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WELCOME LETTER FROM THE TITANIUM EUROPE COMMITTEE CHAIR

Dear Delegates,

As this year’s conference chair, it is my pleasure to welcome you to the 4th TITANIUM EUROPE 2016 conference in Paris, France.

This year’s conference will draw attendance from a wide range of industry professionals. The morning sessions will address the World Titanium Industry Supply and Demand Trends. We especially want to welcome Dr. Claudio DALLE DONNE, VP Materials and Processes and Raphael DUFLOS, VP Metallic Materials Procurement from Airbus S.A.S. who will present Titanium Aerospace Demand & Integrated Supply Chain on Tuesday morning.

The afternoon program will consist of interesting presentation tracks in parallel with important information covering medical application, powder metallurgy, titanium aluminides, industrial markets, manufacturing and melting technologies.

The keynote address will be given by Mr. Thierry VIGUIER, purchasing director of materials for Safran SA, Paris. Safran is a French multinational designer and manufacturer of aircraft and rocket engines related aerospace components. Mr. VIGUIER will share his expertise to address trends in the global aerospace industry, a key market for titanium mill products. Growth in the aerospace industry along with the higher use of carbon fiber composites, which are compatible with titanium, is likely to increase the demand for titanium. As lightweight materials that provide outstanding corrosion resistance and high-temperature properties, titanium mill products have long been the preferred material of choice for aircraft manufacturers in a range of applications such as structural components and engine parts.

Charles Armitage, European Aerospace & Defence Equity Analyst with UBS and Bill Bihlman, President of Aerolytics LLC will host the Development of Commercial Aerospace & Economic Impact session on Wednesday and then we will close the program with industry related tours, your choice of ONERA, the French national aerospace research centre or the Musée Aeronautique et spatial Safran (Safran Aerospace Museum) which hosts an exhibition of the first aircraft engines to the Ariane 5 launcher.

TITANIUM EUROPE 2016 is a platform providing insights into the European titanium industry an excellent opportunity for you to meet with ITA members from all over the world, creating an opportunity for networking, collaboration, sharing of information and the building of relationships internationally.

For those of you returning, we appreciate your continued participation and for those of you who join us for the first time, thank you for attending this year’s event and I look forward to meeting you in Paris.
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Marisa Henriksen  
Conference Registration & Housing

Rebecca Verhaeghe  
Membership Services Associate

Contributor

Michael Gabriele  
A former managing editor with American Metal Market, Michael C. Gabriele has been a journalist for over 35 years and has done extensive freelance work for the International Titanium Association since 2005. He is based in Clifton, NJ.

Educational Instructors

Dietmar Fischer

James Robison

Frauke Hogue
ABOUT THE INTERNATIONAL TITANIUM ASSOCIATION

The ITA is a membership based international trade association dedicated to the titanium metal industry. Established in 1984, the ITA is the only international trade association dedicated exclusively to titanium metal. The Association's main mission is to connect the public interested in using titanium with specialists from across the globe who may offer sales and technical assistance.

The Association benefits from having a wide variety of Member organizations consisting of Producers, Fabricators, Suppliers, End users, Consumers, and Academia from over 20 countries worldwide. Current membership is comprised of over 200 organizations, which consists of over 1,500 individual members.

ITA also sponsors educational workshops, manages a variety of technical and marketing committees, and hosts the TITANIUM Conference series dedicated exclusively to the titanium metal industry.

Contact us to learn more about membership benefits or ask an ITA Staff member for a membership application today.

Visit us at www.titanium.org

NO PHOTOGRAPHY AT TITANIUM

ENGLISH
Absolutely no photography or video is permitted in the General Session or Exhibition Hall.
Copies of all presentations will be provided to delegates in the ITA Conference Proceedings.
Thank you for your cooperation and understanding.

GERMAN
Während der Hauptversammlung sowie in der Ausstellungshalle sind Foto- und Videoaufnahmen strikt untersagt.
Die Tagungsteilnehmer erhalten Kopien aller Präsentationen in den ITA-Tagungsberichten.
Vielen Dank für Ihr Entgegenkommen und Ihr Verständnis.

ITALIAN
È tassativamente vietato scattare fotografie ed effettuare riprese video durante la Sessione generale e nella Sala esposizioni.
Una copia di tutte le presentazioni sarà inclusa negli Atti del Congresso ITA.
Vi ringraziamo per la collaborazione e comprensione.

Simplified Chinese
在综合会议室或展览大厅内，绝对不允许进行摄影或录像。
参加ITA会议的代表将会得到所有陈述的副本。
谢谢您的合作和谅解。

Japanese
一般セッションまたは展示ホールにおいての写真およびビデオ撮影は禁止されています。
全プレゼンテーションのコピーは、ITA会議議事録として代表者に配布される予定です。
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TITANIUM EUROPE 2016 | April 18-20 | Paris, France
Why You Should Attend
This comprehensive workshop will provide attendees with detailed information on the types, uses, and properties of common titanium alloys. Attendees will leave with an understanding of applied titanium metallurgy fundamentals.

Course Information
Objectives & Content:
Fundamentals of Titanium will prepare you to present and work effectively with job related functions that involve titanium.
You will receive a complete overview of titanium and a thorough grounding in its metallurgy, characteristics, properties and uses.
As part of the course, ITA will provide attendees with a comprehensive study guide to serve as reference tools to utilize the information as needed in the workplace.

Class Information
Workshop registration fee includes: refreshments, lunch, and study guide

Instructor
Mr. Fischer has been involved in the titanium industry for almost 50 years. His main focus is dedicated to the current status and future development of the titanium market (Germany, Europe, World). His fields of application for titanium materials include aerospace and industrial applications, medical engineering and mechanical engineering. Current concentration is on optimization of value chain with producers, suppliers, traders or customers and improvement of production engineering or facilities, claim management and settlement, material testing and other issues.

Dipl.-Ing.
Dietmar Fischer,
Titanium Consultancy & Training
# TITANIUM EUROPE 2016 AGENDA

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## Monday, 18 April
Registration Open 12:00 - 19:00

- **08:00 – 17:00** Fundamentals of Titanium
- **09:00 – 16:30** Metallography of Titanium and its Alloys

## Tuesday, 19 April
Registration Open 07:00 - 19:00
Exhibition: 09:00 - 12:00

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- **08:30 - 16:30** Optional Sessions
- **18:00 – 20:00** Welcome Reception

## Wednesday, 20 April
ITA Safety Committee Meeting 07:00 - 08:00
Registration Open 07:00 - 13:00
Exhibition: 09:00 - 12:00

- **08:00 - 09:00** Keynote Speaker
- **09:00 - 09:30** Break
- **09:30 - 10:45** World Titanium Supply Trends

- **11:00 - 12:15** Development of Commercial Aerospace & Economic Impact
- **12:15 - 13:00** Networking Luncheon

- **14:00 – 20:00** Exhibitor Tear Down
- **13:00 – 17:30** ONERA Laboratories Tour
- **13:00 – 18:00** Safran Museum Tour

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- Alcoa
- Aerometals & Alloys
- CEFIVAL

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**Optional Sessions**

**Breaks/Meals**

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WOMEN IN TITANIUM 2016 ACTIVITIES

We hope you will mark your calendar, forward this message to friends and colleagues, and will find time to join us for one or more of the following events.

Monday April 18th – 4:30 – 6:00 pm
Paris Marriott Rive Gauche Hotel & Conference Center
17 Boulevard Saint-Jacques
Paris 75014 France

Join us for table top displays outlining the services and programs Women in Titanium offers, network with other like-minded professionals, and enjoy refreshments and canapés. Members of the WiT Executive Committee will be in attendance to answer any questions you have regarding WiT’s mission and objectives.

Thursday June 16th – Friday June 17th
Sheraton Pittsburgh Hotel at Station Square
300 W Station Square Dr.
Pittsburgh, Pennsylvania, 15219 USA
1-888-627-7029 To Reserve a Guest Room

Our Fundamentals of Titanium Workshop will be offered all day Thursday, followed by an evening networking reception at the Grand Concourse Seafood Restaurant. On Friday transportation will be provided to Dynamet Incorporated where we have been invited to an industry tour of their facility where we will see the Rolling Mill, Bar, Wire and Fine Wire Finishing.

Sunday September 25th
10:00 am – 5:00 pm
2nd Annual WiT Conference

The 2nd annual Women in Titanium (WiT) conference will be held in conjunction with the 2016 TITANIUM USA Conference and Exhibition at the J. W. Marriott Desert Ridge Resort and Spa in Scottsdale, Arizona US.

The WiT forum will feature a lineup of guest speakers with expertise in various fields of business and career development. Dawne S. Hickton, ITA’s president, WiT chair, and the former chief executive officer of RTI International Metals Inc., will welcome attendees and offer opening comments.

One-on-one coaching sessions with Echo Communications will also be offered to the first 12 participants who register so reserve your space today!

The primary mission of the WiT committee is two-fold: to develop a networking group of collegial women currently employed in the titanium industry; and to attract high school and college female students to enter the titanium industry.

You do not need to be an ITA Member to attend WiT events.

Call Us Today to Learn More!

ITA Women in Titanium Executive Committee Members

Dawne Hickton
ITA President
Women in Titanium Chair
Former CEO, RTI International Metals, Inc.

Holly Both
Vice President of Marketing
Plymouth Tube Co.

Cindy Heatherington
Vice President,
Human Resources
TIMET, Titanium Metals Corporation

Jill McGibbney
Medical Products Manager
Metalwerks PMD, Inc.

Michelle Pharand
Director Sales & Business Development
Dynamet Incorporated
WiT Vice Chair

Call Us Today to Learn More!
MODERATOR & ITA PRESIDENT:
Dawne S. Hickton,
ITA President, Women in Titanium Chair
Former CEO RTI International Metals, Inc.

Dawne S. Hickton is the former Vice Chair, President and Chief Executive
Officer of RTI International Metals, Inc. (RTI), where she was employed for
over 18 years. RTI was a global supplier of advanced titanium and specialty
metals products and services in commercial aerospace, defense, propulsion,
medical device, energy and other markets. Ms. Hickton served as CEO from
April 2007 until July 2015, when Alcoa acquired RTI.

For the past 2 years Ms. Hickton has been recognized as one of the top 100
global leaders in STEM by STEMconnector.

Ms. Hickton serves on the board of the Federal Reserve Bank of Cleveland.

In addition, she is a member of the board of directors of Norsk Titanium AS,
Oslo, Norway, a global leader in manufacturing performance critical titanium
components for aerospace and industrial applications. She is also a board
member of Jacobs Engineering Group, Inc., one of the world’s largest and most
diverse providers of technical professional and construction services, serving
on the audit committee. She is also a member of the board of directors
of Triumph Group, Inc., a global leader in manufacturing and overhauling
aerospace structures, systems and components, and serves on that board’s
audit and nominating and corporate governance committees.

Ms. Hickton is a member of the Board of Directors of the Smithsonian’s
National Air and Space Museum and a director of The Wings Club. She is a
member of the University of Pittsburgh’s Board of Trustees, serving on the
student affairs and property and facilities committees, as well as chairing the
School of Law’s Board of Visitors.

Ms. Hickton is a 1979 graduate of the University of Rochester and received
her law degree from the University of Pittsburgh, School of Law in 1983. She
resides in Pittsburgh with her husband, The Honorable David J. Hickton, U.S.
Attorney for the Western District of Pennsylvania, and their children.
Titanium in the Military:
Driving Market Growth Through Innovation

Eric Roegner
Chief Operating Officer, Alcoa Investment Castings, Titanium and Engineered Products; President, Alcoa Titanium & Engineered Products; President, Alcoa Defense, Cleveland, Ohio

Mr. Roegner’s discussion is a call to action for ITA members to work outside of the box to advance the use of titanium in military through innovation. Eric Roegner is Chief Operating Officer responsible for Alcoa Power & Propulsion (APP) and Alcoa Titanium & Engineered Products (ATEP) and President of ATEP. He also serves as President of Alcoa Defense, a role he has held since 2012.

As COO, Eric oversees APP, a global leader in advanced nickel airfoils, and nickel and titanium structural castings, primarily for jet engines and industrial gas turbines, and ATEP, the designation for the recently acquired titanium aerospace leader RTI International Metals, which he also leads as President. Eric continues as President of Alcoa Defense, which develops new technologies for military applications across air, land and sea. ATEP, APP and Alcoa Defense are part of Alcoa’s Engineered Products & Solutions Segment, which is primarily focused on aerospace. In addition to these roles, Eric serves on Alcoa’s Executive Council, the senior leadership team that sets strategic direction for the company.

Most recently, Eric served as Chief Operating Officer, Alcoa Investment Castings,Forgings & Extrusions in Alcoa’s Engineered Products & Solutions Segment, a position he assumed in 2013. In that role, Eric was responsible for Alcoa’s Power and Propulsion and Alcoa Forgings and Extrusions businesses.


Prior to Alcoa, Eric was a partner with management consulting firm McKinsey & Company and held engineering positions with Nordson Corporation, a producer of precision dispensing equipment, and for Schlumberger Limited, the world’s leading oilfield-services provider.

Eric holds a bachelor’s degree in mechanical and aerospace engineering from Princeton University and an MBA degree from Case Western Reserve University. He currently sits on the Board of Governors of the Aerospace Industries Association (AIA) and the Executive Committee of the Board of Directors of the Ohio Chamber of Commerce (OCC).

Titanium Demand and Trends in the Airframe Market

Wade Leach, Jr.
Senior Vice President, Commercial ATI Specialty Materials

Titanium is a preferred option in a wide variety of airframe applications from small fasteners weighing a few grams to landing gear and large wing beams weighing close to one ton. New applications for titanium will drive increased usage in the next generation of aircraft. The combination of mechanical properties, low density and compatibility with composite structures make it an excellent material for use in aerostructures. This presentation discusses the market trends, the applications and how the industry is answering the growth challenge.

