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MEDICAL EDITION

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Editorial

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itanium in the 21st century has emerged as a high-performance metal specified for demanding industrial, medical and commercial applications throughout the world.

Titanium has been used in medical applications since the 1950's. It's the most biocompatible of all metals and in prosthetic and joint-replacement devices it actually allows human bone growth to adhere to the implants so they last longer. Pacemaker cases are made from titanium because it resists attack from body fluids, is lightweight, flexible and non-magnetic. Artificial heart valves are also made of titanium. Many medical and dental implants simply perform best when they are manufactured from titanium, due to the metal's unique combination of superior mechanical, corrosion resistance and physical properties. Titanium's low modulus means excellent flexibility and strong spring back characteristics. This promotes its use in medical implants that must move with the body.

Titanium improves the quality of individual lives when it is used for medical and dental implants, prosthetic devices, eyeglasses and even lightweight wheelchairs.

The Baby-Boomer generation continues to pursue active, healthy lifestyles, which include an emphasis of recreational activities. As a result, there will be a steady, growing demand for medical implants and devices to repair and replace broken bones and wornout joints. The industry is encouraged that titanium will maintain its superiority as a cost-effective material of choice for existing and new medical applications.

The International Titanium Association serves the titanium metal industry by providing referrals to the public about the products & services of our member organizations; educates and fosters the development of new applications for titanium metal; and provides a forum for the exchange of ideas within the industry. The ITA furthers its mission through sponsorship of 2 annual conferences in Europe and the US, educational workshops, committees and seminars.

We hope you enjoy this edition of Titanium Today.

MEET THE ITA

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- **D** The most used titanium alloy in knee femoral implants is Ti6Al4V. Titanium and titanium alloys have great corrosion resistance, making them an inert biomaterial (meaning they will not change after being implanted in the body). Titanium and its alloys have a lower density compared to other metals used in knee implants. Additionally, the elastic nature of titanium and titanium alloys is lower than that of the other metals used in knee implants. Because of this, the titanium implant acts more like the natural joint, and as a result, the risk of some complications like bone resorption and atrophy are reduced. http://bonesmart.org/knee/ knee-replacement-implant-materials/
- **E&F** Hip replacement One of the most common applications of titanium alloys is artificial hip joints that consist of an articulating bearing (femoral head and cup) and stem, where metallic cup and hip stem components are made of titanium. Many replacements will last the full lifetime of the recipient, depending on the age of the patient. Most femoral stems are medical grade titanium. The bearing metal surfaces are made of cobalt-chrome because it is more resistant to scratching and wear compared to the softer titanium. Photos provided by GIE Media www.giemedia.com

ITA's 'Women in Titanium' Develops a Roadmap to Mentor STEM Students



Putting vision and policy into action, "Women in Titanium" (WiT), a new committee sponsored by the International Titanium Association (ITA), held its first meeting on Feb. 27 at the Manhattan Beach Marriott and Golf Club, Los Angeles, to officially approve the group's charter as well as layout an initial slate of near-term goals.

Dawne S. Hickton, the vice chair, president and chief executive officer of RTI International Metals Inc., Pittsburgh, served as the keynote speaker for the event. Hickton, who last year was tapped as the first female president of the executive board for the ITA, announced plans to establish the committee, during TITANIUM USA 2014, the ITA's annual industry conference and exhibition, which was held in Chicago last September.

As spelled out in the approved charter, the primary mission of the WiT committee is two-fold: first, to develop a networking group of collegial women presently in the titanium industry; and second, to promote, attract, and encourage high school and college female students to enter the titanium industry.

The objective of the committee is to contribute to the growth of the overall titanium industry by providing networking opportunities for women, and to take part in programs that advance gender equality in STEM (science, technology, engineering and mathematics) courses for high school and college women. WiT will look to attract, advance and retain professional women interested in the titanium field. Committee meetings will take place approximately three times a year, offering a mentoring lecture followed by an industry-related tour.

Hickton, during the 2014 conference in Chicago, in a spirit of stewardship and outreach, said she wanted to use her position on the ITA board to help establish a permanent path for other women to follow, so that they too can develop careers and leadership positions in the global titanium industry. The formation of the WiT committee is the result of Hickton's vision. In recent vears, Hickton and other ITA leaders have focused on the need for industry stewardship programs-dedicated efforts to cultivate the next generation of titanium designers, engineers, metallurgists and executives. The ITA's WiT initiative is part of that overall effort.

The committee gathering in Los Angeles included more than 30 registrants: eight executive officers; five managers from human resources, quality, and export services; three technical representatives; 13 sales/procurement professionals; and three high school students. In addition, Jennifer Simpson, the ITA's executive director, also attended the event.

Michelle M. Pharand, the director of sales and business development for Dynamet Inc., was selected as the vice chair of the WiT committee for the 2015-2016 term. Pharand will work with Hickton to develop and implement plans for the group. Dynamet, a subsidiary of Wyomissing, PA-based Carpenter Technology Corp., is an international supplier of titanium alloy products for the aerospace, medical, consumer and recreation industries.

Pharand said she looks forward to serving as a mentor. "I want to work with young women in the industry and provide perspective on their challenges by sharing my challenges. I want to give them confidence. Yes, they can be successful in the titanium industry."

Another goal for the WiT committee will be to support women involved in STEM in high schools and universities. The STEM education movement has

EXECUTIVE PROFILE; WOMEN IN TITANIUM



Michelle Pharand

Michelle M. Pharand is the director of sales and business development for Dynamet Inc., a subsidiary of Carpenter Technology Corp., Wyomissing, PA, which is an international supplier of titanium alloy products for the aerospace, medical, consumer and recreation industries. Pharand will serve as the vice chair of the International Titanium Association's (ITA) "Women in Titanium" (WiT) committee for the 2015-2016 term. She will work with Dawne S. Hickton, the vice chair, president and chief executive officer of **RTI International Metals Inc.**, Pittsburgh, to develop and implement plans for the group. Hickton, who last year was tapped as the first female president of the executive board for the ITA, announced plans to establish the WiT committee, during TITANIUM USA 2014, the ITA's annual industry conference and exhibition, which was held in Chicago last September.

Women in Titanium (continued)



WiT Meeting Participants & Tour of Space X Plant, February 28, 2015 Los Angeles, CA.

gained traction in the United States in recent years; a curriculum designed to attract students, female and male, by providing them with skills needed for 21st century manufacturing and engineering fields.

Since January 2013 Pharand has served as director of sales and business development for Dynamet Inc. She has global commercial responsibility for titanium customer satisfaction, sales, customer service, logistics, conversion and sales offices.

As for reflecting on her own success in the titanium sector, Pharand cited two factors: her business mentors, male and females; and her global experience. "I've had great bosses over the years, mostly men," she explained. "They took an interest in my success. They supported me and were loyal to me. They took time to teach me the skills I needed." As a result, she hopes to bring that same spirit of mentoring to WiT.

Pharand, who hails from Sudbury, Ontario, Canada, spent more than six years at Carpenter's Asia/Pacific headquarters located in Singapore, where she focused on developing business opportunities in China. In 2007 the company relocated her to Reading, PA; two years ago she accepted her current position, which is based in Pittsburgh. Pharand, who is fluent in French and English, achieved an honors bachelor of commerce degree in marketing and finance from Laurentian University, Greater Sudbury, Ontario, Canada. She graduated in 1993.

Some of the ideas generated in the brainstorming session of the WiT

committee's recent Los Angeles meeting included:

Building a roadmap to educate and provide instruction on how WiT members can reach out to middle school, high school and college students that have an interest in STEM courses.

Connecting with ASM International to add basic titanium metallurgy to its ASM Summer Camp, which educates teachers interested in learning more about titanium (a service provided to teachers free of charge).

Contacting the Minerals, Metals & Materials Society (TMS) Diversity Committee to learn more about its activities and how WiT might be able to participate.

Organizing industry-related tours in conjunction with the annual ITA TITANIUM conferences in Europe and North America.

Hosting regional meetings with the long-term goal of establishing an annual women's leadership forum, which would include a variety of high-level speakers, training and networking sessions, and joint efforts with other professional organizations.

The WiT gathering in Los Angeles also offered a "Fundamentals of Titanium" workshop taught by Dr. James Robison. The full-day workshop provided technical knowledge of titanium design properties, procedures, products, treatment and safety. In addition, attendees enjoyed a tour of SpaceX facilities located in Hawthorne, a city in southwestern Los Angeles County. According to information posted on its website, SpaceX, founded in 2002, SpaceX designs,



Upcoming Women in Titanium (WiT) Meeting information

Monday, May 11th

Meeting and Guest Speaker, Dr. Susan Durbin and Dr. Ana Lopes "Designing a Mentoring Scheme for Female Professionals in the Aviation and Aerospace Industry: Research and Reflections"

Birmingham, United Kingdom

Wednesday, May 13th

Industry Tour RTI International Metals Tamworth plant Birmingham, England UK

Thursday, August 20th

Fundamentals of Titanium & Evening Networking Reception

Friday, August 21st

Meeting & Guest Speaker, Ms. Stacie Greenfield Stone, Goldman Titanium, "Review of Scrap Titanium Recycling Process" with plant tour of Goldman Titanium, Inc. scrap facility Buffalo, New York USA

Wednesday, October 7th

Meeting with Guest Speaker and Networking Reception Orlando, Florida USA

To learn more about Women in Titanium, please contact ITA or visit www.titanium.org

manufacturers and launches advanced rockets and spacecraft, which utilize titanium components.

Interviewed last September, Hickton urged those working to promote STEM

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ISO 9001/AS 9100 Certified Nadcap Accredited education to develop meaningful, long-term partnerships with business community in order to understand what types of STEM skill sets are needed in the workplace. Quoted in a 2013 online interview posted on the STEM Blog (http:// blog.stemconnector.org), Hickton described how her company, RTI, has launched a comprehensive strategy to connect diversity awareness with the STEM education thrust. RTI, she said, has an ongoing interest in recruiting material science (metallurgy), accounting/finance, engineering and IT professionals.

"As a business leader and woman in the STEM field, I am passionate about finding ways to increase the number of women and minorities in the field," she said. "We believe that committing early to student education in the STEM fields will build robust pipelines of future STEM employees. Top-notch STEM professionals are critical for American businesses to stay at the forefront of global innovation, but our technical schools, colleges and universities are not graduating enough of these professionals to meet the demand," she warned. "We must develop and support rigorous math and science curriculums in all American elementary and secondary schools so that there is a wide and deep pool of graduating seniors that are genuinely prepared for technical school and college-level STEM studies."

Hickton became the chief executive officer of RTI in April 2007 and serves as a member of RTI's board of directors. She has over 25 years of diversified metals business experience, including more than 16 years in the titanium industry. She serves as a director of the Federal Reserve Bank of Cleveland, and a trustee for the University of Pittsburgh. She is a 1979 graduate of the University of Rochester, NY, and received her juris doctor degree from the University of Pittsburgh's School of Law in 1983.

The next WiT meeting is slated for May 11 as part of the TITANIUM EUROPE 2015 conference and expo. A plant tour of RTI's Tamworth, UK, facility will also be offered on May 13 following the conference. For additional information on the ITA's WiT committee, contact ITA's headquarters in Colorado USA www.titanium.org.

PHARAND'S INITIAL GOAL AS WIT VICE CHAIR

'I plan to make myself available for mentoring. I want to work with young women in the industry and provide perspective on their challenges by sharing my challenges. I want to give them confidence. Yes, women can be successful in the titanium industry. I look forward to connecting with female involved in STEM (science, technology, engineering and mathematics) studies and will determine how best to reach out to STEM-related organizations.

RECALLING HER MENTORS

'I've had great bosses over the years, mostly men. They took an interest in my success. They supported me and were loyal to me. They took time to teach me the skills I needed. As a result, I hope to bring that same spirit of mentoring to WiT.'

WHAT ENERGIZES YOU TO GO TO WORK EACH DAY?

Dynamet/Carpenter Technology Corp. is a good place to work and they have great people.

WHAT IS YOUR STRONGEST SKILL SET AS AN EXECUTIVE AND AS A PERSON?

Enthusiasm and drive combined with my strong work ethic.

GLOBAL EXPERIENCE

Pharand, who hails from Sudbury, Ontario, Canada, spent more than six years at Carpenter's Asia Pacific headquarters located in Singapore where she focused on developing business in the China market. In 2007 the company relocated her to Wyomissing; two years ago she filled her current position, which is based in Pittsburgh. As an executive with Carpenter, she's worked in various divisions and has had global responsibilities. She is fluent in French and English.

RESUME

Since January 2013 she has served as director of sales and business development for Dynamet Inc. In this role she has global commercial responsibility for titanium customer satisfaction, sales, customer service, logistics, conversion and sales offices. She had developed long-range plan to identify growth, new products, and evaluate the global competitive landscape for Dynamet. Prior to her current post, she served for three years (February 2010 to January 2013) as the director of Carpenter's wire, strip and plate business unit. In that position she focused on short- and long-term strategic planning as well as new market development.

MEET THE PRESS

In April 2012 Pharand, while serving as Carpenter's director of wire, strip and plate business, was interviewed by the Reading Eagle Business Weekly for an article titled "Carpenter Technology Cuts a New Path." The story offered a profile of Carpenter's efforts to develop specialty steel alloys for high-end knife makers. As quoted in the feature, she said 'custom knife makers are a point of entry for us.' Carpenter's CTS Series of alloys was developed specifically for making fine-edged blades such as scissors, shears, surgical instruments and commercial cutlery. The company reached out to knife makers through a series of symposiums and invited leading craftsmen to take part in plant tours and discussions about the alloys with Carpenter's metallurgists and engineers.

EDUCATION

Pharand achieved an honors bachelor of commerce degree in marketing and finance from Laurentian University/ Universite Laurentienne, Greater Sudbury, Ontario, Canada. She graduated in 1993.

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President Titanium Earns a Place on Biomet's Approved Suppler List

President Titanium Inc., Hanson, MA, recently became qualified as an approved supplier of titanium mill products for Biomet Inc., Warsaw, IN, a global producer of orthopedic and musculoskeletal products—a move that could spark expanded business for President Titanium in the medical industry.

Shawn MacLeod, President Titanium's vice president, said Biomet began auditing the titanium distributor's operations last January and one month later placed President on its approved supplier list (ASL). "Biomet did a full quality audit and they were very impressed," MacLeod said. "Our hope is that, by being on the ASL for Biomet, it will open new doors for us in the medical field."





The ASL qualification is significant vote of confidence for a supplier like President. Ten years ago, off-spec titanium from Asia found its way into U.S. medical applications, creating significant quality issues for medical device and implant original equipment manufacturers. Since then, there has been greater scrutiny on companies participating in the medical supply chain. MacLeod said President stocks only titanium products melted and manufactured in the United States.



Established in 1973, President is a family owned global supplier of titanium mill products, working in the aerospace, medical and military business sectors. Joseph E. MacLeod, Shawn's father, is the president and founder of the company. In addition to its 5,000 North American customers, President ships products to Australia, Singapore, Israel, South America, China, and Europe an estimated 500 offshore companies. According to information posted on its website (http://www.presidenttitanium. com), President is ISO 9001:2008 registered and is an approved suppler for Pratt & Whitney (LCS), Boeing, Rolls Royce, GE and others.

President has a 40,000-square-foot facility in Hanson with 23 employees and 15 stations for cutting titanium bar and plate. MacLeod said the company can provide near-net-shape specialty sizes of material for its customers. On average, President carries over 1 million pounds of titanium inventory.

