawn in the center of the lumen minus corresponding non-contrast measurements. Randomized imaging series were viewed on a clinical PACS system to rate vascular conspicuity on a 5-point Likert scale (0 = no vascular enhancement; 1 = faintly seen or visible but discontinuous; 2 = adequate contrast of main vessel, not all branches seen; 3 = good contrast of main vessel and depiction of branches; 4 = excellent contrast of main vessel and deep branches).

Results: Mean vascular enhancement was significantly higher for **TaCZ** in all examined blood vessels at all time points compared to iopromide; aortic arch at 6s (263 vs. 217; $p < 0.01$), at 40s (265 vs. 145; $p < 0.01$), at 75s (240 vs. 119; $p < 0,01$), at 136s (217 vs. 93; $p < 0,01$) and at 240s (183 vs. 73; $p < 0.01$), pulmonary artery at 6s (296 vs. 266; $p < 0.01$), at 40s (263 vs. 138; $p < 0.01$), at 75s (246 vs. 102; p <

0.01), at 136s (213 vs. 83; p < 0.01) and at 240s (174 vs. 64; p < 0.01)), superior vena cava at 6s (307 vs. 211; p< 0.01), at 40s (255 vs. 127; p < 0.01), at 75s (239 vs. 96; p < 0.01), at 136s (196 vs. 79; p < 0.01) and at 240s (169 vs. 49; p < 0.01) and the subclavian vein at 6s (280 vs. 225; p < 0.01), at 40s (254 vs. 111; p < 0.01), at 75s (236 vs. 86; p < 0.01), at 136s (205 vs. 67; p < 0.01), and at 240s (170 vs. 54; p < 0.01). The mean vascular enhancement of TaCZ at a 136s delay provided comparable results to the 6s arterial phase of iopromide (213 vs. 223; p > 0.05). Overall, vascular enhancement correlated well with perceived vascular conspicuity scores for both agents.

Conclusion: TaCZ provides both an absolute and relative contrast advantage compared to iopromide for improved visualization of the thoracic arteries and veins across a broad range of timepoints after contrast injection.

Clinical Relevance/Application:
TaCZ gives superior prolonged thoracic vascular enhancement over iodine agents at CT and warrants clinical testing as a means to improve the quality and consistency of CT angiograms and venograms.

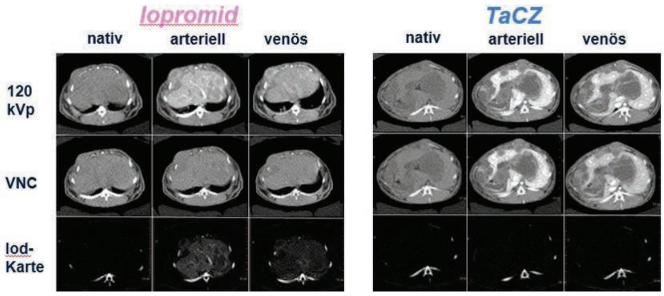


Heimer MM, **Sun Y**, Okwelogu N, **Bonitatibus PJ**, Meyer DE, Bales B, Houshmand S, **Yeh BM** ”Benchmarking a Novel Intravascular Tantalum Oxide-based CT Contrast Agent in a Multiphase Protocol: Preliminary Results of a Preclinical Study” RöFo 2023, 195(S01), S43. DOI:10.1055/s-0043-1763058. Also presented at the German X-ray Congress; Wiesbaden, Germany; May 2023.

Zielsetzung: To compare the CT imaging performance of a novel intravenous carboxybetaine zwitterionic coated **tantalum** oxide (**TaCZ**) nanoparticle CT contrast agent with that of a conventional iodinated (iopamidol) contrast agent in a rabbit model.