Wade Leach joined ATI in August 1983 as a Product Engineer after graduating from North Carolina State University with degrees in Mechanical Engineering and Materials Engineering. In September of 1985, he joined the Sales Department as an Inside Salesperson and transitioned to Field Sales for the Southeastern United States in January of 1986. In April of 1988, Wade moved to the Los Angeles area to become Western Regional Sales Manager. Wade was promoted to Plant Manager of ATI’s South Boston, Virginia, facility in October 1992. In that role he oversaw a significant expansion of the plant and successfully led the effort to increase the business and product offerings of that facility. In September 1996, he was named General Manager of Tool Steel Products. In August 1998, he became Director of Long-Term Agreements and added the responsibilities for Product Management in August 2000. Wade was appointed Vice President of Sales, Marketing, and Product Management in February 2006. In that role Wade’s responsibilities included the U.S.-based field and inside sales groups, product management, and long-term agreements with customers. In October 2014, Wade was promoted to Senior Vice President – Commercial, ATI Specialty Materials.
Developments in Jet Engines: A Titanium Perspective

Henry S. Seiner
Vice President – Business Strategy
TIMET, Titanium Metals Corporation

Today’s engine market is very different than the one we saw in the 1960s during the dawn of the jet engine. Engine size and performance characteristics have evolved in conjunction with changes in the market landscape. This presentation will examine this aforementioned history and provide a forecast that accounts for future challenges and opportunities for the next generation of commercial aerospace jet engines.

Mr. Seiner, TIMET’s Vice President of Business Strategy, oversees the Marketing, Product Management, Purchasing and Production Planning organizations for TIMET. In this role, he has responsibility for and visibility into all aspects of TIMET’s supply chain.

Henry is based in TIMET’s Toronto, OH facility – which is geographically and structurally in the middle of TIMET’s global supply chain. He has held various positions in Production Planning, Manufacturing, Purchasing and Marketing in his 24 year tenure at TIMET.

Prior to coming to TIMET, Henry spent six years at U. S. Steel Corporation in Sales, Marketing and Production Planning. His educational background includes a Masters Degree from Carnegie Mellon University in Pittsburgh, PA and a Bachelors Degree from Duke University in Durham, NC. Henry is a native of Pittsburgh and continues to reside in Western Pennsylvania.

Titanium Aerospace Demand & Integrated Supply Chain

Dr. Claudio Dalle Donne
VP Materials and Processes
Airbus S.A.S.

Dr. Claudio Dalle Donne is Vice President Materials and Processes for Airbus S.A.S.. In 2015 he headed the Technical Capability Centre “Metallic Technologies and Surface Engineering” of Airbus Group Innovations with labs in Munich, Paris and Filton (UK). His team developed the eco-efficient surface technologies, metallic materials and processes and is supporting Airbus Group business units in manufacturing, testing and failure analysis. He received a mechanical engineering degree (1991) and a PhD degree (1996) from the University of Karlsruhe. From 1991 to 2004 he was scientific officer and group leader in the Institute of Materials Research of the German Aerospace Center DLR in Cologne. In parallel he was teaching at the University of Parma, Italy. In 2004 he joined EADS Corporate Research Center in Munich as Head of the Metallic Structures Dept.

Raphael Duflos
VP Metallic Materials Procurement
Airbus S.A.S.

Mr Raphael DUFLOS is an Engineer, with a degree from the Engineering School of Central Lyon and the University of Salford, with a post-graduation in Telecom Paris. He started his career in 1989 at Aerospatiale Missile as Design Engineer then as Cooperation Contract negotiator. In 1995, he joined Airbus in various program roles around Cost Sharing between partners. Following the launch of the A380 and the start of the EADS group, he went back abroad in 2001, as Senior Manager Sourcing Strategy for EADS, based in Munich. In June 2004, he led the Procurement Directorate and became a member of the Executive Committee of EADS Socata in Tarbes. 3 years later, he joined Astrium to implement innovative Supply Chain Solutions in the space domain. Finally, he participate to the creation of Aerolia as Chief Procurement, Quality & Supply Chain officer.

Aerolia is an aeronautical tier one equipment supplier and European leader of b Aerostructures. Since its creation in 2009, Mr DUFLOS has taken an active part in the strong growth of the company, the procurement budget passing from 500M€ to more than B€ 1 in 6 years with the creation of Stelia.

In his career, Mr DUFLOS gives priority to overall costs and advocates in his approach the collaborative work with suppliers to be competitive and to respect the market’s requirements.
Overview of Russian Market for Titanium Mill Products

Michael G. Metz
President
VSMPO Tirus US

Demand for titanium in the Russian Federation is growing significantly, with overall demand expected to double between 2010 and 2017. Aircraft industry demand is the primary driver for growth, along with solid demand from power generation, shipbuilding, and general industrial uses for titanium.

Michael Metz joined VSMPO - Tirus, US in November 2003 as Vice President, Commercial and was named President of the organization in 2007. VSMPO is the largest producer of titanium in the world, vertically integrated from titanium sponge manufacture through melting and mill products such as plate, sheet, bar, billet, wire, and welded and seamless tubing. In addition, VSMPO supplies titanium closed die forgings for airframe and engine applications. Mike has served on the International Titanium Association Board of Directors since 2007 holding the positions of Director, Vice President and President.

He has significant experience in the titanium industry, having held positions in sales, distribution, product management, market research and forecasting at Titanium Metals Corporation from 1986 to 2003 before joining VSMPO. Mike graduated from Hamilton College in 1981 with a BA in economics, and from Carnegie – Mellon University in 1983 with an MBA.

Global Trends Industrial Markets

Albert Bruneau
Executive Vice President
Vallourec Heat Exchanger Tubes (VHET)

Significant volume of Titanium is consumed every year as plates, sheets or tubes by the Power Generation, Process and Desalination markets. These volumes have been fluctuating significantly over the recent past, generating lack of visibility and concern for all the players along the supply chain. What are the drivers and trend on market? Thanks to its long and worldwide presence, VHET has a unique understanding of the dynamics and trends of Titanium usage by these complex markets.

Albert BRUNEAU will discuss the key drivers of titanium consumption in the industrial market and provide an estimate of the evolution in the coming years.

Albert BRUNEAU is Executive VP of Vallourec Heat Exchanger Tubes since 2013. Subsidiary of Vallourec group, headquartered in France, Vallourec Heat Exchanger Tubes is the worldwide leader of titanium and stainless steel welded tubes for heat exchangers, with facilities and sales forces based in five countries on three continents: France, United States, China, India and Korea.

Prior to Vallourec Heat Exchanger Tubes, Albert Bruneau has held numerous senior sales & marketing management positions within Vallourec group mainly for the Oil & Gas industry, involved in Europe, South America, Africa and Middle East.

Albert Bruneau graduated from French Engineering School ESPCI and conducted one Executive MBA at the French Business School HEC.
MODERATOR:

Dr. Christian Lehnert
ALD Vacuum Technologies GmbH

From Powder to Demanding Components – Titanium and Powder Metallurgy

Dr. Thomas Ebel
Head of Department “Materials Design and Characterisation”
Institute of Materials Research, Division “Metallic Biomaterials”
Helmholtz-Zentrum Geesthacht

Powder metallurgy (P/M) still represents a niche in processing of titanium and titanium alloys. Though, usage of fine powders as raw material offers unique possibilities related to design of the part, fabrication and shaping of special alloys as well as significant cost reduction. Currently, additive manufacturing (“3D-printing”), in particular, is of high interest, even for the manufacturing of critical Ti-components. However, concerns mainly exist related to mechanical properties, especially low fatigue resistance due to residual porosity or embrittlement by impurity uptake during processing. Successful P/M processing of titanium implies understanding of the specific features of the material and corresponding adaption of the manufacturing chain. In this presentation an introduction to P/M processing and its current status related to titanium materials is given. The special properties of titanium and titanium powders and the critical issues during production and processing are pointed out as well as ways to overcome these challenges. Technologies like additive manufacturing and metal injection molding are introduced enabling near-net-shape forming of parts. As a conclusion, successes and challenges of titanium P/M including current research topics are shown.

Since 2006 Dr. Ebel has been the Head of department at Helmholtz-Zentrum Geesthacht, firstly, department “Powder technology”, now “Materials Design and Characterisation”. Focus on powder metallurgical (P/M) techniques for processing of titanium and magnesium. Expertise: metal injection molding. Main interest: development of P/M alloys.

Titanium Powder Markets – Chances and Risks

Christoph Genter
Managing Partner
AMCG Unternehmensberatung GmbH
Market Intelligence • Consulting

The high buy-to-fly ratio of titanium in the aerospace industry is a major driver for the growing use of titanium powder as a substitute for conventional titanium mill products and processes. Titanium powder and powder metallurgy is a disruptive technology with chances and risks for the complete titanium metal value chain. The current market volumes for titanium powder in total as well as by powder manufacturing and processing technologies will be shown together with the volumes by market segments. Furthermore, an outlook for the titanium powder markets is given. Finally, chances and risks for the players in the value chain are evaluated.

Christoph Genter is founder and managing partner of AMCG Unternehmensberatung. He has more than 30 years experience in the titanium industry from projects in Europe, North America and Asia. Christoph Genter has an M.B.A. from University in Munich and M.Sc. on Chemical Engineering from University in Karlsruhe. AMCG is a management consulting company focused on market intelligence and business development for the customer industries special metals, chemicals and engineering. AMCG’s customers are global players and medium-sized companies as well as public organizations.

Sponsored by

AMG
ALD
Titanium PM and AM / 3D Printing

Chris van Dam
General Manager
Airborne Metals

The lecture will cover industrial aspects of titanium powder manufacturing, powder manufacturing techniques, 3D modeling and 3D printing. Some potential aerospace applications will be shown and described. The lecture will describe the current state of affairs from an industrial point of view. As such, it will be general in nature avoiding detailed, specialized subjects.

Chris van Dam is an aerospace engineer from Delft University of Technology, The Netherlands. He is specialized in aerospace materials - like metals and composites, and manufacturing. His thesis work was done at the (then still existing) Fokker Aircraft, where he designed, manufactured and tested a primary aircraft structure designed as a composite sandwich panel.

He has extensive experience in the international trading of high quality and aerospace grade metals, including titanium.

In 2014, he set up startup company Airborne Metals. Airborne Metals is a distributor of aerospace grade raw materials and semifinished products working with mills holding relevant system certifications. The company is also seeking access to innovative technologies in the industry, like powder metallurgy and additive manufacturing.

Pilot-Scale Research in Ti Powder Production

Neill McDonald
Directeur
MetaFensch: Institut de Métallurgie du Val de Fensch

Tailor-designed titanium powders are in increasing demand due to new applications and stringent final product specifications in various industrial sectors. The growth of tailored titanium powders is also linked to the evolving requirements of additive manufacturing processes such as HIP, LBM, EBM, MIM, etc. The development of such powders – from idea to industrialization - is complex and time consuming.

Pilot- and semi-industrial scale research on titanium powder is an often underestimated step in this process and beneficial in order to reduce risk, in particular related to investments, and to optimize processes and productivity both before and after industrialization. In addition, pilot-scale equipment can provide suitable quantities of powder to facilitate tests on existing AM equipment and to produce small powder batch series. The investment (CAPEX/OPEX) for such pilot-scale equipment is significant for most companies and questions related to upscaling persist even after successful trials.

MetaFensch is a publicly funded R&D centre created in France in 2014 and dedicated to accompanying innovative metallurgical projects through to industrialization. In order to carry out this mission, a platform has been created in Lorraine (near the Belgian, German and Luxembourgish borders) which houses pilot-scale melting, casting and powder manufacturing equipment and the personnel and infrastructure necessary to operate them. A major theme for this platform is titanium powder production including an EIGA furnace with the possibility to employ up to 100 mm diameter electrodes.

This presentation aims to provide an overview of the challenges related to pilot-scale Ti powder production as well as the solutions put in place by MetaFensch in order to meet them.
A New High-Throughput Ultra-High Precision Process for the Manufacture of Fiber-Optical Components

Rand Dannenberg, Ph.D.
CTO’s Office
nanoPrecision products

nanoPrecision Products, Inc. has developed a breakthrough ultra-high precision, high-throughput titanium stamping process that will disrupt the single-mode fiber-optic ferrule interconnect marketplace. The market is anticipated to be on the order of 500 million parts per year by 2020, and our product will consume 1600 metric tons per year of titanium grade 2. The name of our product is the Ferrolder®. The manufacturing process that presently pervades the marketplace is based on precision grinding of ceramic zirconia ferrules and alignment sleeves, which is slow and expensive. nanoPrecision’s cost-and-performance competitive advantage stems from our stamping technique, that retains the traditional high production throughput of stamping, yet enables us to achieve geometrical form tolerances on the stamped parts on the order of 100 nanometers. The performance of our titanium interconnects has exceeded the standard ceramic product on both the Telcordia GR-386 metric, and on the even more stringent Verizon metric. The Ferrolder® based single-fiber connector SC/UPC Kit now has Verizon quality acceptance. The Ferrolder® is presently produced on a 2 million part-per-month prototype production line. Crucial to our competitive advantage in this space is the use of commercially pure titanium grade 2 as the material for a variety of attributes which will be outlined in the presentation.

Dr. Dannenberg is a materials scientist and optical physicist working in the CTO’s Office of nanoPrecision Products, Inc. on novel high-precision applications of metalforming for use in optics.

Linear Friction Welding for Increased Industrial Titanium Productivity

Bertrand Flipo
Senior Project Leader
TWI Ltd

Focusing on the state of the art technique for Near Net Shape manufacturing; this presentation will describe recent developments.
and economical assessments in the joining of Titanium alloys using Linear Friction Welding (LFW). Currently, many such components are machined from solid blocks of Titanium alloys, resulting in relatively poor scrap ratios. The use of near net shape parts produced by LFW can significantly reduce production costs for a wide range of components.

Build up of near net shape parts by LFW also provides the opportunity for selection of appropriate dissimilar alloys in different parts of the part structure. This approach allows the production of tailored components, resulting in both functional and economic benefits. Examples will be shown of the application of this approach to aerospace components, from simple LFW fabrications, to more complex components produced by sequential LFW of multiple parts to build up structures.

In summary this presentation will provide an update on recent Linear Friction Welding developments and their potential economic benefits, aimed at improving product effectiveness and reducing production costs for a wide range of aerospace components.

Specialised in Linear Friction Welding, Bert has an extensive experience on the LFW technology for the Aerospace industry. Bert has been involved in all aspects of the LFW implementation:
- Innovation strategies,
- Process development,
- Machine design and manufacture,
- New products introduction,
- Production and manufacturing improvements,
- Quality monitoring,
- Product life cycle.