Biomet, founded in 1977, has annual sales over \$2.5 billion with 9,000 employees. It designs and

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Per-Ingvar Branemark, 85; Pioneeered Osseointegration for Dental Implants

The passing of Swedish physician Dr. Per-Ingvar Branemark on Dec. 20, 2014 marked the final chapter for the life of a titanium pioneer, whose legacy lives on as the "father of the modern dental implant." Branemark, who was 85, succumbed in his hometown of Gothenburg, Sweden.

An obituary in the Dec. 27, 2014 edition of *The New York Times*, praised Branemark as the person who achieved a "major advance in dentistry, liberating millions of elderly people from painful, ill-fitting dentures, a diet of soft foods and the ignominy of a sneeze that sends false teeth flying out of the mouth."

"Per-Ingvar Branemark, who was known as the father of the modern dental implant, played an integral role in advancing the oral health of millions of people," Dr. Maxine Feinberg, the president of the Chicago-based American Dental Association (ADA), said. "The development and use of (titanium) implants was one of the greatest advances in dentistry during the past 40 years."

The discovery that bone fuses to titanium—a process called osseointegration—led to permanent dental replacements, the Times obituary noted. With the fusing of titanium implants to bone, implants "locked into the jaw bone as cells attach to its titanium surface." Gosta Larsson, a man with a cleft palate, jaw deformities and no teeth in his lower jaw, became Branemark's first titanium dental implant patient during the mid-1960s.

According to the obituary, Branemark's discovery of titanium osseointegration was an accident. "At the start of his career, he was studying how blood flow affects bone healing. In 1952, he and his team put optical devices encased in titanium into the lower legs of rabbits in order to study the healing process. When the research period ended and they went to remove the devices,



Dr. Per-Ingvar Branemark

they discovered to their surprise that the titanium had fused into the bone and could not be removed. Branemark's research took a whole new direction as he realized that if the body could tolerate the long-term presence of titanium, the metal could be used to create an anchor for artificial teeth."

However, despite demonstrating the success and potential of osseointegration in titanium dental implants, there were various challenges to convince the medical and dental establishment that titanium could be integrated into living issue. The conventional wisdom was that the introduction of any foreign material into the body would inevitably lead to inflammation and, ultimately, rejection. The Times article stated that, for years, Branemark's applications for grants to study implants anchored in bone tissue were rejected. The United States National Institutes of Health finally financed the project, and in the 1970s, Sweden's National Board of Health and Welfare approved the Branemark implants.

A turning point came in 1982 at a professional meeting in Toronto, where Branemark made the case for osseointegration and won widespread recognition for his materials and methods. Since then, millions of people worldwide have been spared dentures because of his work.

Branemark received an honorary ADA membership from the ADA Board of Trustees in 2008 for his dedication to the profession of dentistry. "I think what impresses me the most is that Dr. Branemark's ability to think beyond his own medical specialty area allowed him to take a serendipitous finding and apply it to dentistry, leading to the development and widespread acceptance of dental implants," said John Dmytryk, Department of Periodontics professor at the University of Oklahoma College of Dentistry and ADA Council on Scientific Affairs member. Dmytryk was quoted in an article in the Jan. 7, 2015 edition of ADA News. "Implants became a major advancement in dentistry after Dr. Branemark and his team accidentally discovered that titanium could fuse into bone safely."

Branemark's system of dental implants is now manufactured and sold by Nobel Biocare and still marketed as the "Branemark System. Headquartered in Zurich, Switzerland, Nobel Biocare is a global company that provides "innovative implant-based dental restorations...offering high-precision individualized prosthetics and CAD/ CAM systems as well as diagnostics, treatment planning, guided surgery solutions and biomaterials," according to information posted on the company's website.

As it turns out, Branemark's work in the development of titanium dental implants has extended to other medical applications. The Times obituary pointed



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Industry Executives Track Opportunities, Cost Pressures in Global Medical Market

itanium industry executives, offering presentations at the annual TITANIUM conferences during the last two years, have underlined the importance of the medical sector as a global, high-growth market. They've pointed out that while some business sectors have suffered significant deterioration and employment cutbacks in the wake of the 2008/2009 financial crisis, the medical industry continues to expand. However, while titanium's near-term opportunities in the medical field are lucrative, several speakers have offered words of caution regarding downward cost pressures and challenges to the global supply chain for medical devices.

Some industry sources said they don't foresee any major material advances on the horizon, in terms of new titanium alloys that target medical applications. Instead, the expectation is for steady, incremental improvements in metal grades that offer enhanced strength, wear resistance, and properties that encourage bone to fuse to titanium—a process called osseointegration.

Members of the Baby-Boomer generation continue to age gracefully (and somewhat defiantly) while pursuing active, healthy lifestyles, which include an emphasis of a host of recreational pursuits such as golf, tennis, running, cycling, softball and swimming. As a result, the conventional wisdom is that there will be a steady, growing demand for medical implants and devices to repair and replace broken bones and worn-out joints. In addition, controlling healthcare costs remains a major economic and political issue in the United States and the hope among industry leaders is that titanium maintains its edge as a costeffective material of choice for medical applications.

One example of the importance of the medical market for titanium is

illustrated by the Remmele Medical unit of the Engineered Products and Service Segment business of RTI International Metals Inc., Pittsburgh. Remmele, based in Minneapolis, had revenues of \$55.5 million in 2012. By contrast, revenues for aerospace that year by RTI's Engineered Products and Service Segment totaled nearly \$214 million. Products for the Remmele group include minimally invasive surgical tools (jaws, blades, and grips), spinal and dental implants, urology sling components, and drug infusion components. Production capabilities for the Remmele unit feature automated machining cells, 3-, 4- and 5-axis milling, laser machining, and various secondary operations.

Many titanium industry executives look to ongoing improvements in additive/3-D manufacturing technology and titanium alloys as areas that will yield significant advances in medical part production (see related story in this edition). Ric Snyder, product manager, Fort Wayne Metals, Fort Wayne, IN, said his company is one year into the roll out of 4TiTUDE[™], which he said combines the strength of an alloved titanium grade with the beneficial attributes of commercially pure Grade 4 Titanium. Snyder said the material is being evaluated for medical applications such as dental implants and orthopedic bone screws.

According to company literature, 4TiTUDE provides a balance between the beneficial properties of commercially pure Titanium and the strength of alloyed titanium such as TiZr or Ti 6Al-4V. "With a minimum tensile strength of 1,172 Mpa (170 ksi) in diameters up to 4 mm and 1,103 Mpa (160 ksi) in diameters from 4-6 mm, 4TiTUDE is just as strong as cold-worked alloyed titanium," the company wrote. "This is a significant increase from cold-worked commercially pure Grade 4 titanium, which typically exhibits tensile strengths in the range of 950 Mpa (138 ksi). This means that 4TiTIUDE allows you to design smaller implants from unalloyed titanium, without sacrificing strength."

Fort Wayne, on its website, states that, apart from a significant increase in strength, 4TiTUDE is "equivalent" to commercially pure Grade 4 titanium as it "meets all requirements of ASTM F67, which means that it won't release toxic aluminum or vanadium ions. Since 4TiTUDE is commercially pure, it doesn't only promote osseointegration, we also expect it to be compatible with osseointegrative coatings such as hydroxyapatite or calcium phosphate."

The vast majority of Fort Wayne's business is dedicated to the medical market, Snyder said. In addition to titanium, the company offers other materials such as stainless steel, cobalt/ chrome and Nitinol. Products include helical hollow strand (HHS) tubing, wire, strands and cables, straight linear torque (SLT) wire, composites, and centerless ground bar.

Andy McElwee, vice president, sales and operations, VSMPO-Tirus, US in Leetsdale, PA, said orthopedic applications, especially hip and knee replacements, continue to drive medical market applications for titanium. Trauma applications, such as bone plates and screws, and spinal components represent the two other major sales areas for the medical market. Industry sources estimate the current United States orthopedic market is valued at \$15 billion.

McElwee attributed this demand for orthopedic applications to Baby Boomer lifestyles. "As the Baby Boomer generation keeps getting older, there will be more demand for implants," McElwee observed. "Baby Boomers are staying more active, playing sports and getting hurt more often. They're wearing out

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out that osseointegration is now used in medical and veterinary applications. Examples include titanium implants for people with large facial injuries and those in need of external hearing aids.

Among his many accolades during his distinguished career, Branemark was awarded the Swedish Engineering Academy's medal for technical innovation, the Swedish Society of Medicine's Soderberg Prize and the European Inventor Award for Lifetime Achievement.

A close associate of Branemark was fellow Swedish citizen Dr. Tomas Albrektsson, who contributed to the development of osseointegrated oral and craniofacial clinical treatment, with international breakthroughs in 1982 and 1992. He also is a senior member of team that has developed new osseointegrated hip arthroplasties for clinical usage.

Albrektsson was a head of Bone Research Group at the Laboratory of Experimental Biology, Department of Anatomy, University of Göteborg, Sweden from 1980 to 1986. Today he serves as a member of the Department of Clinical Sciences at Sahlgren's Academy, Göteborg University, and frequently speaks at medical and dental forums throughout the world. He is the author of about 650 abstracts, reviews and scientific papers on bone grafts, vital microscopy of bone, experimental implants, oral and craniofacial reconstructions and orthopaedic implants.

their hips and knees."

The technology for hip and knee implants, as well as the medical techniques to operate and replace these parts, also has gotten significantly better during the last 10 years—in part, due to the Baby Boomer attitudes as the "impatient" generation. "Boomers say they want to have their knee or hip fixed right away, and they want to be playing golf or tennis in six weeks," he said with a chuckle. In addition, he said new generations of titanium materials and product designs have improved for medical applications, which translate into longer-lasting joint replacements and reduced pain and rehab time.

In terms of business trends, McElwee noted the ongoing consolidation among hospitals, treatment clinics and medical centers, as well as consolidation among the original equipment manufacturers that produce titanium implants. He said executives in the titanium industry would be wise to follow these developments and anticipate how it will affect business in the medium and long term. Some industry executives and observers anticipate there will be downward pressure on titanium pricing and profits due to this consolidation. (See the related market analysis article in this edition on speculation concerning Stryker Corp. and Smith & Nephew Plc.)

Another key business trend worth tracking is the global growth and demand for titanium medical products and implants. "Right now, a large majority of the medical business for titanium implants is in North America, Western Europe and Japan," McElwee said. "But now we're starting to see demand coming from places like China, India and South America. These are regions with a growing middle class. At the moment, these markets are in their infancy, but they represent growth markets for titanium medical applications." Considering the emerging trends of global growth and downward pressure on titanium prices and profit

margins, the titanium industry will need to closely monitor its supply chain metrics and logistics.

Like McElwee, a marketing executive with Vulcanium Metals International LLC, has observed the downward pressure to control prices in the medical market. He said this pressure comes from the hospital/medical center level, a highly leveraged group looking to keep costs low.

This Vulcanium executive said current market dynamics require metal distributors and service centers to provide a diverse portfolio of product choices. As such, in addition to titanium bar, plate and sheet, Vulcanium also offers specialty stainless steels grades and cobalt/chrome/molybdenum alloys. "Our strategy is to work with our customer base in a business development role, to provide the materials they need, whether it's titanium or other metal alloys," he said. Vulcanium is part of the highperformance metals group of O'Neal Steel Inc., Birmingham, AL.

The conversation with the Vulcanium executive also proved to be instructive regarding American business history, as he pointed out that nearby Warsaw, IN, is the global hub for the orthopedic device and implant business, with roots that date back to the 1890s.

The OrthoWorxIndiana website (http://orthoworxindiana.com) touted Warsaw's orthopedic/medical device cluster of original equipment manufacturers and tier-two vendors (a total of over 40 companies and 13,000 employees) as "one of the most concentrated centers of economic activity anywhere in the United States." The "who's who" list of heavyweight companies includes Medtronic, Zimmer, DePuy (J&J), Symmetry and Biomet. Overall, the Warsaw cluster represents nearly one-third of the estimated \$38-billion global orthopedic sales market, according to OrthoWorxIndiana.

Market Observers Weigh Mergers by Medical Device Manufacturers

When the consolidation that has taken place in the titanium industry in recent years, presumably to fortify the global supply chain and reduce costs by integrating upstream and downstream operations, the original equipment manufacturers in the medical sector—companies that produce titanium orthopedic/ surgical implants and related devices are undergoing similar merger and acquisition activities.

One of the more active players has been Stryker Corp., Kalamazoo, MI, which, earlier this year, was the subject of market speculation for its acquisition strategy. Various news sources, including Bloomberg, reported Stryker was mulling the purchase of Londonbased Smith & Nephew Plc. A Stryker spokeswoman based in Kalamazoo, when questioned on the press reports, would only say that "as a matter of company policy, Stryker does not comment on merger and acquisition matters."

Smith & Nephew, according to information posted on its website, describes itself as a global medical technology company producing implants and devices used in orthopaedic reconstruction (jointreplacement systems for knees, hips and shoulders); advanced woundmanagement products; sports medicine (minimally invasive joint surgery); and trauma (devices and inserts used to repair broken bones). Smith & Nephew has 14,000 employees, operates in more than 90 countries, including the United States, and in 2014 registered annual sales of \$4.6 billion.

Stryker produces medical reconstructive, surgical, neurotechnology and spine products. Like Smith & Nephew, Stryker has a global reach, operating in over 100 countries. In 2014, Stryker's net sales totaled \$9.7 billion, with net earnings of \$515 million.

In March, Stryker announced plans to buy back an additional \$2 billion worth of shares, a move to boost shareholder value and, according to some business analysts, "quell speculation" it would bid for Smith & Nephew. *The Wall Street Journal* reported the Stryker board's approval of the repurchase brings the company's stock-buyback program to a total of roughly \$2.58 billion.

Stryker Chief Executive Officer Kevin Lobo, quoted in various news wire stories, said the company remains committed to a capital allocation strategy that includes acquisitions, share buybacks, as well as dividends. "While (merger and acquisition) activity across the breadth of our product and service offerings will remain the primary focus of our long-term growth strategy, this new authorization recognizes that the strength of our balance sheet is sufficient to enable more significant share repurchases."

While it declined to comment on any interest it may have in Smith & Nephew, Stryker, in February, opened its new European regional headquarters Amsterdam, the Netherlands. According to a company press release, Lonny Carpenter, Stryker's group president for global quality and operations, and European business operations, said the opening of the Amsterdam site "is an exciting milestone for Stryker that demonstrates our long-term commitment to Europe and our global business. There is significant opportunity for growth in Europe. Stryker is committed to continuously improving our business in this region so we have established the new headquarters to support these aspirations."

Along with eyeing business opportunities in Europe, Stryker has been active on the acquisition trail in order to diversify and strengthen its reach into the healthcare sector. In January, the company purchased the assets of privately-held CHG Hospital Beds Inc., based in London, Ontario, Canada. CHG sells hospital beds that serve markets across Canada, the United States and the United Kingdom.

In recent years, Stryker acquired Small Bone Innovations Inc., a producer of ankle replacement products, and Trauson Holdings Co. Ltd. of China, manufacturer of instruments and implants for trauma and spine. The Wall Street Journal, in its Sept. 25, 2013 edition, reported that Stryker agreed to acquire Mako Surgical Corp. and its roboticsurgery platform, "a move aimed at distinguishing Stryker's line of replacement knees and hips for its increasingly cost-conscious hospital customers," according to a company spokeswoman. She noted that Mako would help Stryker cater to hospital and insurance executives who increasingly want new devices to help reduce overall costs.

For its part, Smith & Nephew, in May 2014, finalized its acquisition of Austin, TX-based ArthroCare Corp., in a \$1.5 billion deal to gain orthopedics products used in sports medicine for minimally invasive surgery.

Bloomberg recently reported that two large manufacturers of surgical



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products and medical supplies, Medtronic Inc. and Covidien Plc, are in the process of completing a merger, Zimmer Holdings Inc.'s agreement to buy Biomet Inc. for \$13.4 billion is undergoing regulatory review.