Material und Methoden: Four rabbits were serially placed inside an adipose-equivalent encasement emulating normal abdominal girth of 102 cm and scanned on a Spectral CT scanner (Philips IQon, Best, Netherlands) at arterial and venous delays after intravenous injection of 540 mg element (Ta or I) per kilogram of body weight of **TaCZ** or iopamidol. For each time point, contrast enhancement of the aorta, portal and hepatic veins, as well as the liver parenchyma were measured in Hounsfield Units (HU) by placing circular regions of interest. Effective Z-numbers were also measured for the aorta and liver parenchyma. Findings were compared using a paired T-test for independent samples.
Ergebnisse: Mean peak enhancement for both arterial and venous phases were higher for **TaCZ** than for iopamidol in the aorta (365 vs. 264 HU p=0,62; and 227 vs. 142 HU p<0,001), portal vein (406 vs. 220 HU p=0,01; and 251 vs. 145 HU p=0,001), hepatic vein (227 vs. 168 HU p=0,34; and 257 vs. 145 HU p<0,001) and liver parenchyma (166 vs. 112 HU p=0,049; and 147 vs. 110 HU p=0,029). Effective-Z measurements were significantly lower in both the aorta (6,72 vs. 9,94 p=0,019; and 7,04 vs. 8,79 p<0,001) and liver parenchyma (7,01 vs. 8,24 p=0,002; and 7,07 vs. 8,14 p<0,001) after injection of **TaCZ** compared to iopamidol.

Schlussfolgerungen: An experimental **tantalum** nanoparticle–based intravenous contrast agent showed greater contrast enhancement compared with iopamidol at arterial and venous delay phases in a rabbit model; spectral decomposition algorithms allow differentiation of **tantalum** and iodine which indicates valuable applications for multi-energy CT imaging.



Sun Y, Heimer MM, Yin Z, Bales B, **Bonitatibus PJ**, **Yeh BM** "Evaluation of an Experimental Tantalum Oxide Contrast Material for Material Separation from Iodine and Gadolinium using DECT and PCCT" Radiological Society of North America (RSNA); Chicago, IL; November 2023.

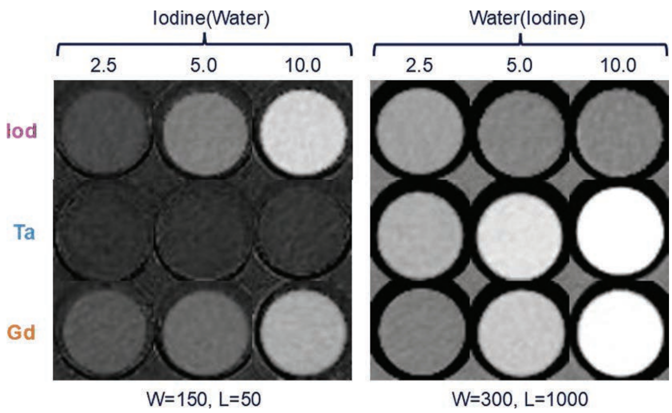
Purpose: To evaluate material separation of an experimental **tantalum**-oxide nanoparticle contrast agent (TaCZ) from iodine and gadolinium, using clinical DECT and a prototype deep silicon PCCT scanner.

Materials and Methods: Vials of the following concentrations of contrast agents: 2.5, 5.0, 10.0 mg iodine/mL (Ultravist, Bayer); 2.5, 4.0, 5.0, 12.0 mg Gd/mL (Multihance, Bracco); 2.0, 2.5, 4.0, 5.0, 6.0, 8.0, 10.0, 12.0 mg Ta/mL (TaCZ) were scanned in a water-equivalent CT phantom (MECT Phantom, Gammex) on a clinical fast-kV switching DECT scanner (Revolution CT, GE) and a prototype deep silicon PCCT. Paired iodine and water material decomposition (MD) images were generated for both scanners. Also, PCCT bin images were generated (bin A, 44–52 keV; bin B, 52–60 keV; and bin C, 60–80 keV). ROIs were drawn on 10 slices per vial for all image reconstructions to measure average CT attenuation, iodine and water signals. Slopes of iodine vs material concentration graphs were compared for MD images, and higher to lower bin CT number ratios were compared in the bin images.

Results: Slopes of iodine signal versus elemental concentration for DECT and PCCT are 1.06 and 0.93 for iodine; 0.38 and 0.02 for Gd; and 0.10 and -0.04 for Ta, respectively. For MD maps, a larger slope difference is seen for iodine vs Ta than for iodine vs Gd, suggesting better spectral separation of iodine from Ta by DECT and possibly PCCT. Separation of Ta from Gd appears modest (Δ = 0.28) but poor for PCCT (Δ = 0.14) because both materials are correctly classified as non-iodine by 2-MD. However, in PCCT bin images, Gd signal (K-edge 50.2 keV) is optimized between bins A & B with an attenuation ratio of ~1.38 between those bins, while Ta signal (K-edge 67.4 keV) is optimized between bins B & C with a ratio of ~1.26. Attenuation ratios of other materials, including iodine and water are all ≤ 1.0 for these same bin pairs, indicating promising bin-based material separation of Ta and Gd from iodine and other materials.