Titanium Alloy Bars for Renewal of Civil Infrastructure

Christopher Higgins, Ph.D., P.E.
School of Civil and Construction Engineering
Oregon State University

Internationally, civil transportation infrastructure continues to age and deteriorate. Society has increased demands on these systems and requires them to carry higher volume, heavier loads, and remain in-service beyond their intended design life. Simultaneously, new and larger hazards have emerged from natural and manmade sources. Large investments are needed to maintain safety, mobility, and ensure continuous performance, yet replacement of existing assets is beyond fiscal reach. Due to limited resources, strengthening, rehabilitation, and renewal of existing infrastructure have become necessary alternatives to replacement. Carbon-fiber reinforced polymers (CFRP) have become the material of choice for rehabilitation projects but have many drawbacks that can be overcome using titanium alloy bars. Challenges to widespread acceptance of titanium alloy bars for civil infrastructure include the industry’s ignorance of titanium’s mechanical properties and long-term benefits, perception that the material is cost prohibitive, and lack of performance data for structures with titanium reinforcement.

Research is presently underway to develop methods and demonstrate the potential of using titanium alloy bars to strengthen aging and deficient reinforced concrete bridges. The addition of titanium alloy bars will allow the bridges to carry heavier truck loads and resist large earthquakes. Ti-6-4 bars with special surface deformations were developed for this application. The surface deformation pattern permits epoxy bonding to the underlying concrete. Fabrication of the bars is performed using conventional methods.

Christopher Higgins is the Cecil and Sally Drinkward Professor of Structural Engineering in the School of Civil and Construction Engineering in the College of Engineering at Oregon State University. His field is structural engineering and he created and directs the Structural Engineering Research Laboratory at OSU. He holds a B.S.C.E. from Marquette University, M.S. from The University of Texas at Austin, and Ph.D. from Lehigh University. He is a registered Professional Engineer.

Dr. Higgins teaches graduate and undergraduate courses, mentors students, and conducts research in Structural, Bridge, and Earthquake Engineering. He has received numerous teaching and research awards including the 2015 Titanium Applications Development Award.
MEDICAL APPLICATIONS

MODERATOR:

Frank L. Perryman
President and Chief Executive Officer - Perryman Company

Titanium Alloys in Metals & Processing for the Orthopaedic Global Markets

François Ory
President and Owner Forecreu

François Ory was born in 1959. He earned his MBA at New York City’s Pace University in 1983. Mr. Ory worked in the industrial development with the French Industrial Development Agency, then Pechiney Group. He began a Supply Chain management team at Snecma, a French aircraft engine group. He moved to Forecreu in the 90 and conducted LBO in 2006 with private equity support.

He is currently the President and Owner of Forecreu, a group specialized in extruded & drawn hollow bars in special steel and titanium alloys used for the manufacturing of cutting tools, orthopaedic and trauma instrument or implants.

Additive Manufacturing of Implants - The Path to Production

Lars Ryberg
Area Sales Director Arcam AB Sweden

Experiences from how the implant manufacturers who have implemented Additive Manufacturing in their production have gone about obtaining CE certification and FDA clearance for their EBM-manufactured orthopedic and spinal implants.

Microstructure and Oxidation Resistance of the (ZrO2+8%Y2O3)+(TiAl3+TiAl2) Coatings Produced on Near α Timetal 1100 Titanium Alloy Via a Two-Step Process.

Jaroslaw Mizera
Professor Warsaw University of Technology

We examined microstructure and oxidation resistance of the thermal barrier coatings of the type (ZrO2+8%Y2O3)+(TiAl3+TiAl2).

Those protective coatings were produced in two steps onto a near-α Timetal 1100 titanium alloy substrate. First, a pack cementation method produced diffusion Ti-Al intermetallic layers. Next, low pressure plasma spraying of the ZrO2+8%Y2O3 produced thermal barrier coatings.

Investigations of the microstructure and chemical composition of the inner Ti-Al intermetallic layer by the scanning electron microscopy showed that this 16 µm thick layer was composed of two sublayers: the outer one, which was about 9µm thick, and the inner one, which was 7µm thick. The X-ray phase analysis indicated that the inner layer was chiefly composed of the TiAl3 and TiAl2 intermetallic phases.

Investigations of the microstructure of the outer ZrO2+8%Y2O3 layer by transmission electron microscopy showed its nanocrystalline structure and lack of micro-cracks and pores, which indicated good substrate adherence of the coating. Same was observed for the self-grown oxides in-between the ZrO2+8%Y2O3 and Ti-Al intermetallic layers.

Finally, we conducted the studies of resistance to isothermal oxidation of the near-α Timetal 1100 titanium alloy with the (ZrO2+8%Y2O3)+(TiAl3+TiAl2) coating. The coating was oxidized in air+1%H2O+1%SO2 atmosphere and at temperature of 800°C for 100 hours. The results showed that the coating improved significantly corrosion resistance of the alloy.
MODERATOR:
Henrik Franz
Head of R&D Vacuum Metallurgy
ALD Vacuum Technologies GmbH

Alloy Development and Production of TiAl TNM Forging Stocks for Low Pressure Turbine Blades
Dr. Volker Güther
AMG TITANIUM ALLOYS & COATINGS
GfE Metalle und Materialien GmbH

A beta stabilized Titanium Aluminide exhibiting improved wrought processing capability has been developed. Based on this alloy (TNM) an entire production line for LPT blades for the PW1000G aircraft engine has been established in Germany consisting of:
• VAR TNM ingot production
• VAR Skull melting / Induction Skull Melting with subsequent centrifugal casting
• HIP
• Isothermal forging
• Thermal treatments
• Machining to final blade

Alloy development was based on thermodynamic modeling. The adjustment of the final composition has been made after the evaluation of the thermomechanical properties of different alloy variations. Due to the defined fracture of beta phase in the microstructure, the TNM alloy shows outstanding wrought processing capability. Furthermore, tensile strength, fatigue strength and creep resistance exceed the figures of conventional TiAl alloys.

Can TiAl Oversized Powder Coming from EIGA Process be Managed?

Dr Matthias De Sousa Ph.D.
R&D Manager
SILIMELT

Due to its low ductility and poor-machinability, TiAl-parts are quite hard to manufacture using classical shaping techniques. Powder metallurgy, like Metallic Injection Molding (MIM), or additive manufacturing techniques allows to develop structural TiAl-parts manufacturing, even if it is highly related to the powder quality and cost.

Because of its high reactivity, TiAl powders are usually produced thanks to free-crucible gas atomization like for example, Electrode Induction Gas Atomization (EIGA) or Rotating Electrode Process (REP). These two methods produce a quite large size distribution (from 5 up to 300 µm), in particular for the REP technique. Powders with particles size above 100 µm are called “oversized” powder, because their low-value market compared to powders with particles size below 100 µm.

A study led by the companies Silimelt and ALD Vacuum Technologies allowed to work out a two-step process for TiAl powder manufacturing. The first step consists in producing TiAl powder using EIGA process, developed by ALD Vacuum Technologies. The EIGA-produced powder contains around 55% of particles sized below 100 µm and only 22% sized below 50 µm. The second step deals with the plasma fragmentation of oversized TiAl powders (>100 µm), in order to convert coarse powders into finer ones. A parametric study of this new plasma process has been led in order to define a range of optimized operating conditions for enhancing the production of fine particles. Starting from particles size above 100 µm, up to 50% of the raw material can be converted into particles sized below 100 µm, after in-flight plasma treatment.
Status of Titanium Aluminides for Aero Engine Applications

Dr. Wilfried Smarsly
Representative Advanced Materials
MTU Aero Engines GmbH

Advances in gas-turbine development are driven by the need to reduce fuel consumption, emissions and costs.

From material aspect, these requirements enhanced the development of highly creep and oxidation resistant materials of greater temperature potential than titanium alloys and of lower density than nickel superalloys. Advanced TiAl alloys are complex multi-phase alloys which can be processed by ingot or powder metallurgy as well as precision casting methods or even forging. Each process leads to specific microstructures which can be altered and optimized by thermo-mechanical processing and/or subsequent heat treatments. The blades can be forged using isothermal forging equipment.

Subsequent, two-step heat treatments were conducted to adjust balanced mechanical properties i.e. a sufficiently high plastic fracture strain at room temperature and good creep properties at elevated temperatures.

Wilfried Smarsly received his Dr.rer.nat. degree in material science at Technical University Aachen. He has joined MTU in 1987 and started his career in the materials development field. He was responsible for the development of powder metallurgical processes related to aluminum, titanium and nickel superalloy aero engine components. Wilfried Smarsly was appointed Head of Advanced Materials and Designs in 1997. He is responsible as project manager for the development of light weight high temperature materials.
High Quality Ti-Based Powder Production and Recycling by Induction Plasma Technology

Dr. Romain Vert, Ph.D.
Technical sales and R&D Manager Europe TEKNA Group

The performances of metal powder-based additive manufacturing (AM) technologies like electron-beam melting (EBM) and selective laser melting (SLM) greatly depend on powder characteristics such as flowability, packing density and purity. Particles exhibiting a perfectly spherical morphology largely contribute at optimizing both the flowability and the packing density of a powder. However, not all the powder manufacturing processes succeed at optimizing these critical characteristics for the AM needs since satellites, pores and/or particles of irregular morphologies are regularly observed in commercial powders. Furthermore, powder flowability, packing density and purity can be altered to different extent by the AM process and this is known to limit the recyclability of the powders.

The inductively-coupled plasma (ICP) proprietary technology developed by Tekna over the last 25 years has the capability to produce pure Titanium or titanium alloys such as Ti64, Ti6242 or TiAl for example. Moreover, the processing of used powders allows to transform particles of various shape into perfect spheres. On top of that, Tekna has developed a proprietary classification process specifically for removing ultrafine particles within a powder, allowing thereby the re-use of powders in AM processes that would otherwise be out of specification in terms of powder purity and flowability. Tekna’s ICP technology will be briefly described and case studies with powders made with different manufacturing processes will be presented.

Dr. Vert has worked for Tekna since 2012 and is in charge of the R&D activities and a part of the sales activities for Tekna in Europe. The main R&D activities are related to materials development for various industry sectors such as, ceramic industry, aerospace, automotive, medical or oil&gas industry.

Previously Dr. Vert obtained his PhD in the field of materials science and has worked in the thermal spray industry.

Advanced Technologies for Hard Metals Forming

Guillaume Sana
R&D Process Manager
ACB

Titanium alloys and hard metals in general as Nickel based or Cobalt based alloys are very attractive regarding their mechanical and chemical properties (corrosion, oxidation) for aircraft parts application, either for structural or engine parts.

The main issue is the low formability of these alloys in ambient condition which do not allow to produce complex shape parts in simple way. Actually in ambient condition bending ratio or springback effect set the limit of part design and manufacturing processes. At the same time customer requirements concerning processes and parts repeatability is growing up. For those main reasons other processes must be considered.

For several decades ACB (France) and its sister company Cyril Bath (USA), have developed several processes in order to solve this customer demand and to develop and promote the use of hard metals in the aerospace industry especially titanium alloys (Ti-6Al-4, Ti-6242, Beta-21S). As hydraulic press and part supplier both companies can focus on supplier and customer point of view simultaneously.

Thanks to this strategy advanced technologies can now be applied to part manufacturing with following objectives:
- To produce parts without springback
- To guarantee process repeatability and homogeneous part quality
- To provide residual stress free parts
- To improve buy-to-fly ratio

Hot Forming processes are one the best industrial response to these technical and economical requirements.

In this presentation a state of the art on Hot Forming processes will be done to show how it can match current customer needs. In addition to thin titanium parts (0.4 to 4 mm thickness) an introduction to bulk part manufacturing will be done explaining how Linear Friction Welding technology can challenge actual machining strategy.
New Electron Beam Equipment for Additive Manufacturing of Titanium

Dmytro Kovalchuk
Director
JSC NVO Chervona Hvilya

Additive manufacturing is considered as one of the most prospective technologies for near-net-shape production of titanium parts. Among all currently available the electron beam additive manufacturing technologies look most attractive for titanium thanks to high power of an electron beam and production of parts completely in vacuum. But in spite of impressive progress in implementation of additive manufacturing into titanium industry during last few years there are still numerous technological problems caused by the imperfection of existing methods and equipment including residual porosity, non-uniform mechanical properties in different directions, residual stresses as well. In addition currently applied equipment and feedstock materials are quite expensive.

Authors will present new method of an electron beam additive manufacturing which was developed to solve the most of above mentioned problems. It is based on the concept of direct deposition of feedstock in the form of wire or powder using special low-voltage gas-discharge electron beam guns. New method can enable additive manufacturing of rather small and accurate parts as well as large scale production with high efficiency. Equipment based on new method will make additive manufacturing technology more accessible both for R&D purpose and for normal use in industry.

Pilot electron beam installation based on the said method was put into operation this year. Its technical data and technological capabilities will be presented.

Mr. Dmytro Kovalchuk is co-owner and director of JSC NVO Chervona Hvilya since Company foundation in 1997. He has 26 years of experience in development of electron beam technologies and their implementation to industrial application. Over the late 1990th and early 2000th he was involved as project manager in creation of complete production chains in Ukraine with titanium ingots and mill products. Since 2005 JSC NVO Chervona Hvilya has started activity in the field of development and manufacture of advanced electron beam equipment mainly for melting and EB-PVD application. Gas-discharge electron beam guns of own design with power up to 600 kW have been the key element of this activity. Until now electron beam equipment produced by JSC NVO Chervona Hvilya was supplied to leading companies in Ukraine, USA, Russia, Europe, China as well.
MELTING TECHNOLOGIES

MODERATOR:

Pierre-Francois Louvigne
Titanium Expert, Consultant

Production of Industrial Ingots of the Intermetallic VTI-4 Alloy Using Vacuum-Arc and Skull Melts

Alexander Alexandrov
Leading Research Engineer of the Central Scientific Research Laboratory (CSRL)
JSC «Chepetsky Mechanical Plant»

Multicomponent complex VTI-4 alloy is an ortho-alloy on the basis of the Ti2NbAl compound. The composition of VTI-4 alloy comprises six alloying elements, wt. %: (10-12) Al, (38-42) Nb, (1-1,5) Zr, (0,5-1,0) Mo, (0,5-1,0) V, (0,1-0,25) Si. It is intended, in particular, for production of blades and disks of aircraft engine's high pressure compressor with a working temperature at a long-term usage up to 700 °C. Despite the known advantages of such alloys, any ortho-alloy still isn’t used abroad because of complexity in metallurgical production.