What's driving the merger and activity moves among producers of medical implants and devices? What will it mean for the titanium industry? All signs point to the critical need to reduce cost in the global supply chain as well increase product quality and make distribution more reliable and timely. It's likely that a more consolidated titanium supply chain will be doing business with consolidated original equipment manufacturers in the medical device market.

Business executives, who have addressed the annual TITANIUM conferences during the last two years, have said that while many markets have suffered significant deterioration and employment cutbacks in the wake of the 2008/2009 financial crisis, the medical industry continues to expand. The orthopedic market in the United States is valued at \$15 billion.

However, while titanium's nearterm opportunities in the medical field are lucrative, several experts offered words of caution regarding downward cost pressures and challenges to the global supply chain for medical devices. News reports note that medical device companies are looking to consolidate as hospitals and insurers demand better prices from suppliers to tame rising costs.

For example, Robert J. Daigle, senior vice president, Structure Medical, LLC, Naples, FL, outlined how medical device manufacturers are under mounting pressure to reduce costs—a trend that would impact the titanium industry. He said stakeholders in the healthcare industry "are communicating their plans to seek less expensive alternatives to brand-name medical devices that could provide similar clinical outcomes, potentially squeezing profits from manufacturers and the supply chain.

"Medical device manufacturers are reporting increasing pressure to lower prices, driven by stakeholders' interest in lowering their cost," he continued. "This pressure is being driven down through the supply chain. Hospital sustainability depends on their ability to reduce cost."

He urged titanium companies that do business in the medical field to concentrate on supply-chain issues. "Remove the waste from your operations. Make it easy and cost efficient to do business with your company. Work closely with your customers to identify waste, and then remove it. Provide your customers with solutions; if not, someone else will."



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Solving Titanium Implant Osseointegration Problems by Using Epoxy/Carbon-Fiber-Reinforced Composite

Introduction

This article, published online on Dec. 5, 2014 by the National Institute of Health Public Access (http://www.ncbi.nlm.nih. gov/pmc/articles/PMC4307950), presents recent developments in material research with bisphenyl-polymer/carbon-fiberreinforced composite that have produced highly influential results toward improving upon current titanium bone implant clinical osseointegration success.

As indicated in the online posting, this is the publisher's final edited version of this article. The text, as it appears here in Titanium Today, is a further condensed and edited version of the article by Petersen.

Petersen acknowledges that titanium is the standard intra-oral tooth root/bone implant material with biocompatible interface relationships that confer potential osseointegration. Titanium produces a TiO2 oxide surface layer reactively that can provide chemical bonding through various electron interactions as a possible explanation for biocompatibility. Nevertheless, titanium alloy implants produce corrosion particles and fail by mechanisms generally related to surface interaction on bone to promote an inflammation with fibrous aseptic loosening or infection, which can require implant removal.

To provide improved osseointegration many different coating processes and alternate polymer-matrix composite (PMC) solutions have been considered that supply new designing potential to possibly overcome problems with titanium bone implants. PMCs have decisive biofunctional fabrication possibilities while maintaining mechanical properties from addition of high-strengthening varied fiberreinforcement and complex fillers/ additives to include hydroxyapatite or antimicrobial incorporation through thermoset polymers that cure at low temperatures.

Petersen, in this article, reviews titanium corrosion, implant infection, coatings and the new epoxy/carbonfiber implant results discussing osseointegration with biocompatibility related to nonpolar molecular attractions with secondary bonding, carbon fiber in-vivo properties, electrical semiconductors, stress transfer, additives with low thermal PMC processing and new coating possibilities.

Titanium for Dental Applications

Commercially pure titanium (CPTi) is generally reserved for dental applications due to an extremely stable oxide TiO2 thin surface layer that resists corrosion under physiologic conditions and forms a fine interfacial direct metal-to-bone contact as osseointegration. Titanium metal has a relatively low modulus for metal. Subsequent low-modulus materials close to bone reduce problems with "stress shielding" so that more uniform stress transfer occurs between the implant and bone to prevent bone resorption from periods with lack of pressure.

In addition, the workhorse titanium aerospace alloy, Ti-6Al-4V, is used for dental implants. Though stronger than CPTi, biocompatibility is a concern for this ally due to aluminum and vanadium ions. Ti-6Al-4V also has been used for orthopedic hip implant stems, but the alloy is particularly prone to geometrical notch sensitivity with crack propagation and further wears excessively as the chief concern.

Various titanium alloys are also used in medical applications to repair craniofacial defects caused by trauma, surgical removal of cysts and tumors, infections, fractures that do not join and congenital or developmental conditions. Titanium failures in medical applications occur and appear related to factors that discourage stabilized bone osseointegration, such as trauma from overloading, micromotion and surgical burden to support inflammation without proper healing; and in a small percentage, due to infection next to exposed metal surface as the final destructive mechanisms for implant loosening. Also, the healing response involves serumprotein adhesion to the implant that can promote bacterial attachment to a biomaterial surface.

Recent technology, supported through aerospace/aeronautical development with epoxy/carbon-fiber-reinforced composites, has demonstrated farreaching osseointegration increases for titanium implants when compared to Ti-6Al-4V alloy in animal research. Fiber-reinforced composite can offer superior mechanical properties than metals on a strength-to-weight basis for both strength and modulus.

Occlusal forces (the muscular force exerted on teeth when the jaws are closed or tightened) interact with titanium implants more harshly than natural tooth structure because of intimate bone osseointegration contact without a damping protective periodontal ligament where titanium metal cannot adsorb damaging energy similar to a PMC.

In-vivo animal testing with extreme loads produced defects lateral to osseointegration between bone and metal implant. Conversely, in relation to encouraging test results PMCs with carbon fiber reinforcement can supply densities/modulus much closer to bone than titanium for improved mechanical deformation providing viscoelastic damping energy adsorption/dissipation and healthy stress transfer with tissues/ cell membranes.

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Corrosion

Corrosion is a diffusion interfacial electron-transfer process that occurs on the surface of metals. Titanium reacts with oxygen electrochemically rapidly in the presence of water to form a fine oxide layer of TiO2 that prevents further oxidation. The TiO2 surface layer protects titanium under normal biologic conditions to regenerate if removed by reactive corrosion equilibrium products as passivation barrier formation and confers high corrosion resistance. Titanium can form an oxide layer 10 angstroms thick in a millisecond and 100 angstroms in a minute. In the passivated state, TiO2 biomaterials generally corrode less than 20 µm/year.

Different types of common corrosion have been classified for titanium implants. When acid breaks down the passive TiO2 oxide layer on a flat surface pitting corrosion occurs. On the other hand, geometric implant material confinement of acid produces increased metal dissolution known at crevice corrosion. Friction between the TiO2 oxide layer against another surface causes fretting corrosion. When titanium is in direct contact with a dissimilar metal that is common to both oral and orthopedic implants galvanic corrosion occurs.

Subsequent electrochemical corrosion products from metal implants are thought to be damaging on local tissues particularly with respect to low intensity electromagnetic fields that are known to develop by corrosion and can then inhibit osteoblast growth. Aseptic loosening of implants is thought to occur as a reaction to metal particles from corrosion that can produce an electric occurrence with electromagnetic field, where lower pH next to a titanium implant needs overall general consideration.

Titanium particles from implants are reduced in size by corrosion over time to commonly produce a dark blackened tissue stain. Titanium particles found in adjacent soft tissue have been known to produce inflammation, fibrosis and necrotic tissue while infection was found to be a key reason for implant failure where pain was further noted as a clinical concern. Microbial influences can also increase corrosion. In terms of inflammation, titanium metal alloy particle release from implants can result in bone destruction. Alternatively, after surgical implant placement, chronic inflammation that continually heals can eventually form a fibrous capsule union between the implant and bone that leads to failure.

Osseointegration and antimicrobial properties are hard to realize with titanium/titanium alloy implants, probably because biocompatibility with function is difficult using metal. Although polymers have been identified for biomaterial use because of high biologic functionality, polymers lack mechanical strength needed with hard tissue implants. In terms of polymer biocompatibility with sufficient strength, PMCs using high-strength fibers provide answers. Fibers are the strongest and possibly the stiffest forms of a substance matter.

When combined into a thermoset cure crosslinking polymer matrix, fiberreinforced composite materials provide design possibilities for ultimate potential in bone implant osseointegration toward biocompatibility with biofunction. Most importantly, fiber-reinforced PMCs compete with metals especially on a strength-to-weight basis in required mechanical properties.

In comparison to a new bisphenolepoxy/carbon fiber-reinforced composite implant material, titanium alloy Ti-6Al-4V produces significantly less bone forming near the implant with much lower levels of osseointegration contact in a bone-marrow animal implant model.

Conclusions

Osseointegration bonding occurs by different covalent electron sharing and ionic mineralization mechanisms. TiO2 osseointegration produces ionic bonds by even oxidation states that act in coordination with the mineralization phase of bone. PMC osseointegration appears to produce covalent bonds by free-radical crosslinking with exposed unpaired electrons of the polymer following acid degradation while organic portions of the bone matrix or bone-cell plasma membrane condense by covalent bonding onto acid or hydroxyl groups of the oxidized carbon fibers.

Further mechanical interlocking is achieved with rougher surfaces and with the PMC by acid degradation polymer removal can occur even with possible bone growth surrounding individual 7 µm diameter carbon fibers.

Low pH polymer softening by acid is considered now to aid in adsorbing excessive stresses by a protective damping mechanism. Low-temperature thermoset polymer cure allows fillers and organic additives to be incorporated by planned design with new tissue engineering for bone implants toward biosuccess. Fillers and additives can be included either in the bulk implant material that is polished to reduce microbial attachment colonization or in extremely mild resorbable coatings for rapid release to stabilize the initial implant surgical placement.

Future research directions should examine implications clinically for the robust benefits and also surgical problems particularly during possible revision taking into account such strong osseointegration for the bisphenol-epoxy/ carbon-fiber implant.

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Praxis Tames Metal Injection Molding Process to Produce Implantable Titanium Medical Parts

tilizing the metal injection molding (MIM) process, Praxis Technology, Queensbury NY, shipped its first implantable titanium MIM orthopedic medical parts in early 2015.

Working as a full-service contract manufacturer, Praxis is focused on developing titanium parts for the medical market. "Historically, titanium MIM is a challenging process," Joe Grohowski, Praxis president and chief executive officer said, adding that Praxis is among the select few companies doing titanium MIM, and touts itself as having the only qualified production line.

The Praxis MIM process was qualified for the production of Grade 5 titanium implants in late 2014. Grohowski declined to identify the customer or the type of titanium parts being made via MIM.

Praxis began implantable part production in 2008, manufacturing porous ingrowth surfaces using titanium powder metallurgy. Two years later, Praxis began to build out the titanium MIM production line. "Doing development work in a lab isn't the same as a commercial manufacturing line," he said.

According to company literature, Praxis' OrthoMIM technology offers design flexibility and cost savings specifically for orthopedic devices. It combines the company's high-fatigue performance material (TiRx[™]) with net-shape surfacing technology (3DT[™]) to create complex surfaces on medical implants.

Along with the MIM process, the company also developed technology to impart the proper porous surface and texture to facilitate osseointegration (bone growth) for orthopedic implants. Praxis' third-generation porous surface technology creates net shape porous



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surfaces on high performance Ti-6Al-4V co-formed substrates. Net-shape osseointegration surfaces are achieved by placing additively manufactured "sacrificial" inserts, which mold the surface and the body of the implant in one injection step, he said.

A typical integration layer may include a fixation texture region-the portion of an implant that provides for initial fixation of the device during surgery. Grohowski said most orthopedic devices are manufactured with some type of integration surface. This surface may be a simple roughened "on-growth" surface or a more complex porous "ingrowth" surface. In-growth surfaces are increasingly becoming the standard of care on many orthopedic devices. The ingrowth region is the portion of implant that is intended to promote growth of tissue into the device for long-term fixation. By incorporating the formation

of these surfaces into the molding process, he said value is added and overall cost is reduced for the TiMIM product.

TiMIM is a four step manufacturing process comprised of compounding, injection molding, debinding and sintering to produce a final geometry, Grohowski said. The compounded mixture is pelletized to form a feedstock suitable for injection molding. Praxis has validated Ti-MIM process in relation to ASTM F2885, as well as additional technologies that have been developed to enhance Ti-MIM's applicability to the orthopedic market and other markets demanding high fatigue performance.

Praxis purchases its titanium powder from an outside vendor. The Ti-6Al-4V Grade 5 material is produced in an ISO-13485 certified environment. Titanium powder goes through a proprietary, computer-controlled



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compounding line, which includes the introduction of a thermoplastic binder to create the titanium MIM pellets. The titanium powder and thermoplastic are compounded at precise levels.

The production line includes a 4.5 cubic foot MIM sintering furnace and a single electric injection molding machine built by ARBURG GmbH & Co. KG, Lossburg, Germany. (Grohowski declined to provide details on the size or capabilities of the equipment.) "While we currently have one (injection molding) machine, our molding bay has room for four more," he pointed out. The line operates in a dedicated facility to prevent contamination for medicalgrade material and end products. He said special care is taken to prevent the buildup of combustible titanium dust.

After debinding, the MIM parts are placed on ceramic setters and loaded into a furnace for high-temperature processing. During the early stage of sintering, the remaining binder is thermally decomposed. Following this initial stage, the parts are heated to a high temperature where densification occurs, resulting is significant shrinkage of up to 20 percent. Once this process is complete, the part is hot isostatic pressed to achieve full density.

Grohowski said production includes a broad spectrum of parts; from net-shape

components to parts that need secondary machining operations. Depending on the parts' requirements and specifications, finishing operations may include machining, surface enhancements, coining, passivation, anodization, and assembly. Praxis has in-house CNC machining and surface-finishing capabilities.

Near-term plans call for Praxis to expand the operation to a second dedicated production line. Grohowski founded the company in 1999. The 18,500-square-foot facility has 40 employees and is ISO 13485 certified and will be AS9100 certified in the third quarter of this year.



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Prolog Titanium Corporation is Thailand's largest supplier, distributor and stockiest of high quality titanium metal products. With its unique combination of strength, light weight, corrosion resistance and other metallurgical properties, titanium is used in hundreds of diverse aerospace, defense, medical, chemical, electrical, automotive and other industrial applications where no other metal is a as reliable or economical, especially on a life cycle costing basis. We can supply to other high performance reactive metals such as Niobium, Molybdenum, Tungsten, Zirconium and Tantalum which have best properties to resist extremely corrosive, abrasive and ultra high temperature.

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We produce titanium bars and wires and process titanium tubes and plates. We are approved by AS9100: EN9100: ISO 13485: ISO9001; TUV Factory certificate. We manufacture the products according to AWS, AMS and ASTM specifications. Tipro is one of the biggest titanium wire manufacturers and supplies 30 MT alloy and 35 MT C.P. titanium wires. We have our own vacuum annealing furnace.

Titanium welding wires AWS A 5.16-2007 Titanium wires ASTM B348,B863 Size: 0.8mm - 6.35mm in Straight wires ; in coil ; in spool Grades: ERTI- 1 ; ERTI-2 ; ERTI-3 ; ERTI-5 ; ERTI- 7;ERTI-9 ; ERTI-12... Packing: Straight wire 5 kgs each Wires in spool: 7-11kg each Wires in coil: 30-120kg each Label on the end of each wire



www.Titanium.org



TRICOR METALS EXPANDS MARKET PRESENCE IN SE USA; STEVE BEAVER, NEW REGIONAL MARKET MANAGER

Tricor Metals announced today that Steve Beaver has joined Tricor Metals to develop their titanium mill products and fabrication sales in the southeastern US. Steve is an experienced marketer of titanium metals and fabrications in the region for chemical, pulp & paper, medical and aerospace served markets. Steve will report directly to Chuck Young, our Business Development Manager.