Conclusion: Iodine signal is more readily separated from that of Ta than Gd by DECT material decomposition images and is slightly more readily separated from that of Ta than Gd by PCCT. When using PCCT bin (non-MD) images, both Gd and Ta signals are readily differentiated from that of iodine, from each other, and from other materials.

Clinical Relevance: Experimental **TaCZ** contrast gives a strong "color" signal that should be readily separated from iodine signal by both DECT and PCCT, and from Gd for PCCT, and may enable future multi-color contrast discrimination.



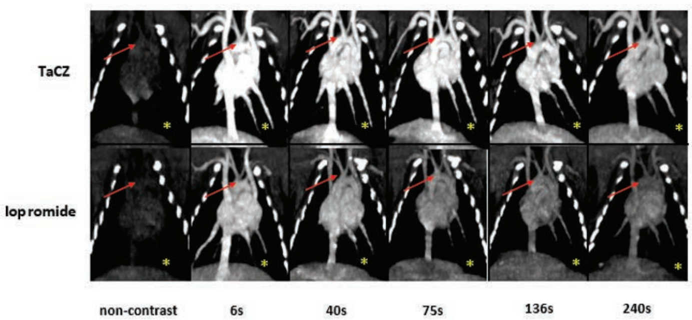
Heimer MM, **Sun Y**, Grosu SR, Cyran CC, **Bonitatibus PJ**, Okwelogu N, Bales B, Meyer DE, **Yeh BM** "Novel Intravascular Tantalum Oxide-based CT Contrast Agent Achieves Improved Vascular Contrast Enhancement and Conspicuity Compared to Iopromide in an Animal Multiphase CT Protocol" Investigative Radiology 2024, Under Review.

Purpose: To assess temporal thoracic vascular contrast enhancement of a novel intravenous **tantalum** oxide (TaCZ) nanoparticle CT contrast agent compared to a conventional iodinated CT contrast agent (iopromide) in a rabbit multiphase CT protocol.

Materials and Methods: Five New Zealand White rabbits were scanned inside a human-torso-sized adipose-equivalent encasement on a clinical CT system (Philips IQon, Best, Netherlands) before and 6, 40, 75, 136, and 240 s after intravenous injection of 540 mg element (Ta or I) per kilogram of body weight of TaCZ or iopromide. Both contrast agents were assessed in a single session. Net contrast enhancement of various arteries and veins as well as image noise were measured. Randomized scan series were reviewed by three independent readers on a clinical PACS system and assessed for vascular conspicuity and image artifacts on 5-point Likert scales.

Results: Overall, vascular enhancement achieved with TaCZ was superior to iopromide in all examined thoracic vessels and at all time points (all; $p < 0.05$), except for the inferior vena cava (IVC) at 6 s ($p = 0.132$); achieved contrast enhancement was highest for TaCZ at 6 s (296.3 ± 21.4 HU) and lowest for iopromide at 240s (49.3 ± 10.9 HU). Overall, achieved arterial contrast enhancements of TaCZ at delays of 6, 40, and 75 s were superior to optimum achieved iopromide contrast enhancement (all; $p < 0.05$, except IVC at 6s). Vascular conspicuity achieved with TaCZ was superior compared to iopromide at all time points (all; $p < 0.05$), with substantial inter-reader reliability ($\kappa = 0.61$; $p < 0.001$) and strong positive monotonic correlation between subjective conspicuity scores and objective measurements ($\rho = 0.828$; $p < 0.001$).

Conclusion: TaCZ provides absolute and relative contrast advantage compared to iopromide for improved visualization of thoracic arteries and veins in a multiphase CT protocol.



65th GENERAL ASSEMBLY, TECHNICAL PROGRAMME

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Monday September 9th, 2024

All presentations will be held in the plenary room: 1F Apollon -

(Coffee Break 9:30 – 10:00) 1F Orion

Session 1 *(10:00 to 11:45)*

New Member, ExCom & President Introductions

10:15 to 10:45

#1: KEYNOTE:
Japan Organization for Metals and Energy Security (JOGMEC) – Critical Minerals
Speaker - Mr. KUBOTA Hiroshi, Executive Vice President, Member of the Board, Metals.