JSC «Chepetsky Mechanical Plant» is mastering now the production of industrial ingots of the intermetallic VTI-4 alloy at maintenance of VIAM (Moscow) - the developer of this alloy. The present report is devoted to the manufacturing of two triple remelted ingots of VTI-4 alloy: the first – with the estimated weight of 490 kg with use of only vacuum-arc melting, the second – with the estimated weight of 630 kg with carrying out one remelting in the vacuum-arc skull furnace.

The following materials were used for smelting of VTI-4 alloy’s ingots: titanium sponge, aluminium, silicon, zirconium and master alloys aluminum-molybdenum-vanadium-titan, vanadium-aluminum, niobium-titanium.

The briquettes from burden materials were pressed on a vertical hydraulic press and then welded into consumable electrodes in the electron-beam unit.

Smelting of ingots was carried out with use of vacuum-arc and vacuum-arc skull furnaces. The final third vacuum-arc remelting was carried out in a mold with a diameter of 360 mm.

The chemical analysis of ingots, conducted on three belts of the lateral surface, corresponded to the established requirements.

The statistical analysis of distribution of the alloying elements on the lateral surface of ingots showed that the ingot obtained with the use of skull melting has a more uniform distribution in comparison with an ingot of triple vacuum-arc remelting.

Titanium in France, Market and Actors

Benoit Noel
South Europe Sales Director
Service and distribution operations Director
TIMET

This presentation will examine the role of French companies involved in Titanium for the Aerospace market, their influence on the supply chain and the changes in titanium demand.

Mr. Noel has been working in the aerospace industry for the past 20 years, involved in metal forming and melting. Mr. Noel is the South Europe Sales Director and Service and distribution operations Director for TIMET for the past 6 years. Since 1950, TIMET has been leading the industry in mill and melted products, supplying nearly one-fifth of the world’s titanium demand. TIMET is the only supplier with production facilities in both the United States and Europe to support our multinational customer base.

Previously, Mr. Noel was VP Sales of the Manoir Aerospace group that has been since acquired by the Lisi group. He also lived in the USA where he was Managing Director of Manoir Special Forging. Manoir Aerospace serves the aerospace industry with Forging and castings for Engine and structure elements.

Born in the East of France, Benoit Noel has travelled since his early childhood. After some time in New-Caledonia and Africa, his family settled in Nantes. Benoit Noel graduated from the business school Audencia-Nantes and from the Institut Français de Gestion. In his professional life or in different associations, Benoit Noel likes to share his “passion of aeronautics”, he was graduated at 15 with a glider pilot license and now flies vintage and aerobatic aircrafts.
UKAD: European Titanium Actor, Close Loop to the Customers

Mohamed Bouzidi
VP, Strategic Business Unit Aerospace
Aubert et Duval

UKAD is a JV between UKTMP from Kazakhstan and Aubert et Duval from France. UKAD has been created in 2008, first billet produced in 2011 and industrialization in 2012.

From 2012 the ramp up has been significant and today UKAD is a big player in Europe.

UKAD is delivering bars and billets to the markets who are forgers, fasteners, machine shop or end users.

UKAD received its ingots from UKTMP produced in VAR furnaces and then transformed in France. Soon UKAD will be able to propose a second route from Plasma furnace. A Plasma (and VAR) furnaces will be installed in UKAD facility in France and in operation by 2018.

The goals is thru the chips generated in Europe recycled them and offer a close loop to the customers.

Mohamed Bouzidi is currently VP for the Aerospace – Energy – Defense Strategic Business Unit within AUBERT ET DUVAL. He is in the Aerospace / Titanium industry for more than 25 years. Before being for the last 15 years within A.D. where he serves several commercial and business worldwide positions, he was within SNECMA in charge of R&D for superalloys and purchasing for forgings and raw materials. He held a PhD in metallurgy and MBA for EDHEC business school.

Ceramic Crucible Melting of Titanium Alloys and Intermetallics in VIM

Bernd Friedrich
Head of Institute
RWTH Aachen, IME — Institute of Process Metallurgy and Metal Recycling

Nowadays the recycling of Titanium Aluminum alloys gets more important due to the established use in sectors like aerospace and medicine engineering. A common way to melt Ti in a VIM is to use the so called vacuum induction skull-melting. This means that the material is molten down using a water cooled copper crucible where the strong cooling leads to formation of a solid metal “skull” protecting the copper crucible from the liquid melt.

Due to the enormous amount of cooling water needed this process is very expensive therefore the use of ceramic crucibles would be way more cost efficient.

The challenge when melting Ti-based alloys in a VIM using ceramic crucibles is to avoid any oxygen pickup. As the oxygen affinity of Ti is extremely high, most of the common crucible materials such as Al2O3 or MgO cannot be used. CaO, which is thermodynamically stable enough, is hard to handle as it is very hygroscopic and tends to react with air moisture.

In our research group a lot of investigations have been done to find a way for melting different titanium alloys in ceramic crucibles. Our research is focused on melting intermetallic TiAl alloy (GE 48-2-2) in yttria coated Al2O3-crucibles as well as melting Ti-6Al-2Sn-4Zr-6Mo and Ti-6Al-2Sn-4Zr-2Mo in a CaZrO3 crucible.

The results of our research show that it is possible to use these crucible materials with a reasonable oxygen pickup.
Thierry Viguier
Purchasing Director of Materials
Safran

Mr. Viguier joined Safran in the early eighties, at the Electronic Division of Snecma. He spent 3 years in Binghamton, New York, USA in developing the Full Authority Digital Engine Control (FADEC) of the A320 CFM56 Engine with the Partner GE (former GE-ACSD). Over the next 10 years in France, Mr. Viguier led the business development of Snecma electronics for Western Europe. Thanks to lessons learned in business development, Mr. Viguier found opportunities in the Procurement division in 2003. He took successive positions in Hispano-Suiza and Snecma, dealing with different commodities, before relocating to Safran headquarters. As a Safran Executive, Mr. Viguier is the Vice President for Safran Materials Purchases since 2015. Mr. Viguier achieved the Safran Executive Program by Duke CE, HEC Paris and AON Hewitt, has certification in Lean six sigma Green Belt (Safran), and is Certified IPMA Niveau C in Project Management (AFITEP).
WORLD INDUSTRY SUPPLY TRENDS

MODERATOR:

Robert Baylis
Managing Director - Roskill Information Services, Ltd.

Overview of World Titanium Sponge Supply

Sylvain Gehler
Managing Director
Specialty Metals Company

Mr. Gehler will present an overview of the world Ti sponge supply and analyze the trends which are affecting sponge production today.

World Ti sponge production has gradually gone into a large surplus over the last few years through either increase of capacity or over production with Ti sponge inventory today (except China) increasing to a record level of over 45,000 t in Europe, Asia and the USA. Weakening foreign currencies against the US Dollars have also decreased sponge price to a level equivalent to 6 years ago.

At the same time the demand for Ti from the industrial market has not recovered and the Aerospace industry demand could slow down if the price of oil remains at a low level.

Mr. Gehler is Managing Director of Specialty Metals Company in Brussels, Belgium and Chairman of the Board of the UST Kamenogorskk Titanium and Magnesium Plant, a leading integrated producer of titanium sponge and magnesium located in Kazakhstan.

He is a native of Strasbourg, France and holds a B.A. from Strasbourg University. He began his career in high temperature alloys recycling and held a management position in an international trading company.

Specialty Metals Company, a specialist of metals for high temperature alloys, is a majority shareholder of UKTMP and market their products worldwide.

Master Alloys

Graham P. Walker
Vice President, Sales and Marketing
AMETEK – Reading Alloys

This paper will focus on Masteralloys for the production of Titanium Alloys. Following a short introduction of Masteralloys regarding their production, their application and the current supplier base; the paper will discuss factors expected to influence future changes in supply and demand of Masteralloys. Additionally, the presentation will touch on some of the challenges this expected future brings to Masteralloy producers as well as to Titanium smelters—all from a European point of view.

Graham P. Walker is currently Vice President, Sales and Marketing at AMETEK Specialty Metal Products. He is responsible for all sales and marketing activities associated with the Business Unit. He is a qualified Metallurgist with a BSc from the University of Leeds (UK) and a MBA from Baldwin-Wallace College (OH).

Prior to joining Reading Alloys, he spent over twenty years in a variety of roles within the Foseco Group, specializing in product development and technical sales to the foundry and aluminum industries. His life and career include extensive foreign work and travel that provide a valuable international perspective.

Scrap Overview

Nicholas D. Corby III
Titanium Product Manager
ELG Utica Alloys, Inc.

This paper will focus on two main topics. The first will trace the evolution of the movement of titanium scrap from the scrap generation point back to the various users of titanium scrap, focusing on titanium producers but also including steel and ferro titanium producers. We will look at the various factors that have lead to this evolution including, technical advances, the implementation of buy back agreements, and industry consolidation. We will also explore advances that have allowed for increased use of titanium scrap within the titanium industry and opportunities moving forward that could allow the titanium industry to capture a larger percentage of the overall scrap stream.

ELG Utica Alloys is one of the world’s leading specialists in revert management, and high-performance alloys and metals. With 15 facilities in 10 countries, and over 50 years of experience, we provide our customers with best in class service and value.
DEVELOPMENT OF COMMERCIAL AEROSPACE & ECONOMIC IMPACT

MODERATOR:

Dr. Markus Holz
President, AMG’s Engineering Systems Division CEO, ALD Vacuum Technologies GmbH

Balancing Growth, Risk and Profit to Optimise Valuation

Charles Armitage
European Aerospace & Defence Equity Analyst
UBS

Charles Armitage is the Head of European Aerospace & Defence Equity Research for UBS, which serves private, institutional and corporate clients worldwide, as well as retail clients in Switzerland.

Before joining UBS, Mr. Armitage was a London-based member of the Charles River Associates’ Aerospace & Defense Practice. Prior to joining Charles River Associates, he was a senior director with Merrill Lynch and head of their European Aerospace & Defense equity research team. In this role, he analyzed the sector for investors with specific focus on BAE Systems, Cobham, EADS, Finmeccanica, Meggitt, QinetiQ, Rolls-Royce, Smiths, Thales, Ultra, and VT Group. Before that, he was an equity analyst with Putnam Investments.

Mr. Armitage is a Rolls-Royce-trained engineer, and his key areas of expertise are enterprise valuation, financial forecasting, sector dynamics, and sensitivity and scenario analysis. He holds a Bachelor’s Degree in Mechanical Engineering from University of Bristol Marlborough Colleges.

Key Considerations Beyond Supply Chain Readiness

Bill Bihlman
President
Aerolytics LLC

It is well known the use of titanium in commercial aerospace has increased substantially over the past several years. Both Airbus and Boeing’s composite widebody aircraft have considerably more titanium content. This, along with announced production rate increases, has placed the near-term focus on the performance of the supply chain to meet backlog commitments. Nevertheless, what are other key considerations beyond supply chain readiness? What are the medium-term issues that drive design and certification, and ultimately impact material selection? What is the likelihood of material substitution? And what product forms will be most impacted, including the trade-offs between product categories, such as forgings versus machined bar/plate? What is the anticipated impact of additive manufacturing? Finally, how do these considerations vary between aerostructure, engine and components over the next decade?

Bill Bihlman founded Aerolytics in 2012. Its focus is market share enhancement for OEMs and its suppliers. He started his career in 1995 as an engineer with Raytheon Aircraft, eventually serving as Project Engineer. Subsequently, he was Senior Consultant with AeroStrategy (now part of ICF Int’l). He spent four years working in the US office. Bill led multiple engagements and was responsible for two major intellectual property initiatives, including the Aerospace Raw Materials model. This forecast is presented regularly at the industry’s premier conferences. Other areas of research include aerospace clusters, new product/market development, supply chain, and due diligence. Bill holds a BS and MS in Mechanical Engineering from Purdue University, an MBA and MPA from Cornell University, and is a licensed pilot.
WEDNESDAY, 20 APRIL, 2016
OPTIONAL INDUSTRY TOURS OFFERED

Tour Musée Safran – Safran Aerospace Museum
Aerospace Museum Aeronautics lovers, both young and old will enjoy a visit to the Safran Museum’s unrivaled collection. From the first aircraft engines to the Ariane 5 launcher, this voyage through aerospace history is also an unrivaled opportunity to discover the major achievements of France in general and Safran in particular. Over the years, the team of volunteers who restored the first engines for the museum has continued to grow. In 1989, they banded together to form the Association of Friends of the Snecma Museum, then the Association of Friends of the Safran Museum when Safran was created in 2005. At the same time, the museum’s collection has expanded to include products from all Safran companies.

Itinerary:
12:00  Departure from hotel to Musée Safran (lunch provided)
13:00  Anticipated arrival to Museum
15:30  Anticipated departure from Museum back to hotel
16:30  Anticipated arrival time at Paris Marriott Rive Gauche Hotel

ONERA The French Aerospace Lab
The Office National d’Etudes et de Recherches Aérospatiales (ONERA) is the French national aerospace research centre. It is a public establishment with industrial and commercial operations, and carries out application-oriented research to support enhanced innovation and competitiveness in the aerospace and defense sectors. Join us for this unique opportunity to visit the “The French Aerospace Lab”.

Please note, for security reasons, a copy of your passport must be submitted to the ITA prior to the event in order to be allowed to participate in this tour.

Tour will leave after lunch at approx. 12:30 and will be returning at approximately 17:00
Abstract:
Application of Titanium Alloy Bars for Strengthening Reinforced Concrete Bridge Girders in Flexure
Structurally efficient and cost-effective solutions are needed to extend the service-life of deficient and aging highway infrastructure around the world. One critical need is to increase the flexural strength of older concrete structures to carry heavier and more frequent loads. Titanium alloy bars offer a new opportunity to strengthen such existing structures that has not previously been explored.

Titanium’s combination of strength, ductility, durability, and ability to form mechanical anchorages are essential characteristics for effective repair and retrofit applications and are advantageous over competing materials such as steel and fiber-reinforced polymer (FRP) products. Recent research using titanium alloy bars to strengthen existing civil infrastructure has been undertaken in the laboratory through tests of full-scale bridge girders using two alternative strengthening applications for bending. The first technique is called near-surface mounting (NSM) and the second is called external unbonded reinforcement.