Steve Beaver - Regional Market Manager - Tricor Metals

Mike Stitzlein, President of Tricor

Metals, said; "We know from our experience that our people make the difference for our customers, and ultimately for Tricor too. Steve's experience and attitude makes him a good fit for our team. This new position is evidence of our commitment to continue to serve the world's titanium needs and to provide cost effective corrosion solutions through design and engineering."

Steve comments; "I am glad begin a new challenge with Tricor Metals and look forward to help further develop their already strong titanium mill products and engineered products throughout the south. I feel fortunate to be part of a strong company that prides itself on serving the world's titanium needs."





Swiss medical and watch maker precision foils MetSuisse has a unique grinding facility allowing: precision grinding of titanium foils, sheets and plates: technology applied for the Swiss medical and watch industry no min. quantities for CP Grade 1, 2, 4, Ti6Al4V Eli min. 0.09 +/- 0.015 mm (= in inch 0.003543307" +/- 0.000590551") MetSuisse reflects the precision needs of the medical, watch and other high precision industries.

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ALCOA TO ACQUIRE RTI INTERNATIONAL METALS, BOOSTING VALUE-ADD, MULTI-MATERIAL AEROSPACE PORTFOLIO

Expands Offerings Made of Titanium, Fastest Growing Aerospace Metal; Builds Advanced Manufacturing and Materials Technologies

- Stock-for-stock transaction with enterprise value of \$1.5 billion
- Grows Alcoa's advanced technologies for greater innovation power; Broadens multi-material product suite to meet growing aerospace demand for titanium
- Increases Alcoa's 2014 pro forma aerospace revenues by 13 percent to \$5.6 billion
- Expected to contribute \$1.2 billion in revenues in 2019, up from \$794 million generated in 2014; RTI's profitability expected to reach 25 percent EBITDA margin in 2019, up from 14.5 percent in 2014
- Strong annual global aerospace market growth of 5 to 6 percent; 9-year production order book for commercial jets

NEW YORK and PITTSBURGH, March 9, 2015 – Lightweight, high-performance metals leader Alcoa (NYSE: AA) is announcing another major milestone in its transformation, further building its value-add portfolio for profitable growth. The Company has signed a definitive agreement to acquire RTI International Metals, Inc. (NYSE: RTI), a global supplier of titanium and specialty metal products and services for the commercial aerospace, defense, energy and medical device markets. Alcoa will purchase RTI in a stock-forstock transaction with an enterprise value of \$1.5 billion.

With RTI, Alcoa will grow its value-add businesses and further strengthen its aerospace portfolio. RTI will expand Alcoa's range of titanium offerings and add advanced technologies and materials, increasing the Company's position as a leading industrial innovator.

"Alcoa is accelerating its value-add growth engine by acquiring titanium leader RTI," said Klaus Kleinfeld, Alcoa Chairman and Chief Executive Officer. "We are combining two innovators in materials science and process technology, shifting Alcoa's transformation into a higher gear. RTI expands our aerospace portfolio market reach and positions us to capture future growth to deliver compelling value for customers, shareholders and employees."

"Innovation and scale are critical to winning in both the titanium and aerospace industries today, which is why this transaction is such a natural strategic fit for both RTI and Alcoa," said Dawne Hickton, Vice Chair, President and Chief Executive Officer of RTI International Metals. "We are pleased to have an agreement with Alcoa that delivers immediate value to our shareholders that appropriately reflects the strength of our business. Through this combination of forces, RTI will take its innovative technologies to the next level and deliver even more value-add titanium solutions to meet customer needs. We look forward to continuing to accelerate RTI's success as a part of the Alcoa team." Under the terms of the agreement, Alcoa will acquire all outstanding shares of RTI in a stock-for-stock transaction. RTI shareholders will receive 2.8315 Alcoa shares for each RTI share, representing a value of \$41 per RTI share based on Alcoa's closing price on March 6, 2015. The transaction has an enterprise value of \$1.5 billion, including \$330 million of RTI cash on hand and up to \$517 million in RTI's convertible notes.

Transaction Benefits

The acquisition will offer Alcoa financial benefits with realized net synergies of about \$100 million in 2019, primarily driven by procurement and productivity improvements, leveraging Alcoa's global shared services and driving profitable growth. Alcoa expects RTI to contribute \$1.2 billion in revenues in 2019, up from \$794 million generated in 2014, with 65 percent of revenues supported by contracts over the next five years. RTI is expected to reach profitability of 25 percent EBITDA margin in 2019, up from 14.5 percent in 2014.

This transaction is expected to enable Alcoa to capitalize on strong growth in the commercial aerospace sector. Alcoa projects a compounded annual global aerospace market growth rate of 5 to 6 percent through 2019 and sees a current 9-year production order book for commercial jets at 2014 delivery rates.

RTI grows Alcoa's pro forma 2014 annual aerospace revenues by 13 percent, up from \$5 billion to \$5.6 billion. RTI is expected to increase Alcoa's 2014 pro forma aerospace revenues to 37 percent of value-add sales, up from 35 percent. Alcoa's aerospace business is the largest contributor to Alcoa's value-add businesses.

Eighty percent of RTI's revenues in 2014 were from the aerospace and defense industries, with the balance mainly split between other markets including energy and medical devices, complementing Alcoa's growth markets. Quality Management System Certified to ISO 9001:2008

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RTI – Alcoa (continued)

Strategic Rationale

RTI brings proven midstream and downstream capabilities in titanium, the world's fastest-growing aerospace metal. Spending on titanium aerospace mill products is expected to grow by about five percent annually over the next five years driven by highgrowth, next-generation aircraft programs. RTI's titanium operations span midstream processes such as melting, ingot casting, bloom, billet, plate and sheet production; and downstream extrusions for aerospace, oil and gas applications, high speed machining, and production of integrated subassemblies primarily for aerospace. These capabilities complement Alcoa's titanium investment casting and forging capabilities, and will enable a value-creating closed titanium scrap loop. RTI will increase the percentage of Alcoa's non-aluminum downstream revenues to 64 percent of total downstream sales.

RTI will expand Alcoa's advanced manufacturing and materials technologies. Its highvelocity machining, forming, extruding and parts assembly operations will enable Alcoa to produce some of the largest, most complex aerospace components. Advanced titanium powder metallurgy and processing technology will enable cost-effective production of near net shape aerospace components, as well as medical devices and oil and gas products. RTI will expand Alcoa's additive manufacturing capabilities, such as 3-D printing, to produce titanium, specialty metals and plastic parts for aerospace, medical and energy applications. RTI also grows Alcoa's portfolio of cutting-edge materials, including titanium-aluminides, complementing Alcoa's industry leadership in metallics. Titanium-aluminides are increasingly used to manufacture lightweight, aerodynamic jet engine parts for high-volume, next-generation jet engines.

Timing

The transaction, which has been approved by the Boards of Directors of both companies, remains subject to customary conditions and receipt of regulatory approvals and RTI shareholder approval. Alcoa and RTI expect to obtain all required regulatory clearances and RTI shareholder approval in order to close the transaction in three to six months.

Greenhill & Co. and Morgan Stanley are acting as financial advisors to Alcoa, and Wachtell, Lipton, Rosen & Katz is serving as legal counsel. Barclays is acting as the sole financial advisor to RTI, and Jones Day is serving as legal counsel.

Conference Call Information

Alcoa will host a conference call at 8:30 AM Eastern Daylight Time on March 9, 2015 to discuss the transaction. The meeting will be webcast via alcoa.com. Call information and related details are available at www.alcoa.com under "Invest." Presentation materials used during this meeting will be available for viewing at 7:15 AM EDT at www.alcoa.com. A replay of the call will be available from 12:30 PM EDT on March 9 until March 23 at 11:59 PM EDT.

Additional resources: Go to www.alcoa.com/RTI for more information, photos and broll.

About Alcoa

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, highperformance 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 59,000 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.

For more information, visit www.alcoa.com, follow @Alcoa on Twitter at www.twitter.com/Alcoa and follow us on Facebook at www.facebook.com/Alcoa.

About RTI International Metals



RTI International Metals, Inc. is a leading vertically

integrated global supplier of advanced titanium and specialty metal products and services to commercial aerospace, defense, energy, medical device and other customers across the entire supply chain. For more than 60 years, RTI has been taking titanium further through advanced manufacturing and engineering processes. RTI delivers a full range of titanium mill products as well as other titanium and specialty metals products and services including extruded shapes, formed and 3D-printed parts, and precision engineered and machined components through our downstream integrated supply chain.

Headquartered in Pittsburgh, PA, RTI has locations in the United States, Canada, Europe, and Asia. To learn more about RTI International Metals, Inc., visit our website at www.rtiintl.com.

METALYSIS

METALYSIS APPOINTS DOUGLAS CASTER CBE AS CHAIRMAN



Metalysis, the UK-based specialist metals technology company, today announces the appointment of Douglas Caster CBE, as non-executive chairman with immediate effect. Previously Chief Executive, and now Chairman of Ultra Electronics Holdings plc (Ultra). During his leadership the business has more than doubled in size through organic and acquisition growth to create a leading FTSE250 aerospace and defence technology company.

Douglas Caster

Metalysis is at the forefront of Britain's emerging high value niche metals market, which will target key sectors such as high end technology, defence and electrical component sectors. Mr Caster is joining Metalysis at an important time for the Company's commercialisation and development, which will see a significant expansion of its production capacity in the UK, in addition to exporting its technology internationally through licensing agreements and joint ventures. Mr Caster's deep understanding of, and experience in, fast growth businesses in those sectors will provide valuable support to Metalysis's strategy.

Originally from Teesside, where several generations of his ancestry worked in the steel industry, Mr Caster brings this heritage and his expertise to help build a leading technology business in the production of powder metals, delivering highly focused wealth creation in the old heartland of the British metals industry. Based in South Yorkshire, Metalysis will be a vital contributor to the region's industrial regeneration.

Douglas Caster commented: "The Metalysis business addresses one of the most significant challenges in the development of specialist metals – how to produce high grade metal powders for mass consumption. It has the know-how and the expertise to bring niche, high-performance metals, such as titanium and tantalum, to many new downstream applications. Furthermore its technology is future proofed and patented, which presents the opportunity to attract wealth and investment as the company expands in South Yorkshire and internationally. There is a huge level of excitement around the potential of its transformational technology, which can be applied to various elements of the periodic table."

Commenting on the board changes, Dion Vaughan, chief executive of Metalysis, added: "We look forward to working with Douglas as Metalysis commercialises its leading technology. Douglas's appointment as Chairman marks a significant step in the rapid evolution of our company. His experience in developing a specialist electronics business into a world leader in its chosen fields, along with his rich history in the metals and engineering sectors, will add substantial value to Metalysis's next stage of growth. We thank Tony Pedder for his significant contribution through his advice, knowledge of and contacts within the metals sector, having been CEO of Corus for many years."

Tony Pedder, who temporarily joined the board of Metalysis as nonexecutive chairman in January 2012 on a short-term basis, returns to his position as non-executive director of Metalysis.



REMELT SCIENTIFIC WELCOMES EXECUTIVE-LEVEL DIRECTOR OF SALES!

December 22, 2014, Port Charlotte, FL - ReMelt Scientific, a worldwide premium supplier of chip processing and chip preparation equipment to the metals industry, is proud to announce and welcome Joe Hawkins as the Company's Director of Sales. Joe brings a vast amount of experience to the ReMelt group, having spent his entire career within the metals industry.

Joe is no stranger to chip processing and preparation equipment, as he was the General Manager of Premelt Systems, Inc. (North

Canton, OH) from 2001 thru 2006. Joe began his career as a Regional Sales Manager at Lectrotherm, Inc. (Massillon, OH) from 1991-2001. He most recently served as Sales Manager at ABP Induction (North Brunswick, NJ) prior to joining ReMelt Scientific.

Joe has a BS from Kent State University as well as an MBA from Malone University. Joe and his wife Lore reside in North Canton, Ohio with their three children. Please join us in welcoming Joe to the ReMelt Scientific team!

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	substrates	advantages	benefits
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of Aluminum			
	Aluminum Steel Alloys Titanium	Non-toxic; Non-hazardous; Nonpolluting	Corrosion-resistance No hydrogen embrittlement High operating temperature (1100°F)
Hardcoat Anodizing			
of Aluminum	Aluminum Aluminum Alloys	Hardness; eliminates burning & dissolution of parts	Allows aluminum application where wear, corrosion or other factors would otherwise exclude its use
Solid Film Lubricants			
	Virtually all metals	Automatic & manual application; TFC processes comply with a variety of mil specs; combines with other coatin	Provides excellent lubricity Improves corrosion resistance gs

www.titaniumfinishing.com





SOLAR ATMOSPHERES ADDS NEW CLIMATE CONTROLLED ROOM

Souderton, PA. January 20, 2015 - In today's modern production environment requirements seldom stay the same. In 2015, a prime example is a new third-party accreditation program called MedAccred in the medical industry. This program is going to be the equivalent of the Nadcap program in the aerospace arena. In addition to MedAccred, medical prime contractors are demanding that environmental conditions are controlled, processes validated, and the risk of exposure to foreign object



Solar Atmospheres climate controlled room.

debris (FOD) reduced. Solar Atmospheres has taken preemptive action to develop and build a new area to meet these upcoming requirements.

In mid-2014, Solar Atmospheres installed a new area within the existing shop at our 1983 Clearview Road address. The area is approximately 1500 square feet and incorporates temperature and humidity controls, as well as a slight positive pressure environment. These features will minimize water vapor and dust/debris in the heat treating area. One unique feature of the space is the addition of a brand new, state-of-the-art, all-metal hot-zone vacuum furnace with an oversized pumping system, ability to isolate the quench system during the heat cycle, and all stainless steel chamber.

maintaining a vacuum level of 5x10-6 torr or lower and has successfully processed the most sensitive materials unshielded without any surface contamination. The furnace is positioned outside of the room, and only the door protrudes through the wall into the climate controlled room. This is a very unusual arrangement in the commercial heat treating industry. Early in 2015, an existing furnace will be modified and updated with state-of-the-art controls and

The furnace is capable of

added to this new area as well. Currently two laboratory furnaces also reside within the room bringing the total number of furnaces in the area to four.

This new climate controlled room will add significant value to our customers' operations, a core component of Solar's mission statement, by lowering the risk of discoloration and FOD, and by the time-saving elimination of the need to shield parts during heat treating.

If you have an interest in utilizing this specialized area/equipment for your upcoming projects, please contact Mike Moyer, Director of Sales at 215-721-1502 x1207, or mike@solaratm.com, or visit us at www.solaratm.com.

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Retiring



Carl R. Moulton

Mr. Carl R. Moulton served as Senior Vice President - International at Allegheny Technologies Inc. since May 1, 2011. Mr. Moulton was responsible for ATI's commercial activities in Europe and Asia, and ATI's STAL Precision Rolled Strip(R) and Uniti LLC titanium joint ventures.

Mr. Moulton served as Group Vice President of Allegheny Ludlum Corporation since 1993. Mr. Moulton served as Vice President of International of Allegheny Technologies Inc. from March 2009 to April 2011. He served as President of Jessop Steel Company until he joined Allegheny Ludlum Corporation upon the Allegheny Ludlum Corporation's acquisition of Jessop in 1993. He served as President of Uniti LLC when it formed in 2003. Mr. Moulton served in the U.S. Army as a First Lieutenant, earning a Bronze Star. Following his military career, Mr. Moulton worked as a Sales Representative with Allegheny Ludlum in 1972, before joining Jessop Steel as Vice President, Marketing in 1981. Mr. Moulton has been Vice Chairman at the Specialty Steel Industry of North America (SSINA) since March 2009. He serves as a Director of Uniti LLC, which has become one of the world's leading suppliers of industrial titanium products. He is a graduate from Dartmouth College.