10:45 – 11:15
#2: Tantalum Past, Present & Future: Trends, Issues, Opportunities: - OnG Commodities LLC
Speaker - Dr Andre Matheson

11:15 – 11:45
#3: 50 years of Ta Capacitor Powder Development - JX Advanced Metals Corporation/Taniobis GmbH
Speaker - Dr Melanie Stenzal

65th GENERAL ASSEMBLY, TECHNICAL PROGRAMME

(Lunch 11:45 to 13:00) 1F Orion

Session 2 *(13:00 to 15:00)*

13:00 – 13:30
#4: 50 years of Ta Capacitor Development - KEMET Electronics Corp./YAGEO Group
Speaker - Dr Philip Lessner

13:30 – 14:00
#5: The Future of Ta in AM medical implant applications - Global Advanced Metals
Speaker - Dr Gordon Smith

(Coffee break 14:00 – 14:30) 1F Orion

Session 3 *(14:30 – 15:30)*

14:30 – 15:00
#6: Research on Tantalum and Tantalum alloy Additive Manufacturing (3D Printing) – Ningxia Orient Tantalum Industry Co., Ltd
Speaker - Mr Xu Tao

Day 1 Adjournment

Tuesday September 10th, 2024

All presentations will be held in the plenary room: 1F Apollon

Session 4 *(9:00 to 10:00)*

09:00 to 09:30
#7: KEYNOTE:
Ekeberg Prize Presentation - The clinical translation of a tantalum oxide nanoparticle-based contrast agent for improved diagnostic CT imaging capabilities and patient safety through extensive non-GLP and GLP preclinical development, safety tests, and efficacy tests

09:30 to 10:00
#8: Niobium: Retrospective and Future Outlook - CBMM
Speaker - Isadora Maria Oliveira Anicio Costa

(Coffee Break 10:00 – 10:30) 1F Orion

65th GENERAL ASSEMBLY, TECHNICAL PROGRAMME

Session 5 *(10:30– 12:00)*

10:30 – 11:00
#9: Niobium: Critical, Essential, Dynamic – Project Blue
Speaker - Mr Eric Sardain

11:00 – 11:30
#10: Niobium: Shaping the Future of Energy Storage and Conversion - CBMM
Speaker - Dr Marc Meads

11:30 – 12:00
#11: AM & C-103 for Space Applications – Castheon Inc./Addman Group
Speaker - Dr Jacob Rindler

(Lunch 12:00 to 13:00) 1F Orion

Session 6 *(13:00 – 15:00)*

13:00 to 13:30
#12: Revolutionizing Tantalum and Niobium Recovery with MOE (Metal Oxide Electrolysis) Technology - Boston Metal
Speaker - Gustavo Macedo

13:30 to 14.00
 # 13: A Guide to Utilizing ITSCI Supporting Information - RBA/RMI
Speaker - Josue Ruiz

14:00 to 15:00
#14: Future Innovation in Ta and Nb – Panel Discussion

Panel Members:
Dr. Philip Lessner - CTO KEMET Electronics/YAGEO Group
Dr. Gordon Smith - CTO Global Advanced Metals
Dr. Rafael Agnelli Mesquita - CTO CBMM
Mr Takeo Okabe - Deputy General Manager, Thin Film Material Division, JX Metals
Mr Fred Carrington - Director of Sales - Exotech, Inc

Looking out over the next 5-10 years, the panel will discuss the innovation and changes in form factors necessary to satisfy the technical trends, demands, and opportunities for tantalum and niobium, over the 5-10 year period, and beyond.

Day 2 Adjournment

65th GENERAL ASSEMBLY, TECHNICAL PROGRAMME ABSTRACTS

Abstracts are of the lead presenting author and panelists (alphabetical by surname)

Dr. Rafael Agnelli Mesquita, Chief Technical Officer & Director, CBMM Suisse Technology
Future innovation in Ta and Nb - Panel Discussion

Fred D. Carrington, Director of Sales, Exotech
Future innovation in Ta and Nb - Panel Discussion