The NSM retrofit technique involves cutting grooves into the concrete substrate and bonding specially made titanium alloy bars inside the grooves using structural epoxy. The titanium alloy bars serve as supplemental reinforcement to the girder to allow it to carry larger loads and to increase the deformation capacity. This experimental program tested seven full-scale concrete girders retrofitted with NSM titanium alloy bars. Advantages of using titanium with NSM included less labor cost for cutting grooves, lower epoxy costs, and use of higher stresses when compared to stainless steel. The ability to fabricate hooks at the ends of the bars for mechanical anchorage, increased warning of potential failure, and less field labor costs make it competitive compared with FRP. While research on the fatigue effects and environmental durability of the NSM retrofit is ongoing, this technique has already been put into service on an existing bridge in the USA over a major interstate highway at a significant cost savings compared to the FRP alternative.

The external unbonded reinforcement technique requires only drilling holes through the girder. Smooth as-rolled titanium alloy bars are not bonded along the length and 90° hooks are fabricated on the ends. The hooks are placed through the holes and prestressing chucks anchor the bars only. The elimination of grooves and epoxy required for NSM significantly reduced labor and material costs while also allowing application in all exposure conditions. To investigate the effectiveness of the technique, two full-scale concrete girders were strengthened in the laboratory. Only requiring a one-day installation time, this repair can be completed using standard contracting tools, equipment, and labor. The speed of the repair also reduces costs beyond labor by decreasing costs associated with the economic impact of long-term lane closures and bridge ratings.

This poster will discuss the advantages and disadvantages of the NSM and external unbonded reinforcement techniques for flexural strengthening; describe the titanium alloy bars, bridge girders, and construction practices; and detail the laboratory findings on the structural performance of the specimens. It will further demonstrate that titanium alloy bars offer a structurally effective and cost competitive alternative to current materials for maintaining and preserving aging and deteriorated highway infrastructure assets world-wide.

MacKenzie Lostra, Oregon State University, Corvallis, Oregon USA
Lostra received her bachelor’s degree in civil engineering from the University of Arizona in 2014 and is now pursuing a master’s degree in Structural Engineering at Oregon State University. Her background in research has been focused on seismic resiliency of reinforced concrete structures and innovative retrofitting methods. Her advisors include Christopher Higgins and Andre Barbosa.

Abstract:
Titanium retrofitting of seismically vulnerable columns is an opportunity to expand the amount of viable structural materials and methods for improving stability and safety in older concrete structures that do not meet modern seismic code requirements. The enhancement of reinforced concrete (RC) columns with unsatisfactory ductility properties using external titanium bars and spirals poses room for increased understanding of the behavior of rectangular retrofitted RC columns under seismic demands, simulated by monotonic-cyclic loading sequences.

The research utilizes four physical models at full scale, which are modeled after the McKenzie River Bridge in Oregon, to measure changes in ductility and strength. These columns, similar to many others on RC bridges constructed during the 1950-60’s, have poor internal detailing, with insufficient bending and shear...
reinforcement, making them susceptible to seismic forces. Specifically, poor detailing of the internal foundation bar lap splice creates a bond-slip failure mode, in which the longitudinal reinforcement between the foundation and column no longer acts as a continuous development when high stress level is reached; this reduces the stiffness of the joint between the foundation and the column.

The bending stresses imposed on a free-standing column are concentrated in this zone, therefore strengthening of the base of the column is necessary to resist seismic loads. Titanium is both economic and efficient for this purpose and possesses many desirable qualities such as its resistance to corrosion, low stiffness, and high strength. Four cases will be tested in this research: a control specimen (conventionally reinforced) and three retrofitted specimens with the retrofit extended above the lap splice, below the lap splice, and the lap splice removed entirely.

The results are expected to demonstrate improved ductility in the retrofitted columns by increasing passive confinement in the columns and providing additional, more flexible reinforcement. The confinement provided by the titanium coil and the leverage from the vertical ligaments should allow for proactive strengthening and resiliency of the columns, extending the displacement and load capacity. In turn, this can lead to more resilient bridges that are able to withstand larger deformations without losing axial strength. If the testing results in notably improved performance of the retrofitted columns to that of the un-retrofitted column, titanium can continue to be researched as a structural material in civil engineering and become more widely available and practical for use in retrofitting structures that require it.

The tensile and high cycle fatigue properties of the resulting bonded parts were only slightly reduced when compared to that of the bulk material and are equivalent to or better than those obtained by the traditional canned route. Adopting a can-less route offers considerable cost advantages.

The joining of massive titanium sections cut from plate is an attractive alternative to manufacturing large components by forging, as it offers a simple route to near net shaping, reducing the overall cost of components made in this way. A novel approach to this problem, using a process based on diffusion bonding (DB) and hot isostatic pressing (HIP), has been developed as a research PhD project at the Rolls Royce University Technology Centre (RR-UTC) in the University of Nottingham and is currently patented in the United Kingdom.

In this method, gaps between adjoining Titanium plates from dissimilar alloys (Ti-6Al-4V and Ti-6Al-2Sn-4Zr-6Mo) are “sealed” by a shallow laser weld around the majority of the join line. The final part of this interface is sealed in a vacuum by electron beam (EB) welding, thus creating a leak-tight gap containing a vacuum. These structures can then be “HIPed” without needing to be encapsulated, offering considerable cost advantages.

The research will provide preliminary data for an ongoing study of rectangular RC columns and seismic retrofitting at Oregon State University. Testing for this project is expected to conclude over the course of the next two months and future testing under an additional graduate student over the next several years.

Alfonso García, Rolls Royce UTC Nottingham, Faculty of Engineering The University of Nottingham University Park, United Kingdom.

Garcia started a career in design several years ago in Mexico, working for companies in fields such as near net-shape manufacturing, sheet metal forming, advanced manufacturing processes, product and tooling design. He is currently working in a Ph.D. project funded by Rolls Royce at the University of Nottingham.

Abstract:
The joining of massive titanium sections cut from plate is an attractive alternative to manufacturing large components by forging, as it offers a simple route to near net shaping, reducing the overall cost of components made in this way. A novel approach to this problem, using a process based on diffusion bonding (DB) and hot isostatic pressing (HIP), has been developed as a research PhD project at the Rolls Royce University Technology Centre (RR-UTC) in the University of Nottingham and is currently patented in the United Kingdom.

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The tensile and high cycle fatigue properties of the resulting bonded parts were only slightly reduced when compared to that of the bulk material and are equivalent to or better than those obtained by the traditional canned route. Adopting a can-less route offers significant time and cost savings with what appears to be no detriment to the bond strength and integrity.

Beatriz Eugenia Sanabria Arenas, Politecnico di Milano - Dipartimento di Chimica, Materiali e Ingegneria Chimica “Giulio Natta,” Italy

Sanabria Arenas obtained her M.Sc. degree in Chemical Engineering from university of Sao Paulo, Brazil, in 2014 and currently is a Ph.D. student in Materials Engineering from Politecnico di Milano, Italy. Her current research interests include functional nanomaterial synthesis by electrochemical processes for environmental applications. Her advisors include Davide Prando, Alberto Strini, Luca Schiavi, Andrea Brenna, Maria Vittoria Diamanti, and MariaPia Pedeferri.

Abstract:
In the environmental field, the efficiency of nanostructured titanium dioxide for degrading inorganic and organic substances is demonstrated. However, one of the major concerns about the use of nanostructured materials for water remediation and air purification by photocatalysis is their potential dispersion in the gas or liquid phase, where they are used, and the hazard related to their dispersion in the environment. In this context, the use of anodic oxidation represents a powerful technique for generating
photoactive oxides strongly adherent to a metallic substrate—i.e. titanium, and modify their chemical composition by doping. In this work, we present a robust method to obtain immobilized TiO2 by anodic oxidation, in the form of either nanotubes or nanoporous anodic spark deposition (ASD) coatings. The photocatalytic efficiency of these nanostructures was tested and compared in gaseous and liquid phases.

Commercial purity titanium sheets were anodized in three different electrolytes: aqueous solution, fluoride containing aqueous solution and fluoride containing organic solution. The electrolyte applied and the duration of the essays were changed in order to obtain the best nanostructures in each electrolyte. After anodizing in solutions containing fluorides, samples were annealed at 400°C for two hours to promote the formation of anatase phase TiO2.

Photocatalytic activity was evaluated in the degradation of dyes (rhodamine B, RbB) or VOCs (toluene). Degradation was performed by immersing a sample in 25 ml of 105 m/L RhB solution, irradiating for six hours with a solar spectrum lamp (UV-A intensity 3 mW/cm2) and monitoring color variations. Toluene degradation was assessed in air (25°C and 50-percent RH) in a continuous-flow stirred photo reactor operating at constant toluene concentration (0.75 μmol/m3), under UV-A irradiation of 0.6 mW/cm2.

In aqueous and organic solutions containing fluorides, self-aligned vertical nanotubes stem from the substrate; in organic solution the detachment of single nanotubes is less pronounced, creating a sort of porous template rather than a nanotubular array, but with higher thickness. Conversely, in absence of fluorides a large voltage is applied, generating an oxide with glassy appearance and larger pores. The photocatalytic degradation of dyes with these oxides increases with increasing voltage up to 150V; for higher voltages, too much rutile formation and lower anatase content reduce photo activity. When a nanotubular oxide is obtained, a larger reactivity is ensured.

Although nanotubes obtained in organic solution show the highest efficiency, preliminary results in toluene degradation show a larger dispersion of results compared to other the nanostructures. Conversely, nanotubes produced in aqueous solution exhibit excellent repeatability and good efficiency. Oxides without nanotubular morphology exhibit a very low reactivity in gas phase, while showing good degradation of RhB. This is interesting, because it points out the increased differentiation among the oxides photocatalytic activities in gas phase, in spite of the lower differences observed in liquid phase reactions.

In conclusion, the processes here described open the way to the production of photocatalytically efficient nanostructured TiO2 films immobilized onto a metallic substrate at low cost, avoiding environmental issues related to the use and recycle of conventional photocatalysis.

Davide Prando, Politecnico di Milano, Milano, Italy.

Prando, a Ph. D. student at the faculty of Materials Engineering of the University Politecnico di Milano, graduated in 2015 with a thesis about photocatalysis on titanium dioxide. He is currently working on the corrosion phenomena of commercially pure titanium. His advisors include Maria Vittoria Diamanti, Andrea Brenna, Silvia Beretta, MariaPia Pedeferri, and Marco Ormellese.

Abstract:
Titanium is well known to have an excellent corrosion resistance in natural environment. However much more severe conditions are found in industrial applications and alloys with better behavior were developed; these alloys are often prepared with elements more expensive than titanium (such as palladium in ASTM Grade 7 titanium). This work aims to find a surface treatment capable of improving the performances of the cheaper titanium ASTM Grade 2 on the electrochemical point of view, enable it to be used in critical conditions (such as reducing atmosphere or acid deaerated environments) instead of more expensive alloys.

Anodic oxidation of titanium produces a compact, protective and almost insulating oxide (mainly TiO2) on titanium surface; this technique is fast, easy and satisfactorily applied to other metals so it represents the first natural choice for this investigation.

In order to find the best anodizing treatment three main parameters were identified: anodizing electrolyte, applied potential and anodizing current density. The anodic oxidations were carried out in H2SO4 (because of the wide knowledge available on this electrolyte), and then in Na2SO4, (NH4)2SO4 and NH4BF4, trying to find a neutral electrolyte with good oxide growth times. The applied potential is directly linked to the final thickness of the oxide obtained. A higher potential produces thicker film that is expected to behave better from the corrosion point of view, but leads to oxide crystallization that is known to be detrimental. Thus, in order to investigate a proper range and to avoid conditions of difficult industrial implementation, the potentials were kept from 10V to 80V. Anodizing current density was also expected to have effects on crystallization of the oxide, a current density of 20 mA/cm2 was taken as a reference but also 5 mA/cm2 and 50 mA/cm2 were analyzed.

All the surfaces finishing obtained were tested with potentiodynamics analyses carried out in different electrolytes. NaCl35 g/L was initially chosen for the common use of titanium in marine
environment; then, in order to simulate more severe industrial environment, after a screening on different concentration from 1 g/L to 35 g/L, the electrolyte was substituted with NaF3.5 g/L.

The results obtained so far don’t highlight any preferable treatment. Each anodizing sample provided insulation and the consequent lower current density circulating during the potentiodynamic tests. The results concentrate in the region corresponding to a current density one order of magnitude lower than the one circulating in non-treated samples, and didn’t show any better or more reliable behavior with respect neither of used electrolyte nor of applied potential or current density.

For economical reason and a better applicability, the suggestion is to apply a treatment at low potential (10-20V) and to perform it in Na2SO4, which is the cheapest and easier to handle tested electrolyte. Further investigation is required: alloyed titanium is often used to control localized corrosion and this form of attack will be the next method to distinguish the best of the available treatment.

Jonathan Knudtsen, Oregon State University Civil and Construction Engineering, Corvallis, OR

Knudtsen received his bachelor of science degree in Civil Engineering from the Colorado School of Mines in Golden, CO. He is currently working towards his master of science degree in Structural Engineering at Oregon State University. His research is focused on the use of titanium for strengthening concrete bridge girders deficient in shear. His advisor is Dr. Chris Higgins.

Abstract:
Aging and obsolete infrastructure has become a major problem throughout the world. This is particularly evident in the case of concrete bridges. The cost of completely replacing these bridges is prohibitive, meaning engineers must find ways to strengthen them. Many older bridges predate our modern understanding of shear in bridge girders, and were thus built with insufficient internal stirrups. These bridge girders often display diagonal tension cracks in the high-shear zones near the columns. One method commonly used to strengthen these bridge girders is called near-surface mounting (NSM), which involves epoxying bars into vertical grooves cut on the surface of the girder.

Although this method was first developed for use with steel bars, it is now most commonly implemented using carbon fiber rods, due to steel’s corrosive properties. The goal of this research is to establish titanium as a viable alternative to steel and carbon fiber for NSM shear strengthening applications.

Titanium has several advantages over the other materials. It’s noncorrosive, so it does not need to be protected like steel. Titanium bars can easily be bent at the ends to provide anchorage. This is titanium’s main advantage over carbon fiber, since carbon fiber rods cannot be bent, and thus rely solely on epoxy for shear transfer. This means that the ultimate strength of carbon fiber is rarely reached, making it an inefficient repair material. Titanium’s low modulus of elasticity allows for large deflections, giving advance warning of impending failure. Due to titanium’s high yield strength, small diameter bars can be used. This significantly reduces the costs associated with time, labor, and materials, resulting in an overall cost savings when compared to other retrofit materials.