David Warren

Mr. David Warren served as Special Adviser and Director Emeritus of Special Projects at Retech Systems LLC, Mr. Warren worked for Retech, a division of Lockheed Martin and a manufacturer of Vacuum metallurgical equipment, for 33 years. where Mr. Warren served as a Manufacturing

Manager for 5 years, Operations Manager for 15 years and Director of Operations for 3 years. While at Retech, Mr. Warren's primary responsibility was in manufacturing and 160 employees reported to him. Until 1999, Mr. Warren served at Retech. He re-joined Retech in January 2006 as Director of Special Projects and served there until 2015. In 1999, he served with Lectrotherm Inc. Mr. Warren served for 42 years in all phases of operations related to high temperature vacuum metallurgical equipment and thermal treatment equipment for hazardous materials. He has vast experience and knowledge. Mr. Warren is a Member of the International Titanium Association (ITA) and serves on the ITA safety advisory committee. He completed a certificate program in Business Management at Sonoma State University. Mr. Warren completed several education courses at the University of Hawaii, Barstow College, and Mendocino College with emphasis in Manufacturing Engineering.

Career Announcements

Promotions



Gregory Creswell, CSP. SGE Director, EHS Cambridge-Lee Industries II C



Terry Dunlap Director of Matthews



Richard Jeniski Senior Vice President Hitachi Metals America, Ltd.

Kevin Kramer Senior Vice President **Chief Commercial** and Marketing Officer ΔΤΙ



Silvio Rodrigues Ribeiro Diretor da Acnis do Brasil





Dr Pam Whitaker, International Materials Technology Specialist Lucideon



International Corp.





Craig Sullivan Global Marketing & Communications Manager Vallourec



Work Anniversaries



Andrew Bayne Director - Global Materials Planning Celebrating 12 years at TIMET, Titanium Metals Corporation



Manuel Granillo General Manager Celebrating 33 years at Bodycote



Andrew McElwee Vice President Sales and Operations - East Celebrating 3 years at VSMPO-Tirus, US





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Richard A. Sandquist

(November 1925 - February 2015)



Richard Adair Sandquist, 89, of Phoenixville formerly of Jamestown New York, died on Feb. 6, 2015. Born in Jamestown, NY on Nov. 25, 1925, he was the son of the late Ernest H. and Hazel L. Sandquist. Richard was the Loving husband of Rosellen Malta Sandquist.



Richard Served in the US Navy during WWII, and participated in the landing at Omaha Beach, where some of the fierce fighting took place. After his discharge from the Navy in 1945, he returned to finish his High School education. He became the Vice President of Vac Air Alloys, earned his pilot's license and instrument rating, traveling extensively

dealing in stainless steel and titanium scrap. He was searched out by Axel Johnson Co. in Sweden where he was hired to build a Titanium and Stainless Steel reclaiming facility. It became one of the largest of its kind in the world. He also worked with German Engineers to build the world's largest electron Beam Furnace. During his association with Axel Johnson Co., he traveled world -wide dealing in Titanium and stainless steel. He was one of the first Americans to deal with Russians, after the Cold War. He was recognized by his peers as a leading authority of Titanium reclaiming, receiving several awards for his achievements.

Richard is survived by his loving wife Rosellen, his brother Ralph, nephews Mark, David and Patrick Gregor, Timothy Bastian, and Clark Sandquist, and niece Sharon Sandquist, and sister in law Onalee Williams.

Richard was the 2002 Titanium Lifetime Achievement Award Recipient for his pioneering efforts in international titanium scrap procurement, processing, and recycling, leading to the development of the cold hearth melting industry.

Francis John "Jack" O'Donnell

(July 1927 - January 2015)



Francis John "Jack" O'Donnell, 87, of Lanoka Harbor, passed away peacefully at his daughter Karen's home on Monday, January 5, 2015. Jack, son of William and Mary C. O'Donnell, was born in Cranston, RI on July 18, 1927. He attended St. Michael's School and graduated from LaSalle Academy High School in Providence, RI in 1945. He then entered the Merchant Marines until 1948. On returning, he

attended Providence College. He graduated with degrees in Letters and Philosophy in 1952. Jack was an active member of the debate team and he continued to love a good debate for the rest of his days.

In 1951 Jack married the love of his life, the late, Jeanne Carolyn Greene,

Grady Alexander Eudy

(October 1936 - January 2015)



Grady Alexander Eudy, 78, of Jefferson, South Carolina, passed away peacefully at his home on Saturday, January 3rd 2015. He was born October 12, 1936 in Union County. He was the oldest son of Segal Alexander Eudy and Barbara Lucille Morgan Eudy.

Grady is survived by his loving wife of 55 years, Eva "Lois" Short Eudy and two children;

daughter, Annette Carpenter and husband Jamie of Harrisburg, NC and son Dennis and wife Pam (Hatley) Eudy of Monroe, NC; and four grandchildren, Morgan & Caleb Carpenter and Adam & Hunter Eudy.

Grady enjoyed a successful career of over 25 years with Teledyne Allvac in Monroe as a titanium purchasing agent. He graduated from Wingate High School in 1955 and served in the US Navy as radar specialist for two years following high school.

Grady had been a lifelong resident of Monroe before suffering a stroke 21 years ago and building a handicapped accessible home in Jefferson, SC. He was an avid outdoorsman and loved hunting and fishing. Other than watching his grandchildren's various activities, he loved hosting "fishing days" and "fish fries" for family and friends at his pond.

also of Cranston, RI. The love they shared has been and will always be an inspiration to those they leave behind. He is survived by six children, J. Karen Geiger and husband Joseph, John and wife Tina, Robert and wife Lydia, Mary McIntyre and husband Thomas, Elizabeth Smith and husband Dave and Michael; 19 grandchildren and 16 great-grandchildren, with two more due shortly. Jack is survived by his beloved sister, Esther Connelly of Providence, RI and was predeceased by brothers, William, Edward and Robert.

In 1952, Jack began his career in the copper and brass industry, working for both, United Wire and Wolverine Tube. In 1974 Jack started High Performance Tube, Inc., Martinsville, NJ, a manufacturer of titanium finned tubing. He worked there with sons John and Bob until his retirement in 1997.

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ADMA Products, Inc.

Phone: +1-330-650-4000 www.admaproducts.com

ADMA Products Inc. is AS9100 registered fully integrated manufacturer of ADMA Hydrogenated Titanium Powder, ADMATAL® net shape and near net shape powder metallurgy titanium and titanium alloy products. These products, produced by ADMA under its proprietary and patented "solid state" (non melt) consolidation processes, meet all critical specifications and standards, including Aerospace Materials Specifications (AMS). Components made from ADMA Hydrogenated Titanium Powder are characterized by high purity, refined microstructures, low oxygen content, excellent "weld-ability", low energy input, almost 100% "buy to fly ratios", low cost, and performance that is superior to those of titanium ingot based products. ADMA additionally specializes in stainless steel, nickel, niobium, zirconium and other advanced materials produced by powder metallurgy processes.

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Since 1993, Aerometals & Alloys is a leading stockholder and distributor of Titanium, fully dedicated to the aerospace industry. Fully part of the Acnis Group since august 2014, Aerometals & Alloys provides full service thanks to its sawing, laser and water jet cutting machines. From its French quarters located in Paris, Aerometals & Alloys supplies a wide range of Titanium in plates, bars and billets around the world.

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Akrapovič is a producer and supplier of Titanium investment casting and carbon-fiber composites products. With many years of experience and constant development in the Titanium processing industry we can offer our customer high quality build to print products out of required certified material, precision and flexible delivery time and full service approach of our high specialized team support.

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Phone: +1-231-894-7330 www.alcoa.com/howmet

The titanium ingot plant of Alcoa Howmet specializes in the manufacture of titanium ingots in both conventional and experimental composition. The capabilities of this plant also include the ability to make rotating grade ingots.

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ALD is a worldwide leading supplier of advanced furnace systems for melting, casting, coating and heat treatment of metals under vacuum.

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Phone: +1-704-645-0511

Primary melter of titanium and titanium alloys using plasma cold hearth melting furnace. Company also provides various specialized raw material processing functions for itself and other specialty melters.

American Titanium Works LLC

Phone: +1-603-398-3342

American Titanium Works LLC is completing plans to build a new, green-field, integrated, world-class titanium manufacturing facility in the southeast of the United States. ATW is targeting the defense, industrial, commercial, consumer and emerging markets with a range of products and services including alloy and commercially pure titanium plate, bloom, billet, slab, and ingot.

Applications for our products will include defense ballistics and general military equipment construction, chemical processing equipment, oil &gas systems, pulp &paper production facilities, medical implants, and a wide and growing range of consumer goods.



AMETEK - Reading Alloys

Phone: +1-610-693-5822 www.ametekmetals.com

AMETEK - Reading Alloys is a manufacturer of high quality master alloys comprised of Vanadium, Molybdenum, Niobium, Chrome and Aluminum alloy ingredients. Master alloys are for rotor grade, aero, non-aero, commercial and super alloy metals applications. We are manufacturers 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 compliment 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.

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Architectural Titanium provides the most experienced consultants for worldwide applications in architecture, art and design. We look forward to the opportunity to share our expertise and support your design concepts through the entire process of samples, details, specifications, procurement, fabrication and installation.

ATI

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Avon Metals Ltd.

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Avon Metals are a primary &secondary aluminum smelter manufacturing high performance aluminum-based master alloys and alloying products for the wrought aluminum, titanium and superalloy industries. We are actively engaged in the strategic sourcing &trading of primary and scrap metals for industry including Titanium CP &90/6/4 solids &turnings, Titanium sponge, Strontium Metal, Electrolytic Manganese Flake, Silicon Metal, Aluminothermic Chromium Metal, Primary Magnesium, Hafnium Crystal Bar and ingot, Zirconium/Zircalloy, SHG Zinc, Pure Tin ingot, Pure Lead Shot, Rhenium Pellets, Tantalum and Niobium.

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Baoji Jinsheng Metal Material Co., Ltd.

Phone: +86-917-3306972 www.titaniummet.com postmaster@bjjsm.com winnie@bjjsm.com



Baoji Jinsheng Metal Material Co., Ltd is a Hi-Tech enterprise, which is specialized in researching, producing, marketing titanium, tungsten, molybdenum, niobium, zirconium, nickel, tantalum and their alloy. We own manufacturing facilities, such as vacuum arc furnace, vacuum annealing furnace, forging machine, centerless grinding machine, drawing straightening machine, sawing machine, CNC machine and milling machine. The chemical composition, mechanical property testing for finished products are carried out by northwest non-ferrous research institute, the most authoritative institute in China.

We have established strict inspection from material to finished goods, equipped with a full set testing machine, such as the ultrasonic testing equipment, Metallurgical microscope,100KN microcomputer control electronic multiple (tensile force)tester, tester. We can produce varieties of nonferrous mill products and its alloy in shape of wire, bars, sheets, plates, forged rings, discs, fasteners etc.

Baoji Jucheng Titanium

Phone: + 86-18590730713 www.juchengti.com

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Baoji Ronghao Ti Co., Ltd. founded in 2002, has 10+ years experience in production and sales, is committed to providing the best solution & create the most environmentally friendly production processes. Ronghao has experience in the production of titanium and titanium

alloy rich. Ability to control metal grain, meet AMS4928, ASTM F136 and ASTM F67 standards microstructure technical requirements. Ronghao is specialized material manufacturer/seller of Titanium & other Nonferrous metals but also the founder and urger of Heat source Titanium composite profiles, has acquired CE, ISO9001:2008, SGS, CE & BP. We produce high stable & quality pure Titanium & Titanium Alloy, plate, pipe, ring , strip, foil, bar, wire, fasteners, etc which all comply with international implementation of standards (ASTMB265, ASTMB337, ASTMB338, ASTMB363, ASTMB367, ASTM B348, ASTMB381, ASTMB382, ASTMB861, ASTM,B862, ASTMB863, ISO2768, DMS1536J, AMST9046, AMS4000K, AMS4902F, AMS4921G, AMS4947D, AMS4954, AMS4986A, AMS 4972D, AMS 4943F, etc.) Email wuyuf@163.com

Baoji Titanium Industry, Ltd.

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Baoji Titanium Industry Co., Ltd (Baoti) is the biggest manufacturer of titanium mill products and titanium alloys in China. An integrated production system that includes melting, forging, rolling, drawing and fabricating enables Baoti to manufacture various products such as titanium sponge, ingot, billet, bar, wire, plate, sheet, tubing, forging, casting of all grades of CP titanium and most titanium alloys as well as many down-stream products in accordance with AMS, ASTM, MIL, ASME, ISO, DMS, AWS, JIS specification. These products are widely used in every kind of industry ranging from aerospace and automotive to sports, medical, chemical and petrochemical industries. Baoti is an ISO9001 and NADCAP approved company.

Baosteel Special Metals Co., Ltd.

Phone: +86-021-26032903 www.baosteel.com

Baosteel Group is the largest and most advanced integrated steel company in China. Baosteel Special Metals Co., Ltd is a subsidiary company of Baosteel Group. Baosteel Special Metals Co., Ltd grew out of Shanghai No. 5 Steel Works, and started manufacturing of titanium alloys since 1968. The main titanium products include: ingot, slab, billet, bar, plate, coil, stock, isothermal forging and so on.

Beijing Hongda Titanium Science & Trade Co., Ltd

Phone: +86-10-82274866 www.chinabti.com.cn

Beijing Hongda Titanium Science & Trade Co., Ltd was established in 2002, and is located in Beijing, China. We are a professional manufacturer of titanium and titanium alloy. Our products mainly include sheets, plates, bars, strips, rods, wires, forgings, and processing titanium. As a leading corporation of titanium in China, we always stick to "Quality First". We have ISO 9001:2008 quality certificate. We sincerely hope to establish long and friendly business relations with clients from all over the world.

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Dalian BHN Special Materials Ltd. is one of the state-of-the-art manufacturers and suppliers of high-grade master alloys for applications in the titanium, steel and aluminum industries. BHN is a customer-oriented company which is engaged in research, product development, manufacturing and improvement of melting technology, and successfully achieved the EN9100:2003 that is valid from September 2013 to Sep. 2016.

BIBUS METALS

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Bonatech Metal Research Institute

Phone: +86-13-810777433 www.bonatech.cc

Bonatech Metal Research Institute (BMRI) is a leading research institution in China specializing in research and development, technical transfer and technical service of metal material and automated control equipment. BMRI was jointly established in 2004 by a private enterprise, a prestigious domestic university and a professional research academy. It is supported by a group of top science and technology and expert team in the fields of metal, mechanical and electric control, automated control and mineral dressing. At present, BMRI has 50+ researchers, including eight engineers with senior professional titles, two researchers with PhD degrees, five professionals with master degrees, and others with college or bachelor degrees.

Over the past years, we have been focusing on the industrialization of key technologies in light metal and alloy. Significant achievements have already been made in terms of industrialization of energysaving light metal (i.e., titanium & aluminum) electrolysis and smelting equipment.

Butech Bliss

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Butech Bliss is a designer and manufacturer of capital equipment, repair components and engineering and field services for metals producers and processors that roll, forge, melt, flatten, stretch, shear and extrude metals of all types. Butech Bliss is located in Salem, Ohio and is home to one of the largest manufacturing facilities in the industry. With over 50 engineers on staff, 400,000 sq. feet, 100+ machining centers, full fabrication and assembly departments, 200 ton crane capacity and a dedicated rail siding, Butech Bliss is equipped to handle any project. Butech Bliss product offerings include copper crucibles, liners, molds, hearths, etc. for VAR, ESR, PAM and EBM Re-melting equipment as well as Rolling Mills, Forging and Extrusion Press upgrades and Coil, Plate and Sheet processing equipment for all metals. Butech Bliss is comprised of Butech Inc., E.W. Bliss (Bliss-Salem), Loewy Machinery and Lombard Industries.