Isadora Costa, Niobium Metal Production Manager, CBMM
How Niobium Has Revolutionized Technology Over the Past 50 Years
Over the past fifty years, niobium has significantly impacted various technological advancements, emerging as a crucial element in multiple industries. Initially discovered in the early 19th century, its unique properties were not fully recognized until the mid-20th century. Niobium's exceptional strength, light weight, and resistance to corrosion have made it indispensable in the aerospace, automotive, and energy sectors. In the automotive industry, it has enhanced the safety and efficiency of vehicles by strengthening steel and reducing weight, leading to lower fuel consumption and emissions. In aerospace, niobium alloys have improved the performance and durability of jet engines and spacecraft. Furthermore, niobium's superconducting capabilities have revolutionized the field of medical imaging, particularly in MRI machines, providing clearer images and more accurate diagnoses. The energy sector has also benefited, with niobium being a key component in the development of advanced batteries and fuel cells, contributing to cleaner and more sustainable energy solutions. This remarkable element continues to drive innovation, pushing the boundaries of technology and opening new possibilities for future advancements. Niobium's role in transforming technology over the past five decades highlights its importance and potential for ongoing contributions to various scientific and industrial fields. As research continues, the potential applications of niobium are expected to expand, offering new solutions and enhancing technological progress across various fields.

Mr. Kubota Hiroshi, Executive Vice President, Member of the Board, Metals, JOGMEC
Keynote Japan Ministerial Speaker - Critical Minerals

Dr. Philip Lessner, Chief Technology Officer, YAGEO Group

50 Years of Tantalum Capacitor Development & Future innovation in Ta and Nb - Panel Discussion

The first tantalum capacitors developed in the 1930s by Tansitor Electronic Inc. were wound foil wet electrolyte capacitors for military applications. In the 1950s, at the beginning of the transistor age, Bell Laboratories developed the first solid electrolytic tantalum capacitors with a manganese dioxide second electrode. This was followed by rapid commercialization by companies such as Sprague Electric and KEMET. Over time tantalum capacitors have come to be the component of choice in space constrained and high reliability applications due to their high volumetric efficiency and extreme environmental stability. Technological advances such as higher surface area tantalum powders (increased CV/g) resulted in tantalum capacitors with increased performance as electronic circuits became increasingly complex. In the early 1990s, NEC introduced solid tantalum capacitors with the manganese dioxide second electrode replaced by an intrinsically conducting polymer. This dramatically reduced the equivalent series resistance (ESR) of these capacitors allowing tantalum capacitors to be used in many demanding applications in modern electronics. In this presentation, we will look back at this interesting evolution in tantalum capacitors and touch on what might be next.

Dr. Andrew Matheson, OnG Commodities LLC

Tantalum past, Present & Future: Tends, Issues, Opportunities

Gustavo Macedo, Commercial Director, Boston Metal do Brasil

Revolutionizing Tantalum and Niobium Recovery with MOE (Molten Oxide Electrolysis) Technology

Boston Metal is leading the way in sustainable and efficient metal recovery with its innovative Molten Oxide Electrolysis (MOE) technology. This advanced platform uses clean electricity to extract high-value metals like tantalum and niobium from mining and metallurgical waste, addressing key environmental and economic issues. MOE technology excels at converting low-concentration, complex materials into valuable products, significantly reducing the liabilities tied to traditional mining waste. The first commercial plant, located in Minas Gerais, Brazil, will start generating revenue by Q1 2025, showcasing this groundbreaking approach.

The MOE technology is notable for its scalability and flexibility, allowing metal recovery from diverse feedstocks without the need for hydrogen infrastructure, carbon capture, utilization, storage (CCUS), or excessive water consumption. This makes MOE the most cost-effective and sustainable solution in the metal recovery industry. Boston Metal's operations in Brazil benefit from the region's abundant resources and skilled workforce, ensuring a strong supply chain and operational efficiency. As the company advances towards full-scale industrialization, its technology is poised to revolutionize the tantalum and niobium market by offering a greener, more efficient metal recovery process.

Explore how Boston Metal's MOE technology is set to transform the future of metal recovery, driving innovation and sustainability in the tantalum and niobium sectors.

Marc Meads, Business Development Manager for battery products, CBMM

Niobium in Energy Storage Materials, Reducing The Cost and Carbon Footprint of Electrification

This presentation explores the role of niobium in battery electrode active materials and the market potential for niobium powered batteries. Niobium is already used widely as an additive in lithium manganese oxide (LMO) cathode active material as a result of its positive influence on electrode durability and inhibition of performance degrading reactions at the cathode particle surface. Niobium is being adopted industrially in lithium iron manganese phosphate (LMFP) for similar reasons as for LMO, and in nickel-based cathode chemistries, such as nickel, cobalt and manganese oxides (NCM), where the use of niobium oxide can help cathode producers and cell manufacturers to reduce costs. Niobium is also emerging as a key element in anodes, where it enables high input power, high output power and long service life without sacrificing energy density or safety. This combination of benefits makes niobium anode materials particularly attractive for electrification of heavy duty equipment which often relies today on oversized lithium iron phosphate (LFP) battery packs. The high power input capability of niobium anode active materials means that well-formulated niobate anode batteries can be charged quickly, typically within 5 to 10 minutes and in some cases as fast 1 minute. As well as enhancing user convenience, fast-charging niobate batteries and be designed smaller and lighter than alternativie technologies, meaning less material intensity (reduced environmental impact) and helping to reduce total lifetime costs for equipment owners and operators.