For this research program, seven realistically proportioned T-shaped concrete girders were constructed. These girders were intentionally under-designed to force diagonal tension failure, even after being strengthened with NSM titanium bars. The girders were tested in four-point bending. Failure occurred when the titanium bars ruptured at the main diagonal tension crack, meaning their full strength was achieved. This indicates that the method used is highly efficient. To date, four of the seven girders have been tested. Research is ongoing on the effects of fatigue loading and harsh environmental conditions.

Our research has conclusively demonstrated the effectiveness of NSM titanium bars in shear strengthening applications. Titanium has many advantages, including cost, over the methods and materials currently used, and we expect to see it established as a viable repair option for bridges.

Maxim Khatsayuk, Siberian Federal University, Krasnoyarsk Krai, Russia.

In 2013 Khatsayuk defended a thesis of candidate of sciences: “Induction Unit with a Magneto-Hydrodynamic Effects During Preparing and Casting Alloys.” Khatsayuk has 59 published works, three patents, and four software certificates. Khatsayuk currently is engaged in the research and development of a new method for producing the liquid phase of titanium in an electromagnetic field, which will form the basis for his doctoral dissertation. His advisor is Professor V. Demidovich.
Abstract:
The unique opportunity of the obtaining of the liquid phase of titanium alloy inside the cylindrical ingots during the induction heating gives the prospects to develop fundamentally new titanium alloys non-vacuum casting technology.

Such a technology is very competitive and energy efficient in comparison to the existing induction melting technology in a cold crucible. It is because of the fact that, during the process of melting, no additional equipment for vacuum is required. Furthermore, the process of the obtaining of the liquid titanium inside the ingot by the induction method requires a lot less time and energy consumption.

Piotr Wiecinski, Warsaw University of Technology
Piotr Wiecinski, Ph.D. Eng. has scientific experience in characterization of the microstructure, mechanical and tribological properties of the surface layers and coatings obtained by surface engineering methods. He is mostly focused on advanced characterization techniques like focus ion beam, scanning electron microscopy, scanning transmission electron microscopy, nanoindentation.

Abstract:
Progress in properties improvement of titanium and its alloys

One of the goals of our works is improvement of the strength of titanium using severe plastic deformation (SPD) method. Refinement of grain size below 90 nm in titanium grade 2 increases its strength above 1000 MPa, which is close to Ti6Al4V alloy. Nanostructure has a positive influence also on the corrosion properties of titanium in physiological saline (0.9% NaCl). A large number of grain boundaries in nanotitanium promote a rapid formation of homogenous protective passive layer which was evidenced in our work. A combination of good mechanical properties and corrosion resistance in the body fluid indicate that nanocrystalline titanium has a large potential in biomedical applications. Nowadays, our work is focused on methods for improvement of titanium biocompatibility. For example, the most promising method of surface modification of bone implants is mimicking the bone hierarchical surface structure after remodelling process. In order to modify titanium, hybrid method consisting of shot peening, acid etching treatment and laser interference lithography was proposed. Our results evidenced that the appropriate choice of the parameters of such treatment allows to form hierarchical roughness (in a wide range of length scale from nano- to micrometers). Furthermore, laser treatment forms texture favourable for osteogenic passes of the stem cells, which can have a positive impact on the osseointegration process.

Another area of our work is improving the tribological properties of Ti6Al4V alloy, which are insufficient for many industrial applications, by deposition of multilayered coatings using PVD method. Depending on the mechanism of wear, different kinds of multilayer coatings ensure the highest improvement of tribological properties. For example, Cr/CrN multilayer coatings exhibit excellent anti-erosion properties on Ti6Al4V alloy. Moreover, STEM observations evidenced that Cr layers accommodate plastic strain induced by erosion particles while interfaces between layers effectively block crack propagation. These phenomena decrease the number of cracks and ensure structure integrity of the coating during erosion. On the other hand the measurement of wear resistance during pin on disc test reveals the highest improvement of the tribological properties for the TiN/CrN coatings. Our results evidenced that not only the phase composition, but also the number and thickness of layers can influence the properties or even change the mechanism of failure.

Titanium and its alloys with outstanding strength-to-density ratio are potentially prime elements for new constructional alloys to reduce the weight and energy consumption in all transport sectors. In our group mechanical properties of Ti and its hexagonal alloys are successfully predicted utilizing ab initio modeling methods. The calculations methodology includes electronic and atomic structure characterizations of binary (α-Ti+O) and selected ternary systems comprised of substitutional and interstitial alloying elements. Mechanical properties evaluation covers single and polycrystalline elastic constant, plasticity criteria as well as generalized stacking fault energy calculations. The achieved results provide insight into the physics of solute-solute element interactions, dislocation nucleation or dissociation mechanisms and atomic configuration of compact (point defects, dislocation cores) or extended (stacking fault, twins) defects.
Metallography of Titanium and Its Alloys Workshop
Monday, 18th April

Who Should Attend:
This one day class is a practical class for anybody interested in understanding the microstructures of titanium alloys.

Course content will include:
- Brief history of titanium and alloy development
- Overview of the general properties of the alloy groups and their applications
- Basic metallurgy of titanium including the terminology used to describe microstructures
- Microstructures of the most common alloys with variations caused by manufacturing methods and heat treatments
- Defects specific to titanium introduced in primary and secondary manufacturing and heat treatment
- Proper metallographic sample preparation techniques to reveal the true microstructure including a discussion of the effects of various etchants.

Class Information:
Workshop registration fee includes: refreshments, lunch, and study guide

Instructor:
Frauke Hogue, FASM, received her education in metallography and testing of materials in Berlin, Germany. In 1967 she moved to the Los Angeles area and worked for Voi-Shan, a manufacturer of aerospace fasteners, in the Quality Control laboratory for 10 years. 1981 Frauke became an independent consultant in metallography, working mainly in the greater Los Angeles area, providing metallographic services to failure analysis companies. Since 1985 she has been teaching intensive courses at ASM International and at companies throughout the United States and abroad. Frauke developed “Practical Interpretation of Microstructures” in 1998 which consists of a collection of about 300 mounts and a notebook of annotated images of various materials and conditions. This was followed by “Metallography for Fasteners” and “Metallography for Failure Analysis”. 
EXHIBITOR PROFILES
## EXHIBITOR LISTING

### Listing by Kiosk Number

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Above Material Technology Co., Ltd
www.amt-alloys.com

Above Material Technology Co., Ltd is professional in titanium wires since 1997, specialized in R&D and manufacturing. We are proud to be a well known and top quality brand in China, and supplying the world’s top quality Titanium wires with competitive price to all over the world, especially Europe, USA and Japan.

Our top quality Titanium Wires have the four advantages:

A. Shiny clean- Our wires are clean, shining. The competitors are some dull.
B. Full spool and precise weight- Our wires can be weight control precise.
C. Pretty logo printing- Our wires can be stamped beautiful.
D. Neat end-cut- Our wires are neat end-cut, shiny and homogenous color too.

Our quality titanium fine wires can be from diameter 0.1-5.0mm, level winding without support used for 3D printing, with large single weight and neat convenient package.

export@amt-alloys.com

ACNiS International
www.acnis-titanium.com

Since 1991, ACNiS® International is a leading stockholder and distributor of alloyed and non-alloyed Titanium in all forms and sizes for Industrial, medical and aerospace applications. Among our wide product range, we offer bars, sheets, tubes, flat, hexagonal and square bars, tubes, welding wire and fasteners. We serve our customers from our head office in Lyon-France, but also from our 3 service centers located in Paris (Aerometals & Alloys®), Brazil (ACNiS® Do Brasil) and China (ACNiS® Asia). ACNiS® Group distributes high quality Titanium from world renowned producers. Certified ISO 9001, ISO 13485, EN 9120. For further information, please visit our website www.acnis-titanium.com

ALCOA
www.alcoa.com

A global leader in lightweight metals technology, engineering and manufacturing, Alcoa innovates multi-material solutions that advance our world. Our technologies enhance transportation, from automotive and commercial transport to air and space travel, and improve industrial and consumer electronics products. We enable smart buildings, sustainable food and beverage packaging, high performance defense vehicles across air, land and sea, deeper oil and gas drilling and more efficient power generation. We pioneered the aluminum industry over 125 years ago, and today, our approximately 60,000 people in 30 countries deliver value-add products made of titanium, nickel and aluminum, and produce best-in-class bauxite, alumina and primary aluminum products.

ALD Vacuum Technologies GmbH
www.ald-vt.de

ALD Vacuum Technologies GmbH, located in Hanau, Germany - a company with rich tradition, is the leading global supplier of processes and services in the field of vacuum process technology. With its matured technological specialties – vacuum metallurgy and vacuum heat treatment, ALD is a strong partner of important and growing branches of industry. To the rapid rise in the titanium industry, ALD vacuum metallurgical equipments make the outstanding contributions. The processes are mainly employed for the production of special steels, high-temperature alloy, refractory and reactive metals (tantalum, niobium, titanium and zirconium) and their alloys which meet the requirements on the properties and performance of these advanced remelted materials of the aerospace, power generation, defense, medical and nuclear industries.

ALD is company of the AMG Advanced Metallurgical Group N. V., Netherlands.
### Allegheny Technologies Incorporated

**Kiosk # 51**  
www.atimetals.com

ATI is one of the largest and most diversified specialty materials and components producers in the world. As a fully integrated supplier from raw material (titanium sponge) and melt (specialty alloy systems) through highly engineered finished components, we use innovative technologies to offer growing global markets a wide range of specialty material solutions.

Through unsurpassed manufacturing capabilities, industry-leading alloy systems, mill products, and engineered castings and forgings, ATI offers a unique supply chain solution that Creates Value Thru Relentless Innovation®.

### AMETEK - Reading Alloys

**Kiosk # 47**  
www.ametek.com

AMETEK - Reading Alloys is a manufacturer of high quality master alloys comprised of Vanadium, Molybdenum, Niobium, Chrome and Aluminum ingredients. Master alloys are for rotor grade, aero, non-aero, commercial and super alloy metals applications. We are a manufacturer of high purity Titanium powders for thermal spray coatings as well as additive manufacturing. A series of gas atomized specialty powders for hard facing, brazing and thermal spray further complement the product offerings. We also offer toll melting, cold isostatic press, hydride/dehydride and other services. Our quality system is certified to ISO 9001:2008 and AS9100C. Our lab is Nadcap accredited. Visit AMETEK - Reading Alloys via our website at www.ametekmetals.com.

### ARIES MANUFACTURING

**Kiosk # 22**  
www.aries-manufacturing.com

ARIES Manufacturing is dedicated to the supply of complex airframe structure components, in both titanium and aluminum alloys, to leading manufacturers in the aerospace industry.

ARIES Manufacturing is part of the ARIES Alliance, a group of companies focused on developing innovative technology that creates value for the aerospace industry.

For all cold forming, hot forming and friction welding processes, Aries Manufacturing is able to control the entire process, from simulation, development of dies, up to delivery of finished parts to its partners.

### AUBERT & DUVAL

**Kiosk # 53**  
www.aubertduval.com

Aubert & Duval is a reference metallurgist company, manufacturer of Titanium closed-die forgings. Strong experience in closed-die forging process, heat treatment and non-destructive inspection.

Production of Titanium forged and rolled products in Les Ancizes plant.

UKAD is a JV between UKTMP and Aubert & Duval inaugurated in 2011. Located near Aubert & Duval « Les Ancizes » plant, in the center of France.

Conversion of (UKTMP and EcoTitanium) ingots in billets and bars by forging. Production increased by 2 every year, more than 3 000 t in 2015.

### BAHCO

**Kiosk # 44**  
www.bahco.com

Bahco will feature our 3860 Bandsaw product, a Multi Chip Carbide blade developed specifically for cutting Titanium and other high alloys used in the critical industries. We seek partners through the conference who wish to improve and optimize their Bandsaw operation with a World leader in Cutting Technology. In the 1980’s Bahco developed and Patented the first Set Tooth Carbide Bandsaw blade to provide fast, efficient cutting of exotic alloys and have led the way in this sector ever since. Bahco is a registered trade name of SNA Europe. SNA Europe is the premier pan-European manufacturer of handtools and saws, part of Snap-on Incorporated.
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Baoji Titanium Industry Co., Ltd. (shortened form as BAOTI), the largest titanium producer in China, was established in 1999 and was listed in Shanghai Stock Exchange in 2002. Through a few years development and three times mergers and acquisitions, it has developed as an integrated titanium producer and supplier with the products of titanium sponge, ingot, plate & sheet, bar & billet, forgings, tube & pipe, wire & rod and castings.

Baoji Yongshengtai Titanium Industry Co., Ltd. is a high-tech enterprise engaged in titanium and titanium alloys and other nonferrous metal products. We are situated in Baoji, which is well known as "Titanium City". With the total investment of 10 million RMB and covering an area of 2000sqm, we are one of the important enterprises in China.

At present, we possess more than 150 employees and staff members and have 6 sets of VAR furnaces, 2,000 tons of pressing machines, annealing furnaces, turning machines, planning machines, forging hammers, ultrasonic testing equipment, and other meters. Microstructure inspection, physical inspection, chemical composition analysis, and other special test and inspection are carried out in independent labs.

Our company was established in 1992, so we have had more experience in manufacturing, processing and selling titanium & titanium alloy products for many years. We can produce different mill products, such as titanium and its alloy bars and billets, sheets and plates, forged rings and discs, electrodes and wires, and other shapes with China national standards, and AMS ASTM, ASME, ISO, MIL, DIN, and JIS specifications. Up to now, we have an annual capacity to produce 3,000 tons of titanium alloys and mill products, including ingots.

As an ISO9001:2008 certificated company, our products have been exported to Singapore, the UK, the USA, India, Indonesia, Sweden, Germany, France, Austria, Turkey, South Korea, Taiwan area, Brazil, and other countries and regions. For high quality goods, we have won a good reputation from domestic and international markets. Yongshengtai welcomes friends from all over the world by hand in hand to create a new prosperity.

Our company is the application solutions provider of titanium and titanium alloy manufacturing and research integration. It is composed of research and development base in Beijing and manufacturing base in Yunan.
CEFIVAL

www.cefival.fr

Cefival manufactures hot extruded hollow bars and special near net shapes in any kind of steels and titanium alloys, inconel as well as flash butt welded rings for aircraft engines. There is a large variety of aero-structure profiles: seat tracks, floor and wings stiffeners, door hinges... Cefival manufactures also titanium hot bended shapes.