Caledonian Alloys

Phone: +1-252-975-3101 www.pccforgedproducts.com/brands/caledonian_alloys

Caledonian Alloys is the world leader in the management of nickel and cobalt base superalloy and titanium alloy recycling for the aerospace, land-based turbine, and chemical industries. The company transforms revert, through rigourous process, into material which can be re-melted, to produce new nickel, cobalt, or titanium alloys. Revert consists of excess alloy material which can arise from high performance component manufacturing, from decommissioned parts, and from the melting process. Caledonian Alloys provides customers with a range of tailored revert management services designed to enable them to optimize the use and value of their own revert material. Accredited with all major vacuum and high temperature melters worldwide, Caledonian Alloys supplies fully processed nickel and titanium revert material to the melting industry. We also purchase revert material from a wide range of industrial customers throughout the world.

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Chaoyang Jinda Titanium Co., Ltd.

Phone: +86 421 2976177 www.jinda.cc

Chaoyang Jinda Titanium Co., Ltd., A subsidiary of Chaoyang Jinda Group, specialize in manufacturing high purity titanium sponge in lower content of oxygen (0.04%), lower carbon (0.005%) and lower nitrogen(0.004%). Production is 10000 MT per year.

Chesapeake Industrial Cleaning Products, Inc. Phone: +1-410-340-9052

www.chesapeakeindustrial.com

Chesapeake Industrial formulates and supplies manufacturing chemicals and degreasers to titanium recyclers and processors. Cleaners for removing oil from turnings, dirt and oil from scrap, cutting fluids from formed products and other typical operations are our expertise. Chesapeake provides a wide range of formulated products from general cleaners to high spec materials made at facilities in several US locations. Products specifically designed for individual operations can be formulated for costs often lower than 'off-the shelf' materials. Chesapeake has served customers in the titanium industry for over 10 years. Drums, Totes and Bulk deliveries of materials are all available.

China Huaxia Special Metal Limited

Phone: +86-21-58770128 www.nonferrous-metal.com

China Huaxia Special Metal Limited is the professional manufacturer of titanium products, with a complete production line and high technology team. The quality can be guaranteed. Huaxia is working hard to be the best manufacturer of special metal products including titanium sheet, tube/pipe, bar, wire, stainless steel tube/pipe, duplex & super duplex tube/pipe, nickel & nickel alloy, flange, forging, fitting and valve. Huaxia products provide good quality, good price and good service.

China Steel Corporation

Phone: +886-7-802-1111 www.csc.com.tw

China Steel Corporation (CSC), located in Kaohsiung, Taiwan, was founded in December 1971. with annual production (in terms of crude steel)around 10 million tones, CSC produces a range of products that includes plates, bars, wire rod, hot and cold rolled coils, electrogalvanized coils, electrical steel coils, hot-dip galvanized coils, and Ti/Ni- base alloys. The domestic markets takes roughly 65% of CSC's production and the exports take the remaining 35%. CSC is the largest steel company in Taiwan, enjoying more than 50%

of the domestic market. Major export destinations are Mainland China, Japan, and Southeast Asia.

Consarc Corporation

Phone: +1-609-267-8000 www.consarc.com

Consarc Corporation, an Inductotherm Group Company, is a manufacturer of vacuum furnaces for the titanium forging and casting industry. Consarc custom designs and manufactures Reactive Vacuum Arc Remelting (RVAR) furnaces for primary electrode melts of compacted sponge titanium and titanium alloys, and secondary melt furnaces for remelting fully dense electrodes. Consarc also designs and manufactures fully customized Induction Skull Melting (ISM) systems for melting titanium in a refractory free environment for casting or ingot withdrawal. Consarc is ISO 9001-2008 certified, and with operations on 5 continents, is well equipped to tackle fully customized furnace projects globally.

Continental Steel and Tube Company

Phone: +1-954-332-2290 www.continentalsteel.com/Titanium/default.asp

Continental Steel and Tube Company is one of the world's leading value added volume suppliers of quality metals. With an outstanding global reputation, our team of expert sales associates can source a comprehensive inventory of metals to meet any application requirements.

Continental Steel supplies a wide range of metals including, titanium, stainless steel, nickel, steel, aluminum, hot/cold rolled, galvanized, and stainless and electrical steel in carbon and alloy grades. Our long list of Titanium Grades includes Ti 6AL-4V ELI. Our materials are available in coils, sheets, strips, plates, angels, bars, rounds squares, hexagons, and other custom shapes. Continental also offers tubing or pipes in welded, DOM and seamless.

Cristal Metals Inc.

Phone: +1-815-834-2112 www.cristalmetals.com

Cristal Metals was formed in 1997 as International Titanium Powder (ITP) to develop and commercialize Armstrong Process® patented and proprietary technology for high purity metal and alloy powders with specific emphasis on titanium. Armstrong Process® technology is intended to lower the production cost of powders suitable for direct consolidation, to lower the manufacturing costs of titanium products through powder metallurgy processing, and to reduce the environmental impact of titanium production.

CSIRO High Performance Metal Industries

Phone: +61 3 9545 8644 www.csiro.au/titaniumtechnologies www.csiro.au/en/Research/MF/Areas/Metals.aspx

The High Performance Metal Industries Program, is engaged in applied R&D across the metal value chain, specialising in novel metal production techniques, interfaces/corrosion, metal forming, and additive manufacturing / 3D printing, particularly for Titanium and its alloys. HPMI partners with commercial industry in applied research or to develop new technologies as well as provides consulting services use of specialized facilities, and aims to be a global leader in the knowledge and application of fundamental metals technologies. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's primary national research body, with over 5,000 researchers active over a wide range of fundamental and applied research challenges.

Cyril Bath Company

Phone: +1-704-289-8531 www.cyrilbath.com

Cyril Bath produces titanium air frame components by Hot Stretch Forming HSF® titanium profiles in lengths up to 30 feet long. Most of these air frame components are provided as machined and finished, ready for airplane assembly installation. We purchase titanium in extrusion or rolled product forms.

Danieli Corporation

Phone: +1-724-778-5400 www.danieli.com

Danieli Centro Maskin combines Swedish, North American and Italian technology together with know-how gained through our experience of 55 years of activity in the field of Surface Conditioning, NDT Inspection and Finishing Lines for the titanium industry. Danieli Centro Maskin surface conditioning, drawing, straightening, peeling, centerless grinding, cutting, and tube finishing lines, incorporate the most modern engineering and design technologies.

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DGA

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DKSH Switzerland Ltd.

Phone: +41 44 386 72 72 www.dksh.com ti@dksh.com

Pioneers in sourcing of Titanium bars and plates from Japan and China: DKSH Advanced Metals is part of a Swiss group with 140 years of experience in bridging Asia and the West. For the last 30 years, we have been instrumental in introducing high quality titanium and titanium alloys from top quality Japanese and Chinese producers to European, US and South East Asian customers. We serve stockists as well as end users in the Medical, Aerospace, Automotive, Chemical, Oil & Gas and other high tech industries. Our wide range of services includes access to a comprehensive stock of

Ti semi finished products, advanced supply chain management such as vendor managed inventory and subcontracting for machining and forging, tailor made financing solutions and metallurgical expertise. Our deeply rooted knowledge of sourcing and subcontracting markets coupled with our Swiss sense for premium quality ensures that we remain at the forefront of innovation when it comes to serving your needs.

Duferco SA

Phone: +41 91 822 56 00 www.duferco.com

Duferco Group is the ultimate shareholder of Vanchem Vanadium Proudcts (Pty) Ltd. ("Vanchem"). Vanchem is one of the world's top five vanadium producers and its assets comprise mining activities and various vanadium oxide, ferro-vanadium, and vanadium chemical production facilities. Visit our websites at

www.vanchemvanadiumproducts.com and www.duferco.com

Dynamet Incorporated

Phone: +1-800-237-9655 www.cartech.com/dynamet



Dynamet Incorporated was founded in 1967 to produce titanium wire and bar for the aircraft fastener industry. Purchased by Carpenter Technology Corporation in 1997, Dynamet has become a leader in the development of high performance titanium long products for the aerospace, medical, motorsports, recreation and consumer industries. As a supplier of fastener wire, bar, precision shapes, fine wire and weld wire, Dynamet offers unmatched flexibility in manufacturing custom sizes, chemistries and quantities to meet demanding customer specifications and production needs.

ELG Utica Alloys, Inc.

Phone: +1-315-574-1680 www.elguticaalloys.com

EUA is one of the world's largest Titanium, Nickel and Cobalt alloy recycling companies. We operate under the tightest quality standards, utilize the latest equipment, offer unparalleled service, are fed by over 40 sister yards worldwide and have the financial backing of ELG Haniel GmbH.

Evraz Stratcor, Inc.

Phone: +1-312-533-3650 www.evrazstratcor.com



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 everincreasing 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.

EWI

Phone: +1-614-688-5000 www.ewi.org info@ewi.org

EWI is the leading engineering and technology organization in North America dedicated to developing, testing, and implementing

advanced manufacturing technologies for industry. Since 1984, EWI has offered applied research, manufacturing support, and strategic services to leaders in the aerospace, automotive, consumer electronic, medical, energy, government and defense, and heavy manufacturing sectors. By matching our expertise to the needs of forward-thinking manufacturers, our technology team serves as a valuable extension of our clients' innovation and R&D teams to provide premium, game-changing solutions that deliver a competitive advantage in the global marketplace. To learn more, visit www.ewi.org, email info@ewi.org, or call 614.688.5000.

FAE S.A.

Phone: +54-11-6326-1493/94/95 www.fae.com.ar

FAE is an Argentinean company that it is proud to announce that had been qualified by Airbus for supplying hydraulic titanium Ti-3Al-2.5 tubing for Family 320. Also it is the first Latin-American company in getting a tier one contract with EADS group. One of its main activities, apart from aerospace, is the manufacturing of seamless commercial pure titanium and titanium alloy tubes for heat exchangers which are up to 20 meters (65 ft) long. It also produces ingots and bars in titanium alloys and bright annealed finish seamless instrumentation titanium tubes (0.D ¼" up to 5/8"). FAE is certificated according UNE EN 9100: 2009, ISO 9001: 2008, ISO 14001: 2004, OHSAS 18001: 2007, PED 97/23/EC & CSA N285.0 standards. Its products are exported to countries all over the world and they are used in aerospace and corrosion resistant applications.

Fluor Corporation

Phone: +1-864-281-8385 www.fluor.com

Fluor Corporation (NYSE: FLR) is a global engineering and construction firm that designs and builds some of the world's most complex projects. The company creates and delivers innovative solutions for its clients in engineering, procurement, fabrication, construction, maintenance, and project management on a global basis. For more than a century, Fluor has served clients in the energy, chemicals, government, industrial, infrastructure, mining and power market sectors. Headquartered in Irving, Texas, Fluor ranks 109 on the FORTUNE 500 list. With more than 40,000 employees worldwide, the company's revenue for 2013 was \$27.4 billion. Visit Fluor at www. fluor.com and follow on Twitter @FluorCorp.

Fort Wayne Metals

Phone: +1-260-747-4154 www.fwmspecialty.com

Fort Wayne Metals has a long history of producing precision wire and wire components for demanding applications. For many years, our efforts focused exclusively on the medical device industry. But eventually we realized that our unique skills can be valuable to other industries, as well. After all, there are many non-medical applications that depend on wire to save lives – from TT straps in helicopters made from MP35N® or 35N LT® and brush seals from L-605 or C276 to Titanium aerospace wire.

No matter what your application may be – when you source your wire from Fort Wayne Metals Specialty Products, you know you're dealing with a company that understands the critical importance of quality. After all, our employees have experience producing materials



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that ultimately are in the human body. And that means we uphold the highest standards throughout our entire production process. In fact, we are 9100C and ISO 9001 certified and maintain a A2LA - ISO/IEC 17025 compliant Materials Testing Laboratory.

FRIEDRICH KOCKS GmbH & Co KG / KOCKS PITTSBURGH COMPANY

Phone: +49-2103-7900 Phone: +1-412-367-4174 www.kocks.de marketing@kocks.de

FRIEDRICH KOCKS GmbH & Co KG was founded in 1946 by Dr.-Ing. Friedrich Kocks. We have been successfully operating worldwide in the field of rolling mills for tube, wire rod and bar as independent, medium sized family owned company.

By a consistent and future-oriented development of our products, our technology has acquired a leading position on a global scale. KOCKS rolling mills are the benchmark for creative application oriented solutions as well as first class competence in engineering and manufacturing. Following its policy, KOCKS will pursue these constant innovations so that KOCKS will provide tomorrow's technologies today.

Friggi N.A.

Phone: 519-421-9291 www.friggiamerica.com info@friggiamerica.com

Friggi N. A. Inc., provides premium metal cutting solutions to the North American market. With over 70 years experience in the metal cutting industry we now offer horizontal and vertical bandsaws, high-speed carbide saws, plasma, laser, flame, and waterjet cutting solutions. Within our product line, we offer specialized equipment to cut challenging materials like Titanium or exotic metals and Aluminum at high speed. Our plate saw capacity is over 20 feet and our Gantry models will cut blocks up to 135" with minimal material handling. Machines are available in automatic or semiautomatic version to cover any requirement. We service many key market segments including aerospace, automotive, defense, oil and gas, steel service centers, forging and mold makers. Whether the application is to cut ferrous or non-ferrous metals for ingot, bar, block, plate, or sheet we offer the best solution for our clients' production needs.

G&L Manufacturing, Inc.

Phone: +1-931-528-1732 www.gandltubing.com

G&L manufactures welded tubing in a full range of corrosion resistant and high temperature alloys including stainless steels, nickel alloys and titanium. From demanding heat transfer applications, to safety critical fuel delivery systems, to life supporting medical applications G&L's tubing has been exceeding customer expectations for over 30 years. G&L's proprietary tube forming and welding technology is designed to deliver precise dimensional control and consistent weld integrity. G&L tubing is offered in cut to length, level wound and loose wound coil, as well as custom shapes. With 100,000 SQ FT of manufacturing space in Cookeville TN, USA and 30,000 SQ FT in Nanjing, China, G&L is well positioned to serve the global industrial market. G&L Manufacturing, Inc., 1975 Fisk Rd., Cookeville, TN 38506

G&S Titanium, Inc.

Phone: +1-330-263-0564 www.gs-titanium.com

G&S Titanium manufactures many grades of titanium in the form of round and hex bars, fastener wire, spring wire, weld wire, precision ground medical bars, and fine wire. This includes the standard grades such as CP Gr. 1-2-3-4, 6AL-4V, 6AL-4V Eli, as well as hard to find alloys such as 3-8-6-4-4, 13-11-3, 6-2-4-2, 8-1-1, Gr. 7, Gr. 9, Gr. 12, 21S, 230, 679, 685, 829, etc.

Gautier Steel Ltd.

Phone: +1-814-691-6050 www.gautiersteel.com

Gautier Steel Ltd. has the capabilities to turn your ideas into reality. Our 3 rolling mills allow us to provide a broad range of shapes and sizes, whether you desire a non-standard section or a special length. We satisfy the most demanding customer specifications.