Dr. Jacob Rindler, Director of Materials and Manufacturing Technology, ADDMAN

Additive Manufacturing of C103 via L-PBF: Cost , Lead Time, and Performance Improvements Lead Wire Composite

Niobium alloy C-103 is a proven commodity used for critical aerospace applications since it development in the 1960's . It's gained preferred status due to its combination of strength at temperatures above 1000C and ability to be formed, welded , and machined. As the space economy has exploded, so has the demand the for this stalwart alloy. In this presentation attendees will learn some history of the development of this alloy, some of its many famous applications, and how Castheon has reinvented it though Laser Powder Bed Fusion (L-PBF) processing. The authors will present a comprehensive comparison between the wrought and printed microstructure and how this translates into substantial performance benefits. These will be discussed in detail including its mechanical strength across multiple temperature regimes, oxidation resistance, and creep performance. Alongside this data details of how the manufacturing maturity of this unique manufacturing technology have been advanced to utilize it in the most critical of applications including man rated space flight. Finally a review of how traditional cost performance curves have been upset in practice will shared.

Josue Ruiz, RBA/RMI

A Guide to Utilizing ITSCI Supporting Information

The Enhanced Due Diligence (EDD) Process provides essential guidance for facilities sourcing minerals from Conflict-Affected and High-Risk Areas (CAHRAs). This is particularly relevant for facilities in the Great Lakes Region (GLR), where sourcing challenges are significant. To address these challenges, the Responsible Minerals Initiative (RMI) has developed the iTSCi Diagnostic Tool. The iTSCi Diagnostic Tool is a key component of RMI's specialized technical assistance designed to support facilities using iTSCi for EDD. It offers a structured approach to identifying additional measures beyond what iTSCi alone provides. The tool is tailored to help facilities ensure compliance with RMAP standards, enhance transparency, and address specific risks associated with mineral sourcing in CAHRAs. This presentation will focus on the iTSCi Diagnostic Tool, outlining its role, purpose, and scope. It will explain how the tool integrates with the EDD Process to provide comprehensive support for facilities navigating the complexities of responsible mineral sourcing. Key aspects of the tool's functionality, its benefits for compliance, and its impact on improving due diligence practices will be highlighted.

Erik Sardain, Project Blue

Niobium: A critical mineral with a dynamic outlook

Niobium is undergoing a major shift in its market dynamics. Niobium is mainly used as a micro alloy to increase steel's strength and resistance and is therefore often considered as a 'green metal' in a global industry de-carbonisation thematic. Although steel will continue to represent the main end-use for niobium through ferro-niobium, new opportunities are emerging, which could increase niobium's use in critical applications. Niobium oxides are already used in the aerospace and oil & gas industries in the form of vacuum-grade ferroniobium and nickel-niobium but also for optical-grade applications. Promising developments are coming from the medical industry, with the fast-growing magnetic resonance imaging (MRI) market, and other niche applications such as rockets and particle accelerators using niobium alloys. CBMM, the world largest niobium producer, is more specifically betting on batteries for future diversification, both anodes and cathodes, with expectations that the sector will contribute to about 25% of its revenues by the end of the decade. There is still uncertainty about the commercialisation of niobium-containing batteries, as the industry is still in its early development phase and could take longer than expected to come onstream. But, nevertheless, new opportunities are developing, and niobium is likely to become an increasingly critical material in the years to come.