Cefival is one of the main suppliers for flash butt welded rings for engine references CFM56, GE90, GEN X, GP7200, CF6-80, SAM146 and A400M and can provide rough or machined rings.

Cefival is Snecma, Airbus, Boeing and Rolls Royce approved.

Nowadays, manufacturers need to streamline production, reduce operating costs and have good flexibility. Cefival aims to provide a prompt and accurate service of customer’s needs with Titanium shapes. The shapes we propose are said “special” because they are studied and manufactured according to customer’s requirements in a wide range of solid and hollow sections. Homogeneity of the metallurgical structure and non-alteration of the chemical and mechanical properties at the end of the production process, have pretty much developed their application in the aerospace, food processing, power generation, defense, chemical industry, medical and watch industry. . . .

Our competitive advantages:
- Improved material yield compared to blank machining
- Cost efficient even for very small volumes
- Produce to customer designs
- Self developed technology
- Own in house tooling design and production

Homogeneity of the metallurgical structure and non-alteration of the chemical and mechanical properties at the end of the production process, have pretty much developed their application in the aerospace, food processing, power generation, defense, chemical industry, medical and watch industry. . . .

You need it, we create it!

Consarc Engineering Ltd

www.consarceng.com

CONSARC ENGINEERING LTD are world leaders in Vacuum Furnace Technology, as part of the Inductotherm Group of companies Consarc Engineering Ltd design and manufacture vacuum and controlled atmosphere furnaces for the following processes:

- Vacuum Precision Investment Casting (VPIC)
- Vacuum Induction Melting (VIM)
- Vacuum Cap Furnaces (VCP)
- Vacuum Arc Remelting (VAR & RVAR)
- Electroslag Remelting (ESR)
- Induction Skull Melting (ISM)
- Induction Vacuum Ladle (IVL)
- High Temperature Heating
- Chemical Vapour Deposition
- Vacuum Heat Treatment (VHT)
- Vacuum Brazing (VAB)
- Diffusion Bonding
- Vacuum De-Oiling
- Custom/Proprietary Processes

CONSARC will be exhibiting a range of equipment at Titanium Europe 2016 and providing information and expert advice on all their vacuum furnace technologies.

Of particular interest in the field of Titanium processing are:
- Induction Skull Melting (ISM) a method of melting metals in a segmented, water-cooled copper crucible while under vacuum or controlled atmosphere, using an induction coil. This is done metal-to-metal, without a refractory lining for superior quality casting of reactive metals including Titanium.

CONSARC ISM furnaces are available for any application from R&D to high production.
- Reactive Vacuum Arc Remelting (RVAR) furnaces are available for primary melting (compacted sponge or scrap electrodes) or secondary melting (remelting a previous ingot from a primary melt) reactive metals, such as Titanium.

CONSARC RVAR furnaces are available in standard sizes ranging from 200mm to 1250mm diameter.
**DANOBAT**

www.danobatbandsaws.com

Sixty years have gone by since DANOBAT manufactured its first machine. Nowadays DANOBAT Band Saw Machines does not simply make band saws, but innovates in the field of machine tools.

DANOBAT Band Saw Machines strategy is to offer custom solutions for highly complex sawing applications on high-tech products. The aerospace, automotive, rail, industrial resources, windpower, oil and gas sectors and outsourcing workshops are the main trading sectors of DANOBAT Band Saw Machines.

The technological leadership of DANOBAT Band Saw Machines in the development and manufacture of horizontal and vertical band saws makes it possible to offer leading-edge and highly effective sawing solutions to our customers.

DANOBAT Band Saw Machines provide solutions for solid bars, pipes and plates with the highest accuracy. Automatic band saw machines, wagon style or gantry for large dimensions and vertical plate saws are the solutions offered by DANOBAT.

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**ELG Utica Alloys**

www.elguticaalloys.com

ELG Utica Alloys is one of the world’s leading specialists in revert management, and high-performance alloys and metals. With globally 9 processing facilities, 10 offices and over 50 years of experience, ELG Utica Alloys provides their customers with best in class service and value. As a service provider for MRO companies ELG Utica Alloys conducts the collection, controlled transport, certified destruction and sorting of life limited parts and entire engines. These mutilated parts will be upgraded and led back to the recycling stream.

ELG Utica Alloys provides long-term support to the customers, to add real value to their revert management programs. ELG Utica Alloys tailors every arrangement to each individual customer’s needs, but the following elements are often involved:

- On-site collection of revert, including provision of storage;
- Detailed sorting of collected materials;
- Processing of both solids and turnings to vacuum quality;
- Chemical analysis of material collected;
- Approved supply of material into melt shop of choice

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**ENPAR Sonderwerkstoffe GmbH**

www.enpar.de

Enpar Sonderwerkstoffe GmbH is a highly competent and established partner in the European market for specialized metal processing. With core competences in stock-keeping and metal processing, Enpar Sonderwerkstoffe acts as material manager for nickel and titanium alloys, special steel grades and high performance alloys with particular technological properties.

The comprehensive portfolio consists of semi-finished metal products for companies with further processing: bars in flat, square and round dimensions, forging billets, forged pieces (rings, discs, etc.), sheets, plates as well as tubes and fittings. Since 2003, water-jet cut parts according to drawing complete our product range.

Through several co-operation partners in the metal machining and metal processing business as well as extensive stock capacity, Enpar is in the position to react quickly and with flexibility to customer requirements and offer the best suitable technical solution.

The Enpar team will be pleased to share their comprehensive technical expertise and experience gained over the past decades. We will offer our customers the material which exactly complies with their particular demands as well as customized solutions for their special technical requirements.

Enpar Sonderwerkstoffe GmbH – Germany [1295 characters incl. blanks]
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<td>38</td>
<td><a href="http://www.evrazstratcor.com">www.evrazstratcor.com</a></td>
<td>EVRAZ Stratcor offers titanium producers one-stop shopping for all their master-alloy requirements. Using a state-of-the-art, ISO approved production facility that is focused on meeting the ever-increasing quality needs of the aerospace industry, we can provide a full range of vanadium and other master alloys, including innovative and customized specialty alloys that are marketed and managed by EVRAZ Stratcor, Inc., based in Chicago, Illinois.</td>
</tr>
<tr>
<td>Friggi Cutting Solution</td>
<td>54</td>
<td><a href="http://www.friggi.it">www.friggi.it</a></td>
<td>Friggi represents the new excellence MADE IN ITALY known all over the world. Technology, innovation and tradition in the service of the best solutions of industrial cutting solutions, through design and construction of medium and large size plants. Production of band saws for cutting steel and aluminum, with superior quality and highly performing, is the result of a study and a long-term experience and the merger of know-how and resources of two industry-leading business organizations.</td>
</tr>
<tr>
<td>Grandis Titanium</td>
<td>43</td>
<td><a href="http://www.grandis.com">www.grandis.com</a></td>
<td>GRANDIS TITANUM COMPANY is a Major Worldwide Supplier of titanium products: Titanium Sponge, Titanium Ingots, Titanium Bars &amp; Billets, Titanium Sheets, Titanium Plates, Titanium Wire &amp; Tubes and Ferro-Titanium. HQ and main warehouse located in Rancho Santa Margarita, CA, and sales and representative offices in Glenmont (Ohio), Albany (Oregon), Harbin (China), Ekaterinburg (Russia), and Seoul (South Korea), along with warehouses facilities and stock in Paramount (CA), Rotterdam (Netherlands) and Xian (China).</td>
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<tr>
<td>IMEAS SPA</td>
<td>37</td>
<td><a href="http://www.imeas.it">www.imeas.it</a></td>
<td>IMEAS spa is a family-owned, Italian company that is specialized in manufacturing and supplying of special, custom-made machines and turn-key plants for grinding and polishing of stainless metals and special alloys, such as titanium, stainless steel, aluminium and nickel among others. The company is also active in the processing of wood-based panels for the building and furniture industries, as well as plastic, rubber and composite materials. Employing over 100 people worldwide, the company more than 90% of its revenues abroad. In 2016 Imeas will turn its 50th anniversary.</td>
</tr>
<tr>
<td>Independent Forgings &amp; Alloys</td>
<td>19</td>
<td><a href="http://www.independentforgings.com">www.independentforgings.com</a></td>
<td>Independent Forgings &amp; Alloys ltd is an open die forge with expertise in titanium, nickel and steel alloys. Processing ingots to billets, rolled/hammer forged rings and flat bars through our onsite capabilities which include a 1600 tonne open die press, 2 x ring rollers, 3 forging hammers, NADCAP approved heat treatment and machining facility.</td>
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<td>Company Name</td>
<td>Kiosk #</td>
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<tr>
<td>Industrial Metals International Ltd.</td>
<td>35</td>
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<tr>
<td><a href="http://www.industrialmetals.com">www.industrialmetals.com</a></td>
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<td>Industrial Metals International Limited is a full line Steel Distributor. Specializing in the supply of Titanium, Aluminum, Stainless, Alloy, Nickel, and Bronze products. Our warehouse stocks Bar, Tube, Sheet, Wire, and forged products all available for same day shipments. IML as we are know is also, one of the few suppliers to be approved by Boeing, Airbus, Pratt &amp; Whitney, Rolls Royce, UTAS, Lockheed Martine, Bell Helicopter, Embraer, and Bombardier. Allowing us to meet all of your quality requirements.</td>
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<tr>
<td>L.C.M.A.</td>
<td>48</td>
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<td><a href="http://www.lcma.lu">www.lcma.lu</a></td>
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<td>L.C.M.A. is a European manufacturer and distributor of a wide range of CP titanium and titanium alloy semi-finished products, is present on the market since 1996 with strategic location in Luxembourg! Titanium bars, ingots, tubes, sheets/plates and wire belong to the product portfolio of L.C.M.A. The company offers its products and expertise in titanium business for individual projects in the aerospace, medical and petrochemical industries. L.C.M.A is a part of a vertically integrated structure which produces, melts, forges and rolls its products only in Europe, according to international quality standards ISO 9001:2008, EN9100:2009, AS9100:2009 and PED 97/23EC. We offer you: Quality, Expertise, Flexibility, Short lead time, large stock and Competitive Prices.</td>
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<tr>
<td>Luoyang ShunYi Titanium Co., Ltd</td>
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<tr>
<td><a href="http://www.shunyititanium.com">www.shunyititanium.com</a></td>
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<td>Luoyang ShunYi Titanium Co., Ltd. estabished in 2009, is a high-tech enterprise located in Luoxin Industrial Zone of Luoyang. Besides the convenient transportation the environment around is also beautiful. The registered capital of our company is 12 millions Yuan. We’re engaged in manufacturing, processing and selling Titanium, Titanium alloys and other non-ferrous metals domestically and overseas. Our company is under special protection of Xin’an county government. We had ISO9001 certificate of registration in 2012. Our factory covers 25 thousand square meters, on which there are workshops of 10 thousand square meters. The main production facilities include vacuum self-consumable electrode furnaces, a compressor, heating furnaces, a vacuum annealing furnace, a 3150 MT horizontal extrusion press, rolling machines and straighteners. We’re making good use of the professional resources and cooperating with the related research institutes. Depending on our solid research, spirit of innovation, thorough technological process, strict management and advanced equipment, high-end Titanium products are continuously offered. We adhere to the tenet of “Survive on quality, develop by innovation”. We’re getting repayment and developing powerfully when serving the society. Rooting in West Henan, it’s our goal to expand our business around China and the whole world.</td>
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<tr>
<td>Perryman Company</td>
<td>52</td>
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<td><a href="http://www.perrymanco.com">www.perrymanco.com</a></td>
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<td>Perryman Company is a vertically integrated producer of specialty titanium products. From melting, forging, and fabrication to finished product, Perryman’s quality and technical expertise is unmatched. Our Spectralloy facility is engaged in the recycling of titanium revert raw material for use in various titanium melt processes in the manufacture of titanium ingots. Perryman supplies and services customers in the aerospace, medical, consumer, and recreation markets worldwide. Approvals include ISO9001:2008, AS9100, and NADCAP. Perryman Company is headquartered in Houston, Pennsylvania. Company offices are located in Philadelphia, Warsaw, IN, Los Angeles, London, Zurich, Tokyo, and Xi’an.</td>
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<tr>
<td>Saarmetall</td>
<td>Kiosk # 14</td>
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<tr>
<td><a href="http://www.saarmetall.de">www.saarmetall.de</a></td>
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<td>Since 1925 Saarmetall have specialised in the production of forged/fabricated water cooled copper fittings. For numerous applications in the world-wide ferrous and non-ferrous metallurgical industries. Over more than 3 decades Saarmetall (machining and welding shop) and its French subsidiary Solocuivre (forging shop) have manufactured all kinds of copper crucibles for traditional re-melting processes - such as VAR/ESR, VAR/SM and EB/PAM. In ESR copper crucible manufacturing, Saarmetall has produced ESR withdrawal mold systems (dia &gt; 2000 mm) for various customers. Special crucibles for VAR skull melting and casting of Titanium have been manufactured throughout the past years and supplied both to furnace manufacturers or end users. Recently, Saarmetall has increasingly contributed in design and manufacturing of huge EB and PAM cold hearth and withdrawal crucibles assemblies. Saarmetall supplies crucibles and hearth systems of highest quality, with stringent control of copper input materials and operational integrity to the well-known manufacturers of EB and PAM furnaces. Upon request we provide full engineering from scratch. In addition Saarmetall offers repair and maintenance of copper assemblies, either at Saarmetall site (Saarbrücken/Germany) or on customer site abroad. The scope of repair and maintenance ranges from design changes, complete revamping, or on site emergency repair welding of damaged copper assemblies - enabling the end users to reduce down times and sustain production.</td>
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<tr>
<th>RETECH a SECO/WARWICK Company</th>
<th>Kiosk # 24</th>
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<td><a href="http://www.retechsystemsllc.com">www.retechsystemsllc.com</a></td>
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<td>Since 1963, Retech has been the world's leading provider of vacuum melting systems for demanding industries in ever-changing markets. Our advanced technologies have been applied to melting, refining, casting and atomizing reactive and refractory metals, such as Titanium &amp; its alloys, super alloys and rare earth metals. Each custom system produces products with the unique metallurgical and geometric properties that are required by the application. In 2011 Retech became a part of the SECO/WARWICK Group of companies which has an expanded our global presence through added sales and service centers around the world. Both companies RETECH and SECO/WARWICK are the most fully integrated furnace manufacturers in the world, providing customer access to our wide range of in-house resources, including technology, material and process development. Group advanced process technologies include: Plasma Arc and Electron Beam Cold Hearth Melting, Vacuum Induction Melting and Vacuum Arc Remelting. Vacuum metallurgical equipment is manufactured globally in our facilities in China, Europe and the US.</td>
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<tr>
<th>T.I. (Titanium Industries, Inc)</th>
<th>Kiosk # 36</th>
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<tr>
<td><a href="http://www.titanium.com">www.titanium.com</a></td>
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<td>T.I. (Titanium Industries Inc.) is the global leader in performance metal solutions for the aerospace, medical, industrial and oil and gas markets. We are the largest independent distributor of Titanium and Specialty Metals stocked throughout our global service center network. We maintain and are continually expanding our state of the art processing and near net shape capabilities, such as water jet cutting, saw cutting, and shearing. We provide tailored supply chain solutions through our T.I. Materials Management methodologies and Program Management competence. We continuously focus on lean and process improvements while maintaining AS9100 and ISO9001 certifications at all locations worldwide. Our award winning sales team has been providing dependable quality driven solutions to customers since 1972.</td>
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Tekna
www.tekna.com
Tekna is the worldwide leader in induction plasma technology and its applications. A technology used for production of spherical powders, nanopowders, and/or coatings. Tekna also offers high quality powders:
• Spherical powder: High flowability, high density, controlled chemistry and oxygen level. The materials offered could be metallic (Ti64, Inconels, Al Alloys, W, Ta, Mo, …) or ceramic (WC, …)
• Nanopowders: Principally spherical shaped however may also be nanotubes (Cu, Si, B4C, BNNT, …)

Thermo-Calc Software
www.thermocalc.com
Thermo-Calc Software is a leading developer of software and databases for calculations involving computational thermodynamics and diffusion controlled simulations.