From the engineers in our on-site Roll Shop to the highly skilled craftsmen who operate our mills, Gautier is experienced, knowledgeable and versatile. We begin with a flow sheet determining the number of passes it will take on the mill to roll your shape. Our advanced wire EDM machine, templates are cut with exacting tolerances – down to less than .001". These templates are used for operation of tracer lathes and as inspection fixtures. This same system produces programs for turning rolls on our CNC lathe. When it comes to quality at Gautier Steel, you are in control.

GeoCorp, Inc.

Phone: +1-419-433-1101 www.geocorpinc.com



Manufacturer of thermocouples and thermocouple wire with an ISO 17025 accredited temperature calibration lab. All of our products meet the requirements of AMS 2750 Rev. E & BAC 5621K. Custom built thermocouples ship in days-not weeks. We offer material with a maximum temperature tolerance not to exceed +/- 2°F or .2% whichever is greater. This tighter tolerance allows for easier furnace testing during surveys and/or system accuracy tests. GeoCorp has a tenured staff that attends annual Nadcap meetings. We also attend the AMEC (committee that writes AMS 2750 Rev. E) meetings to work on updating specifications and addressing any customer issues with AMS 2750 Rev. E or Nadcap. Call today if you have any questions about thermocouples or wire as they pertain to Nadcap.

GfE Metalle und Materialien GmbH

Phone: +49 911 9315 299 www.gfe.com alloys@gfe.com



GfE, founded in 1911, is a leading manufacturer and global supplier of high performance metals and materials.

During the last 40 years GfE has gained valuable expertise in the production of master alloys. As part of the AMG Advanced Metallurgical Group N.V., GfE offers a wide range of high quality products that meet the highest technical requirements for the aerospace industry. GfE's master alloys are used in titanium and nickel based super alloys, to produce special parts for aircraft

engines, land based turbines, off-shore drilling applications, and exterior shields.

Furthermore titanium as high-purity HDH powder is produced by GfE for thermal spray coatings. Its specific characteristics offer an advantageous material for porous layers on medical implants.

GfE is certificated in accordance to ISO 9001, EN 9100, ISO 14001 as well as BS OHSAS 18001 and operates an accredited laboratory according to DIN EN ISO/IEC 17025.

GIE Media Inc. - Industrial Division

Phone: +1-216-393-0264 www.OnlineTMD.com emodic@gie.net

The Industrial Division of GIE Media publishes four manufacturing and design B2B magazines: Aerospace Manufacturing and Design, Today's Medical Developments, Today's Energy Solutions, and Today's Motor Vehicles. All four publications are manufacturing and design oriented and provide insight into the latest developments in material selection, production processes, equipment, tooling/ workholding, quality/metrology, and automation. View our other publications online at: www.OnlineTMD.com, www.OnlineAMD. com, www.OnlineTES.com, www.TodaysMotorVehicles.com.

Global Titanium Inc.

Phone: +1-313-366-5300 www.globaltitanium.com

Global Titanium is a leading producer of ferrotitanium, titanium scrap products, and titanium HDH powder. Located in Detroit, Michigan, Global Titanium serves the steel, stainless steel, aluminum, and titanium industries. Global Titanium is an ISO 9001:2008 registered company with a strong commitment to safety, quality, and customer service.

GNB Corporation

Phone: +1-916-395-3003 www.gnbvalves.com

GNB has a proven track record of manufacturing high quality, reliable vacuum products since 1968 and is known as America's leading manufacturer of large vacuum valves. In addition, GNB offers a diverse range of vacuum products and services, including: inline chambers, slit valves, gate valves, pendulum valves, angle valves, vacuum chambers, liquid nitrogen traps, custom flanges and fittings, viewports, bellows, multi-coolant baffles, throttle plates, and much more. With our expert group of engineers, GNB can efficiently customize our clients' products. Extensive experience combined with an outstanding reputation for high quality products and customer service, GNB is the valued resource for your next vacuum system.

Grandis Titanium

Phone: +1-949-459-2621 www.grandis.com titanium@grandis.com

GRANDIS TITANUM is a major worldwide supplier of titanium products like Titanium Bars, Sheets, Plates and Wire for Industrial and Chemical applications. Company maintains warehouses in Los Angeles and Rotterdam, and sales offices in USA: California, Ohio and Oregon, also in South Korea, China, Russia, Belgium and Italy.

Haynes International Inc.

Phone: +1-765-456-6000 www.haynesintl.com

Haynes International, Inc., headquartered in Kokomo, Indiana, USA, is a leading developer, manufacturer and marketer of highperformance nickel- and cobalt-based alloys used in corrosion and high-temperature applications. Our highly-trained staff and technicians provide superior customer service, worldwide technical support and one-on-one consultation in selecting the proper alloy for the application. In addition to stocking our standard product forms, our global service centers offer value-added services to shorten your cycle time, reduce material waste and increase your operation's efficiency. Haynes International is a partner in your entire material management system and provides value far beyond the alloys themselves.

Hempel Special Metals GmbH

Phone: +4920862040 www.hempel-metals.com

Hempel Special Metals in Germany is one of the largest stockists for Titanium, Nickel Alloy and Zirconium in Europe with companies in England, Poland, Switzerland, Italy and various sales representatives. Our main businesses are chemical process industry, flue gas desulfurization, oil & gas, medical and watch industry. Beside all standard titanium grades we stock special grades (Grade 4, 5, 5-ELI, 7, 9) in bars, sheet/plates and tubes. Our services include individual stocking, cutting, sawing, plasma, laser- and water jet cutting, individual bar marking and turning. We supply material tailor made and in packages for special projects.

Hi Tech Alloys, Inc.

Phone: +1-925-937-3836

High Performance Alloys, Inc

Phone: +1-765-945-8230 www.hpalloy.com

High Performance Alloys, Inc. has a GFM Model 412 radial forge for producing bar. The GFM uses 4 dies to produce more force to the center of the bar than rolling or drawing methods. Our GFM produces 120 tons of force per die, 900 times per minute. Rolling mills have difficulty with some of the more difficult (Beta) alloys at lower processing temperatures. Our process produces a more refined grain structure due to the 360 degree directed force and the high forging forces.

H.P.A. is a secondary producer of the high performance alloys. We process small to medium lots of materials; excellent for prototype research, and providing low volume or specific alloys (normally requiring a mill quantity). Short production lead times are achievable because we start with existing (available) stock and produce the diameter you require. Call us when your job requires a shorter lead time.

HORIE Corporation

Phone: +81-256-66-2237 www.horie.co.jp

Horie Corporation is the world leader at surface engineering of Titanium such as precision coloring, etching, grain controlling and the solution provider to complex titanium fabrications. Horie has developed its original titanium technology using Horie's electrochemical technology and surface treatment technology. Our titanium knowledge provides our customers with unequaled solutions in titanium. Horie will continue to develop many new products and search the unlimited possibilities and beauty of titanium.

Independent Forgings & Alloys Ltd

Phone: +44-114-234-3000 www.independentforgings.com sales@independentforgings.com

Independent Forgings & Alloys Itd 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.

INDUCTOTHERM

Inductotherm Corp. -Long Products Division

Phone: +1-609-267-9000 www.inductotherm.com sales@inductotherm.com

President: Bernard Raffner General Manager: Bert Armstrong Director – Sales: Andrew Procopio

PRODUCTS and SERVICES - Inductotherm manufactures a complete line of induction heating and boosting systems for titanium slabs, billets, blooms, bars and rods prior to rolling. Other products include vacuum induction melting, holding, pouring, heating and coating equipment for thermal applications in air or controlled atmospheres for the metals industry. Coreless and channel furnaces with capabilities up to 500 tons; power supplies up to 42,000 kW; automatic pouring systems with vision control; computer controls and charge handling systems.

Industrial Metals International Ltd.

Phone: +1-631-981-2300 www.industrialmetals.com

IML is a supplier of bar, sheet, tube, wire, rings and forgings in aluminum, titanium, nickel stainless steel, alloy and bronze products. In business for over 40 years, IML is approved by companies such as Rolls Royce, Boeing, Airbus, and Pratt and Whitney. Located near JFK Airport in NY, IML is able to offer same day shipping to countries worldwide with no minimum order charge for stock items.

Invera

Phone: +1-610-325-0124 www.invera.com peterd@invera.com



Invera is the leading supplier of ERP software for the metal distribution industry. Our STRATIX software provides advanced functions for sales, inventory control, production, shipping and outside processing of specialty metals.

Metal Specifications, Mill Test Certs and third party certificates can be controlled within STRATIX and as required emailed to customers upon shipment.

Full product traceablity enables companies to have complete control and accountability of all material purchased, processed and shipped to customers.

Invera also provides INVEX for eCommerce and Customer Web Service options over the internet. Coupled with the INVEX-CRM applications companies can optimize the sales process by recording quotes, activities and tasks.

Because STRATIX was designed from the ground up for metal distributors and processors the inventory can be accessed using metal industry nomenclature. A complete solution tailor made for titanium metal companies.

Jiangsu Hongbao Group Co., Ltd.

Phone: +86-512-58715276 www.hongbao.com export@hongbao.com

Hongbao is an ISO, PED, Lloyd's, DNV and NORSOK approved manufacturer in China. We melt titanium sponge and produce titanium ingot, bar, plate and tube. We are exporting to USA, U.K., Germany, France, Sweden and Korea etc. and the total quantity is more than 800 tons per year. E-Mail: export@hongbao.com

KASTO Inc.

Phone: +1-724-325-5600 www.kastoinc.com

KASTO, Inc is the world's only COMPLETE supplier of Metal Cutting Machinery offering all available Metal Sawing methods. These include Band Saws, Plate & Block Saws, Cold Circular Saws & Hacksaws. Customers benefit from un-biased recommendations about which Metal-Cutting Equipment is best for their application. We also offer complete Storage and Retrieval Systems!

Keywell Metals, LLC

Phone: +1-773-572-6173 www.Keywell.com

Keywell Metals, LLC is the industry leader in specialty steel recycling and a worldwide purchaser, processor and seller of titanium scrap metal for ingot formulation, alloy additions and ferro-titanium production. In addition to the complete range of processing capabilities, Keywell Metals, LLC operates the largest and most modern fully equipped on site analytical laboratory in the scrap metal industry. Every product shipped from Keywell Metals, LLC is fully certified and guaranteed to meet Customer Specification.





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Kings Mountain International (KMI)

Phone: +1-704-739-4227 www.kmiinc.net

Kings Mountain International (KMI) is an ISO 9001:2008 / AS9100C certified precision grinding company.

KMI processing includes:

- Flat / Tapered / Contoured precision thickness machining
- Tolerances to +/-.001" (.0005" upon request)
- Sizes up to 110" x 360: larger sizes upon request
- Weight control for Aerospace applications
- Thin sheet grinding to .010"
- Surface Finishes from 250 RMS to 12 RMS and finer
- Polishing of sheet and plate to #3,#4 or #8 mirror. Non-directional also available

Benefits:

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- Experience with all types of metals

• Plate / Sheets arrive clean, damage free and ready for fabrication

Industries we serve: • Aerospace / Defense / Energy / Commercial Aircraft / Architecture

L.C.M.A.

Phone: +352 26 55 43-1 www.lcma.lu lcma@pt.lu

Founded in 1996, LCMA is now a fully integrated producer, processor and distributor of a wide range of semi-finished titanium and titanium alloy products for aerospace, medical, petrochemical and industrial applications.

We work with several manufacturers based in Ukraine and Europe who convert our Grade 1 to 5 ingots in forged and rolled bars, sheets, plates, coils, spools, electrodes, tubes and more. LCMA is ISO 9001:2008 and EN9100:2009/AS9100:2009 aerospace approved.

Being part of a vertical structure LCMA controls quality at all production processes and all products are US, EC and HB tested. We deliver to customers all over the world and our Quality, Experience, Flexibility, Short lead time, Large stock and Competitive prices makes us one of the key players on the market. Please contact us at fax: +352 26 55 13 45 or Email : Icma@pt.lu

LHI Metals

Phone: +1-866-949-1699 www.LHImetals.com

Combining the strengths of Alloy Metals, Supra Alloys & Tico Titanium, LHI Metals offers the convenience of "one-stop" shopping with a variety of inventories and value added services. Satisfying customers for a combined 75+ years, our knowledgeable and courteous sales staff is dedicated to meeting and exceeding our customer requirements, from small quantity or specialty items to thousands of pounds of mill products. LHI Metals is ISO 9001 registered, with AS 9120, Pratt & Whitney LCS/MCS, and specialized medical approvals to better serve the aerospace and medical markets. We specialize in titanium for Medical Devices. Plate, sheet, strip, foil, billet, bar and wire. Bar inventory is centerless ground to +/-.0005" and to precision tolerances of +/-.00025" or better. In-house sawing, shearing and waterjet capabilities. Ti 6AL4VELI in various rectangular bar sizes. Inventory certifiable to ASTM F136, F67, F1472 specifications. Testing and certification provided for other OEM specifications.

Lord Steel Industry Company Limited

Phone: +86-512-62861001 www.lordsteel.com



Lord Steel Industry Company Limited (LSI) is a global leading solution provider and manufacturer in Tube & Pipe of Stainless Steel, Nickel Alloy, Copper Alloy and Titanium since 1990. LSI has a registered office in Hongkong as the Financial Center, another office located in Suzhou Industry Park (Lord Steel International Co., Ltd. - Sales & Marketing Center), hold two green and nice factories located in Taiyuan LSI WTNM, and in Nanjing (LSI WORD partial shareholder).

LSI People not only see our products as normal Industry products, we take them as artwork with high quality value. In every LSI people's heart, Quality is always first. High service level shall be our added value in the products. Competitive price and our promise in the lead time shall Strengthen the mutual Trust relationship between LSI people and our clients.

LOTERIOS S.p.A., a TIMET Company

Phone: +39-02-9648281 www.loterios.com

LOTERIOS S.p.A. core business: TIMET Italian Service Center (sheets, plates, bars, forgings, etc.) and leading fabricator of titanium pipe, fittings, shell and tube heat exchangers and vessels as required.

Lucideon

Phone: +1-518-382-0082 www.lucideon.com

Lucideon is a leading global expert in materials development, testing and assurance. Expertise includes chemical analyses, metallurgical evaluations, mechanical testing and failure analysis. Industries served include:

Aerospace & Defense Automotive & Transportation Construction Electronics Industrial Equipment, Components & Metal Fabrication Materials Manufacturing Medical Devices Nuclear Energy Power Generation

Mair Research S.p.a.

Phone: +39 0445 634 444 www.mair-research.com

Since 1977, MAIR Research has offered specialized equipment and services to the steel industry, specifically helping tube and bar producers to create profitable and efficient production processes in a safe environment.

Makino

Phone: +1-513-573-7200 www.makino.com

A world leader in advanced CNC machining centers, Makino provides a wide range of high-precision metal-cutting and EDM machinery, including horizontal machining centers, vertical machining centers, 5-axis machining centers, graphite machining centers, and wire and Ram EDMs. Our flexible automation solutions provide reduced labor costs and increased throughput in a variety of production volumes and designs. With Makino engineering services, we offer industry leading expertise for even the most challenging applications across all industries. For more information visit makino.com.

Materials & Electrochemical Research (MER) Corporation

Phone: +1-520-574-1980 www.mercorp.com

The technologies MER pursues includes: Rapid Additive Manufacturing, Titanium Powder and Fabrication by Additive Manufacturing, Metal and Carbon Matrix Composites, Electrochemical Systems, Porous Materials, Coatings, Spinel and Nanotechnology. MER develops processing to produce titanium more economically that includes lower cost than sponge and down stream additive manufacturing processing to produce low cost titanium components. These technologies include producing titanium powder directly from ore/TiO2 at a cost substantially lower than that of Kroll sponge, engineering the Kroll process entirely in one reactor at a reduced cost, producing titanium alloy powder from ore/TiO2 and one-step production processing near net shape alloy components at a cost of under \$10/lb.