Gordon Smith, Global Advanced Metals
3D Printing Tantalum with a Focus on Medical Devices & Future innovation in Ta and Nb - Panel Discussion
The use of 100% additive technologies (3D Printing) in the production of components and devices is growing at double-digit rates, and this growth rate is expected to continue. The growth of additive technology adoption has created an opportunity to bring alternative material solutions to the market to create products with unique enhanced performance. Traditional materials such as the alloy Ti6Al4V, are widely accepted in additive manufacturing to produce a variety of devices such as acetabular cups (medical device) and jet engine fuel nozzles (aerospace). These traditional materials have deficiencies, but are used due to being the best available offering. Tantalum, with its unique properties, can address traditional material deficiencies in many applications, one of the best examples being medical implants, by enhancing the biocompatibility, thermal performance, and corrosion resistance of devices. These enhancements offer a distinctive product value proposition to the market. Enabling the use of tantalum in additive manufacturing offers a unique capability for device manufacturing, addresses many current consumer challenges, and exposes participants to high growth markets. For many years, Global Advanced Metals (GAM) has been successfully supplying tantalum powder to additive manufacturing customers. Working with printer manufacturers, service bureaus, and autonomous organizations, we are continuously developing a deeper understanding of printed part performance. We will share our understanding of tantalum in additive manufacturing, focusing on medical devices, and our up to date observations on the technical performance of printed tantalum.

Dr. Melanie Stenzel, Director of Marketing, TANIOBIS GmbH
The tantalizing journey of Tantalum. A retro-perspective to powder development.
While the innovations for Tantalum in electronics are of course the driver of our market, it is worthwhile to explore the development of this element from a broader perspective. How has the application split changed over the roughly 100 years of active development?
However, the main focus and innovation driver has always been Tantalum powder for capacitors pushing the boarders of capacity and energy density achievable further and further. While in the 70th a powder providing 8,000 µCV powder was perceived as "high CV" and in the 80th some specialists even anticipated, that "no further improvements in capacitance" would be possible, the "high CV" powders today can provide up to 400,000µF/g. This journey was enabled by excellent scientists and development engineers making important improvements but also inventing new processes to go beyond the status-quo.
This presentation will review the challenges and necessary inventions required to continue the ever-increasing CV/g journey demanded by the leading-edge electronic technologies that guide and drive our daily lives.

Okabe Takeo MEng, Executive Officer, JX Advanced Metals Corporation
Future innovation in Ta and Nb - Panel Discussion

Mr. Xu Tao, Director of Resources Development at CNMC Ningxia Orient Group Corp
Research on Tantalum and Tantalum Alloy Additive Manufacturing (3D Printing)
Additive manufacturing has the advantage of efficiently forming complex structures, providing a new solution for the efficient and high-quality preparation of tantalum and tantalum alloy components for aerospace and military applications. This article studys the preparation process of

pure Ta and Ta10W alloy spherical powders, achieving spherical metal powders with a sphericity more than 95%; similiar density Ta and Ta10W alloys were formed by using laser selective melting additive manufacturing (3D printing) technology. And the effect of heat treatment after 3D printing on the microstructure of Ta10W alloy was further studied. It was found that the grain boundary structure has good thermal stability and can only be eliminated by heat treatment above 1850 °C. At the same time, it was found that the Ta10W alloy formed by additive manufacturing has superior room temperature mechanical properties compared to the pressure processed Ta10W alloy, with slight loss of high-temperature mechanical properties. This article explores the preparation process of spherical powders of tantalum and tantalum tungsten alloys, and realizes the dense additive manufacturing of high-performance tantalum metal and alloys, which has guiding significance for the additive manufacturing of high-performance refractory alloys.

Diary of industry events*

November 2024

RBA and RMI Annual Conference 2024 November 18th to 21st in San Jose, California USA https://www.responsiblebusiness.org/training-events/ac2024/

Formnext Frankfurt, 19th to 22nd November 2024 https://formnext.mesago.com/frankfurt/en.html

IAEA- TRANSSC 49 18th to 22nd November Vienna Austria https://www.iaea.org/events/evt2206925

February 2025

Investing in African Mining INDABA 3rd to 6th February 2025 in CapeTown South Africa https://miningindaba.com/page/associate-your-brand?utm_term=mining%20indaba&utm_campaign=Search+%7C+MI+%7C+2025

April 2025

MMTA International Minor Metals Conference 2025 April 7th to April 9th Lisbon Portugal https://mmta.co.uk/event/mmta-international-minor-metals-conference-2025/

Rapid TCT 2025 April 8th to 9th Detroit USA https://www.rapid3devent.com/

June 2025

PowerMet 2025 June 15th to 18th Phoenix USA https://www.mpif.org/EventsCourses/PowderMet2025/PowderMet2025.aspx