Timesavers International B.V.
www.timesaversint.com
The Timesavers Group has been providing wide-belt grinding machine solutions for the metal, titanium, molybdenum, zirconium, tantalum, zinc and tungsten, and plastic processing industries, as well as for a wide range of other materials for more than sixty years. Today, they can be considered to be one of the largest and technologically most advanced manufacturers of this type of machinery in the belt-widths 220 to 2600 millimeters in the world. Using pioneering technologies, unparalleled expertise, and unmatched services and support, they presently have more than 55,000 machines in service in a multitude of application fields that deliver some truly fine finishes.

TIMET, Titanium Metals Corporation
www.timet.com
Titanium Metals Corporation (TIMET) is one of the world's largest fully integrated titanium producers. Since 1950, TIMET has been leading the industry in mill and melted products, supplying nearly one-fifth of the world's titanium. We convert rutile ore into sponge; melt and refine ingot and slab; and manufacture mill products. TIMET has a global network of service centers supported by its seven primary melting or mill facilities in Henderson, Nevada; Toronto, Ohio; Morgantown, Pennsylvania; Vallejo, California; Witton, England; Waunarlwyd, Wales; and Ugine, France. With products ranging from sophisticated high temperature alloys used in jet engines, to advanced corrosion resistant alloys used in the chemical industry, TIMET's reach spans the breadth of the titanium applications, and has the technical depth to support developments across a wide range of applications. TIMET's fully integrated supply chain, dedicated research facilities, and decades of experience make us the partner of choice for titanium.
TITANUM EUROPE 2016 EXHIBITOR PROFILES (continued)

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<tr>
<th>TIPRO INTERNATIONAL CO., LTD</th>
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<tr>
<td><a href="http://www.tipro-international.com">www.tipro-international.com</a></td>
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<td>Since 1995, TIPRO GROUP has been involved in titanium mill products manufacturing. We have three Subsidiaries companies: TIPRO WELDING WIRES (TWW); METAL TITANIUM (MTCO); TIPRO FASTENERS (TFC); We are a group of professionals who are ready to offer the highest quality to you and your customers. Focus on titanium and Zirconium. Located in Xi’an and Baoji, 8 ton, 10 ton and 15 ton self-consumable VAR furnace; Rolling machine; annealing furnaces, turning machines, forging hammers, ultrasonic testing equipment; Drawing wires machine; 3500 ton free forging oil-hydraulic press… More than 100 employees. • Factory area 10,000.00m² • The biggest titanium wires manufacturer in China • AS9100; EN9100 certificate by BV • ISO 13485 certificate by BV • ISO 9001-2008 certificate by SGS • Factory certificate by TUV To meet high quality standards, our quality control technicians and inspectors perform mechanical testing on all incoming semi-finished material. Sample material from each lot is analyzed to verify the material meets the latest specification revisions. Our software allows infinite traceability of mechanical testing. Tipro products have been exported to West EU; EAST EU; North EU; Middle East; North America; South America; Singapore, Turkey, South Korea, Taiwan area, and other countries and regions.</td>
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<tr>
<th>Tirus International SA (VSMPO-AVISA)</th>
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<td><a href="http://www.vsmpo.ru">www.vsmpo.ru</a></td>
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<td>VSMPO-AVISA Corporation is the world’s largest titanium producer, fully vertically integrated, from titanium sponge to all types of mill products, die-forgings and finished parts, including large machining facilities. The Corporation is a key strategic partner and approved supplier of leading companies in high-technology sectors like aerospace, aero-engines, power generation industry, chemical engineering, ship building as well as the medical industry. VSMPO-AVISA holds more than 300 international quality certifications for quality management system, processes and products. In order to offer a best-in-class logistics and commercial service to its customers worldwide, VSMPO-AVISA has an integrated sales and distribution network, named VSMPO-Tirus. With warehouses located in United States, Germany, England and China, the Tirus network distributes ingot, forgings, slab, sheet, plate, bar, and billet to the aerospace, medical, and consumer products industries. In North America, the VSMPO-Tirus US company also manufactures small diameter bar and coil for medical and aerospace fastener applications.</td>
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### Tricor Metals

**www.tricormetals.com**

**Introduction:**
We are a woman-owned, small business with facilities in Wooster, OH, Conroe, TX, Plymouth, MI and Oxnard, CA with over 25 years’ experience in the supply of titanium mill products, titanium forgings and fabrication of ASME Code equipment for the petrochemical, pharmaceutical, mining, aerospace, and bio-medical served markets.

**Titanium mill products & custom forgings**
One of the world’s most complete inventories of titanium mill products in ASTM grades for corrosion including sheet, plate, pipe, fittings, bar, billet, wire, tubing, and fasteners. And we maintain staged billets for custom forgings. We stock AMS-grades of titanium sheet, plate, bar and billet for aerospace and bio-medical served markets. We offer advanced processing including water jet cutting, saw cutting, and shearing. We provide custom parts manufacturing and just-in-time inventory for ‘blanket’ order processing to meet our customer’s needs.

**Fabrication & weld repair services**
In our ASME code shops in Ohio and Texas we build custom process equipment including: tanks, towers, pressure vessels, piping spools, shell & tube heat exchangers, plate and frame heat exchangers, and custom welded parts. We specialize in advanced metals for solving corrosion such as titanium, tantalum, zirconium, niobium, nickel alloys, duplex stainless and stainless steel.

**Astrolite® Alloys - Welding wire and titanium for aerospace**
Astrolite® high performance welding wire for aerospace and turbine engines.

### United Performance Metals

**www.upmet.com**

United Performance Metals, a leading distributor and processor of titanium and high performance alloys, serves global aerospace, medical device and industrial markets. Headquartered in Hamilton, Ohio, United Performance Metals maintains branches in La Mirada, California; Houston, Texas; and Belfast, Northern Ireland as well as sales and stocking locations worldwide. Facilities in the US and UK carry a complete line of inventories in titanium, stainless steel, nickel, cobalt, and cobalt chrome moly available in sheet, coil, plate, forged block and round bar. First-stage processing services include precision blanks, laser & water jet cutting, cut-to-length, sawing, shearing, chamfering & facing, deburring, first stage machining and laser gauge measurement. O’Neal Industries (onealind.com), the U.S.A.’s largest family-owned group of metals service centers, is the parent company of United Performance Metals. With sales of approximately $2.4 billion in 2015, O’Neal Industries is based in Birmingham, Alabama and has more than 80 specialized facilities throughout North America, Europe, and Asia. AS9100 & 9120, PWA 119, ISO 9001 & 13485, AS7003, EE02-S-422.

### Uniti Titanium

**www.uniti-titanium.com**

Uniti Titanium is a joint venture between Allegheny Technologies (USA) and VSMPO (Russia) supplying a wide range of titanium mill products for the industrial market: Power Generation, Plate Frame Heat Exchangers, Chemical Process Industry, Anodes, etc…. We manufacture bars, billets, sheets and plates, seamless/welded tubes in commercially pure titanium (GR1, GR2, GR3, GR4, GR7, GR11, GR16) and other alloys such as GR05 or GR12.
### Western Superconducting Technologies Co., Ltd

Western Superconducting Technologies Co., Ltd. (WST), founded in 2003, is headquartered in Xi’an, China. WST is leading supplier of titanium and its alloys including Ti6Al4V, Ti6Al4V ELI, Ti6242, Ti6246, Ti662, Ti811, Ti38644, Ti1023, Ti6Al7Nb, NbTi, TiNbZr in the forms of ingot, billet, forging, slab, bar, rod, wire and profile in the domestic & oversea market. Our products are mainly used in aerospace, medical, automotive industries and other critical industries. WST possess most advanced 10 tons VAR furnaces and series of high speed forging presses to manufacture 6000 tons ingots and 4000 tons bars per year. We have gotten the certificate of ISO 9001, AS 9100, NADCAP and ISO 14001, strict quality control system make largest assurance for our high quality products. WST’s titanium alloy bars hold over 85% domestic aerospace market and also WST has good cooperation with larger international aerospace companies like UTAS, Eton etc. and medical companies like Biomet, Smith & Nephew, Medtronic etc.

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### Xian Metals & Minerals

As a leading manufacturer and distributor of Titanium, Molybdenum and Tungsten products in China, Xi’an Metals and Minerals Import & Export Co. Ltd., has joined into manufacturing, researching and competing in Ti industry. We supply Ti and its alloys in various forms as per ASTM, AMS, AWS and other main internationally recognized standards. Our most advantage is our competitive prices as well as guaranteed high quality. Our products are exported worldwide, and gained high reputation because of their excellent performance.

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### Zhejiang Shenji Titanium Industry Co, Ltd.

Zhejiang Shenji Titanium Industry Co., Ltd was established in 2008. With the development and implementation of advanced production facilities and innovative technologies, the company has become one of the leading professional producers of titanium products in China, specializing in sheets and plates, bars and wires, tubes and pipes, and forgings. The company’s main production facilities include a reversible hot rolling mill, a 1.4-metre, 4-high reversible cold rolling mill, as well as associated normalizing and heating furnaces and straightening facilities. The company can supply customized sizes according to clients’ specific requirements, and offer thin sheets in cold rolled width up to 1,250mm. Shenji Titanium is certified to ISO 9001 and PED 97/23/EC, and our titanium products are widely used in many sectors and for many applications including heat exchanger, condenser, power generation, chemical & petrochemical, engines, medical, and sports.
REASONS TO JOIN

- Opportunity to serve on ITA Committees.
- Substantial concessions for exhibition and registration at TITANIUM Conferences.
- Listing in the *Titanium Resource Center*
- Inclusion in the quarterly *Titanium Today* magazine.
- Referrals from sales & technical inquiries.
- Access to annual statistical review, executive summaries, TITANIUM conference presentations, and historical World Conference proceedings.
- Introductions and unlimited networking for your business development.

Download an Application Today at [www.titanium.org](http://www.titanium.org)
ITA IS ACTIVE & ENGAGED

ITA relies on its strong committee activities, bringing added value to Membership. As an ITA Member you are invited to participate in these working groups:

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<tr>
<th>Executive</th>
<th>Awards</th>
<th>Membership</th>
<th>Trade Show</th>
<th>Grants</th>
<th>Safety</th>
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<tr>
<td>Women in Titanium (WiT)</td>
<td>Nominating</td>
<td>TITANIUM EUROPE Conference Planning</td>
<td>TITANIUM USA Conference Planning</td>
<td>REACH Consortium</td>
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<td>Aerospace</td>
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The committees serve as the functioning arms of the Association. They provide a forum in which industry marketing and technical specialists may discuss and address issues faced by the industry in the promotion and use of titanium.

Download an Application Today at www.titanium.org
Join Us

ITA Safety Committee Meeting

Wednesday, 20th April | 7:00 am – 8:00 am
Paris Marriott Rive Gauche Hotel & Conf. Center

The ITA Safety Committee is creating a database to determine whether there should be further updating of key safety standards related to the flammability of titanium, in order to more accurately reflect the rapidly changing types of products and manufacturing technologies being developed by the titanium industry.

The thrust of the effort is to generate accurate, up-to-date information for regulators, not to make recommendations. The study will collect information from ITA members, conduct rigorous scientific studies, and testing as appropriate and engage experts to evaluate the data.

In recent years there has been an accelerated development of new grades of titanium powders dedicated to the leading-edge technology known as 3D or additive manufacturing.

The Safety Committee will provide data to NFPA authorities having jurisdiction in order to help them understand the flammability of what the titanium industry is producing. The titanium industry has expanded the way the metal can be used in manufacturing applications. We are developing data to more accurately reflect titanium in a flammable condition than previously was known.

The fundamental data on regulations for titanium flammability is outdated. The ITA Safety Committee will strive to modernize the data to reflect the substantial changes in the titanium industry.

We hope you will join us for an update of this project. Everyone welcome to participate
• Sales and distribution division of VSMPO-AVISMA, the world’s largest producer of titanium holding more than 300 international quality certifications.

• One of the largest suppliers of titanium mill products to the aerospace, medical and consumer products industries.

• Offering small diameter bar and coil for aero fasteners and medical applications

• Eastern and Western US and European Service Centers reliably meet your specs for products, sizes, quantities and delivery timeframe.

Stocking Programs
• Dedicated Inventories
• Custom Products and Orders
• JIT Delivery

Individual Inquiries
• Off-the-Shelf Availability
• Quantities from Small to Large
• 48-Hour Shipping Turnaround

Complete Processing Services
• Cutting and Shearing
• Heat Treating
• Machining

sales@vsmpo-tirus.com
vsmpo-tirus.com
TIMET
First in Titanium Worldwide

Fully integrated from sponge to mill products

www.timet.com