Medart, Inc.

Phone: +1-724-752-2900 www.straight-to-medart.com

Medart manufactures centerless bar peelers, coil to coil peelers, coil to bar peelers, straighteners, and engineered material handling equipment. Purpose built processing equipment for the titanium industry.

Mega Metals, Inc.

Phone: +1-602-258-6677 www.megametalsunlimited.com

Mega Metals Inc., is a globally recognized high quality processor of Titanium Turnings and Solids. We are certified by major mills and casting houses for prepared aerospace grade material. Our philosophy is to unite the highest quality in customer service with the highest quality of our materials, in order to serve the expanding international demands of the metals recycling industry.

MetaLinx Material Management, Inc.

www.MetaLinx.com

MetaLinx Material Management, Inc. announces the opening of a MetaLinx® Technology Demonstration Site situated near DFW Airport in Carrollton, Texas. The MetaLinx® System, an internationally patented and proven technology, assures complete transparency and accountability of recyclable materials. By this unique means, a high degree of material management and control is achieved from scrap creation through material sale when full containers are released by the system. MetaLinx® identifies system containers and tare weight; continuously monitors content weight and records all variance; automatically transmits action alerts by e-mail, fax, text and voice messaging; issues transaction reports/ invoices computed by index-based price formula; and produces real time and stored inventory data and reports accessible via the MetaLinx® Web Portal. To arrange a demonstration at your earliest convenience; please contact Dr. Bert Erdel at berte@metalinx.com or David H. Jones at davidj@metalinx.com

METALVALUE

Phone: +33680562848 metal@honnart.fr

METALVALUE provides strategic consulting services and invests into selected industrial companies.

Metalwerks PMD, Inc

Phone: +1-724-378-9020 www.metalwerks.com

Metalwerks PMD, Inc. produces a wide variety of specialty metals, superalloys and developmental alloys in Iron, Nickel and Cobalt based alloys. We melt current and developmental titanium alloys in ingot form from 400 grams to VAR ingots weighing up to 5000 pounds. We also convert these ingots into mill products for use by our customers.

Metalysis Ltd.

Phone: +44 (0) 1709 872 111 www.metalysis.com kartik.rao@metalysis.com

Metalysis is a UK-based technology company, which has developed a proprietary process to produce metal powders at low cost using electrolysis. It is currently focused on the production of tantalum and titanium alloy powders for use in conventional and additive manufacturing, with a variety of applications in industries including aerospace, electronics, bio-medical, petro-chemical and automotive.

MetCon, LLC

Phone: +1-724-888-2172 www.metalconditioning.com

MetCon provides conditioning and finishing services for both intermediate and finished products, including bloom, billet, bar, plate, sheet, and machined or fabricated components employing a patented "Green" electrochemical technology. Product yields and costs are dramatically improved when compared to conventional processing. The technology can also provide alpha case removal, precise gauge removal, and ultra-bright micropolishing. MetCon is based in Monaca, PA, 30 miles northwest of Pittsburgh.

METRACO NV

Phone: +32 56 234400 www.metraco.be

European traders of ferro-alloys and non-ferrous metals. Specialized mainly in ferro-titanium, titanium sponge and manganese metal. Supplying all grades of FeTi 70 % and buyers of titanium scrap and

low grade sponge for FeTi production. Supplying steel grade sponge directly to steelmills and masteralloy producers worldwide.

MetSuisse Distribution AG

Phone: +41 44 586 02 74 www.metsuisse.com

MetSuisse reflects the precision and high quality products the industry requires. Being the first metal distribution company specializing in the medical and watch industry, MetSuisse has been able to specialize in sourcing for these industries. The stringent and precise requirements found in the medical & watch industry has given us the experience and abilities required to meet the various requests. Next to our experience we are the first metal distribution company specialized in the medical industry, and operate strictly according to ISO 13485 (Medical) and the GDP standards valid for pharmaceuticals (besides ISO 9001). Currently, we are specialized mainly in the metals titanium, zirconium, CoCrMo, medical stainless and tungsten alloys. However, you can contact us with any of your sourcing requests. We work with dedicated partners worldwide.

MetSuisse has a unique grinding facility allowing: precision grinding of titanium foils, sheets and plates technology applied for the Swiss watch industry no min. quantities for CP Grade 1, 2, 4 and Ti6Al4V Eli min. 0.09 +/- 0.015 mm

(= in inch 0.003543307" +/- 0.000590551")

Mid-West Machine

Phone: +1-205-663-0732 www.vulcangroup.com sales@vulcangroup.com



Mid-West Machine[™] provides metal conditioning equipment and systems for the Steel and Titanium industries. This includes both bonded wheel and coated abrasive belt grinders. We offer Traveling, Stationary, Gantry, Overhead, and Ingot End Grinders as well as material handling equipment for processing slabs, billets and rounds through the grinders.

Monico Alloys

Phone: +1-310-928-0168 www.monicoalloys.com info@monicoalloys.com

Monico Alloys specializes in the processing of titanium scrap in the form of solids and turnings. Monico is a Global Mill processor for Titanium Scrap metal ISO 9001:2008 and approved by every major titanium melter. Monico Alloys prepares bulk-weldable solids, feedstock, cobbles, and turnings to rotor quality specifications. Monico Alloys remains the industry leader by utilizing only the latest scrap processing technology. Monico Alloys offers a wide variety of Titanium Alloy inventory which includes CP, 6-4, 6-2-4-2, 6-6-2, 3-2.5, and others.

Montana Precision Products

Phone: +1-360-653-9388 www.seacast.com

SeaCast operates four full service investment casting foundries which cast a wide range of alloys including stainless steel, nickelbased superalloys, titanium and aluminum. Foundries in Marysville, WA, Seattle, WA, East Greenwich, RI and Butte, MT offer extensive in-house support services such as CNC machining, heat treat, NDT and assembly. The company serves a wide variety of industries including aerospace, defense, industrial pumps, industrial gas turbines, medical, transportation and computer hardware. SeaCast's manufacturing processes have earned ISO9000, AS9100 and NADCAP certifications.

MoTiV Metals, LLC

Phone: +1-412-200-5832 www.motivmetals.com

MoTiV Metals, LLC is an independent sales and marketing company supplying molybdenum, titanium, vanadium and other products to the global steel, titanium and chemical industries. The company has a vast array of expertise and knowledge in domestic and international sales, logistics and supply chain management.

MoTiV Metals LLC offers Master Alloys to the Titanium industry, through its relationship with BHN Special Materials Ltd, including V-AI, Mo-AI, and other alloys.

Nanjing Plate Titanium Industries

Phone: +86-138-5188-2939 www.platetitanium.com.cn

Plate Titanium Industries (PTI) manufactures welded-pipes and its parts, made of special materials such as Titanium, Nickel and Zirconium. PTI is certified with many national and international standards (such as the ISO9001). PTI is also granted a special permit to manufacture pressurized vessels and pipes by National Quality Inspection Bureau of China. PTI is conveniently located at Lishui District of Nanjing, China, only 10 km to Nanjing Lukou International Airport.

nanoPrecision Products, Inc.

Phone: +1-310-597-4991 www.nanoprecision.com

nanoPrecision Products is a designer, developer & manufacturer of precision products with applications in the telecommunication, data communications, consumer electronics, mil/aero and bio & medical device markets. We employ various metals in our products including titanium. The products we are introducing to the market that utilize titanium are anticipated to consume large volume of material.

NF & M International Incorporated Phone: +1-724-774-9200



Phone: +1-724-774-9200 www.nfm-titanium.com

NF&M International, Inc., subsidiary of VSMPO-Tirus US, is a producer of premium quality triple melted and standard grade titanium bar and billet products for the aerospace market and manufacturer of small-diameter precision tolerance bar and seamfree coil products for aerospace fastener, automotive and medical applications. NF&M also provides a wide range of conversion services, including intermediate grinding and finishing of bar/billet, heat treating, straightening, bar peeling, bar polishing, pickling and inspection. NF&M's Nadcap approved laboratory performs room temperature tensile, hardness, hydrogen analysis and micro/ macrostructure evaluation.



Now safely and effectively etch/prepare titanium for anodizing without using Hydrofluoric Acid!

IN USE SINCE 1993, JOIN THE GROWING NUMBER OF MEDICAL, DENTAL AND JEWELRY USERS WHO'VE MADE THE SWITCH TO A MORE ENVIRONMENTALLY SOUND PROCESS.

DEVELOPED AS A SAFE ALTERNATIVE TO THE DANGERS OF HYDROFLUORIC ACID, MULTI ETCH, WITH ITS PH OF 6.8, HAS QUICKLY BECOME THE FAVORED SAFER ETCH TO:



• REMOVE SURFACE OXIDES & CONTAMINANTS ON TITANIUM WHICH CAUSE DULL COLORS AND BLOCK THE FULL COLOR RANGE

• ERASE ANODIZING MISTAKES ON TITANIUM & NIOBIUM

• PREPARE PLATINUM FOR SOLDERING/WELDING

• ENHANCE PATTERNS ON MOKUME AND METEORITE



ANODIZED TITANIUM TREATED WITH MULTI ETCH (TOP) AND UNTREATED (BOTTOM)



North American Alloys

Phone: +1-800-985-2250 www.northamericanalloys.com steve@northamericanalloys.com

Now celebrating our 32nd year in business, North American Alloys processes titanium alloy scrap for recycling and warehouses stocks of new and surplus lots of titanium mill products. North American Alloys warehouse in Kennewick, WA handles titanium sheet, plate, bar, billet and tubing. Please visit our website at www. northamericanalloys.com to view our current inventory of titanium products. North American Alloys is always seeking new sources of excess inventory materials in titanium, cobalt or nickel alloys and specialty metals such as tantalum, columbium, zirconium and beryllium.

Contacts: Michael Shulimson – President, Steve Meredith, Director of Sales and Peter Rockefeller, Warehouse Manager

Nu-Tech Precision Metals

Phone: +1-613-623-6544 www.nutechpm.com

Nu-Tech Precision Metals manufactures by hot extrusion seamless pipe, tube, fittings, bar, rod and shapes for nuclear, aerospace, military, offshore, mining, chemical, sub-sea and corrosive environments. Shapes, especially those for the aerospace industry, fit within a 12" (300 mm) circle size. Our extrusion process creates a near-net shape that reduces material and machining costs overall. Our ability to alpha-beta process results in improved fatigue resistance over beta extrusions...contact us to learn more about how this process will benefit your extrusion requirements. Seamless pipe schedules from 1.5" (40 mm) to 14" (350 mm) plus specialty sizes and wall thickness. Custom extrusions in all grades of Ti Zr Nb Ni Cu Hf Ni, specialty stainless, carbon steels, copper, and high purity aluminum alloys. Bi-metal extrusions such as titanium clad copper, copper clad niobium tubes for RF cavities, nickel clad steel, etc are extruded resulting in a metallurgical bond. Sputtering tubes and backing tubes are our specialty!

Oak Ridge National Laboratory

Phone: +1-865-241-8113 www.ornl.gov

ORNL is a multiprogram science and technology laboratory managed for the U.S. Department of Energy by UT-Battelle, LLC. Scientists and engineers at ORNL conduct basic and applied research and development to create scientific knowledge and technological solutions that strengthen the nation's leadership in key areas of science; increase the availability of clean, abundant energy; restore and protect the environment; and contribute to national security.

OSAKA Titanium technologies Co., Ltd.

Phone: +81 3 5776 3103 www.osaka-ti.co.jp

OSAKA Titanium technologies Co., Ltd. manufactures premium quality titanium sponge mainly for aerospace use, high-purity titanium billet and polycrystalline silicon for semiconductor industry, titanium powder for powder metallurgy and additive manufacturing, and other titanium-silicon related products.

Oscar Production Group Ltd.

Phone: +380 56 770 1234 www.oscar-tube.com.ua mail@oscar-tube.com.ua

Manufacturer of cold and hot formed seamless titanium tubes and rods.

Parker, Messana & Associates, Inc.

Phone: +1-253-926-0884 www.pma-engr.com

PMA Engineering brings a broad and extensive depth of engineering and operating experience in titanium to work for you. Our understanding of the critical requirements of the RG/PG world opens the door for us to benefit your organization. Our experience and ability to assist across all facets of an operation, including sponge, sponge processing, scrap and scrap handling, melting, finishing, flattening, and other operations, allows for comprehensive solutions.

We can work with you to Optimize Processes and assist with reviews of your operations in regards to RG/PG standards and expectations. We will utilize our experience to upgrade or replace equipment to improve or increase your production capabilities. We can provide Feasibility Studies, FEED Studies, and Detailed Engineering for new process and manufacturing facilities, including the integration of your control and data systems for reporting, chronological documentation and MIS reporting. And, we can audit your processes against industry quality standards and provide paths for continuous quality improvement.

We partner to make you better.

PCC Structurals, Inc.

Phone: +1-503-777-3881 www.pccstructurals.com

Precision Castparts Corp. is a worldwide, diversified manufacturer of complex metal components and products. It serves the aerospace, power, and general industrial markets. PCC is the market leader in manufacturing large, complex structural investment castings, airfoil castings, forged components, aerostructures and highly engineered, critical fasteners for aerospace applications. In addition, the Company is the leading producer of airfoil castings for the industrial gas turbine market. PCC manufactures extruded seamless pipe, fittings, forgings, and clad products for power generation and oil & gas applications; commercial and military airframe aerostructures; and metal alloys and other materials to the casting and forging industries.

Perryman Company



Phone: +1- 724-746-9390 www.perrymanco.com

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. 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.

Plymouth Engineered Shapes

Phone: +1-270-484-5844 www.plymouth.com jlake@plymouth.com

Plymouth Engineered Shapes is the premiere provider of near-net extruded shapes for a large variety of applications. All customers want to squeeze more cost out of their parts and Plymouth Engineered Shapes offers the solution in Titanium, Stainless steel, Alloy steel, or Nickel-based alloys. Our Engineers are capable and willing to work with your design engineers to develop the most optimum near-net shapes possible to make your finished parts. No other manufacturer in North America offers so much experience in special shape technology, or provides so many value-added options to meet your product specifications.

Praxis Technology

Phone: +1-518-812-0112 www.praxisti.com

Praxis specializes in titanium powder metallurgy. We produce finished and semi-finished parts via metal injection molding and conventional methods. We work with a variety of different alloys and have the capability to deliver custom or specialized materials as needed. Our primary markets include medical device, industrial, consumer and firearms applications.

President Company Ltd.

Phone: +886-227411-190 www.presico.com.tw presico@presico.com.tw

President Co., Ltd., established in Taiwan in 1969, is one of the largest titanium stockists in the Asia. Our business focus on the trading of high quality titanium with diverse stocks. Besides, our product includes titanium slabs, sheets, bars, wires, pipes, fasteners, castings, etc. We commit to supply the most satisfying high quality titanium materials for users with quick lead time and favorable after sales service. Currently, our sales network is well deployed all over China, Taiwan and South-East Asia countries.

President Titanium Co., Inc.

Phone: +1-800-225-0304 www.presidenttitanium.com sales@presidenttitanium.com



Prolog Titanium Corporation Co. Ltd.

Phone: +662-920-4046 www.titanium.co.th sales@titanium.co.th

Prolog Titanium Corporation is Thailand's largest supplier, distributor and stockiest of high quality titanium metal products. With its unique combination of strength, light weight, corrosion resistance and other metallurgical properties, titanium is used in hundreds of diverse aerospace, defense, medical, chemical, electrical, automotive and other industrial applications where no other metal is a as reliable or economical, especially on a life cycle costing basis. We can supply to other high performance reactive metals such as Niobium, Molybdenum, Tungsten, Zirconium and Tantalum which have best properties to resist extremely corrosive, abrasive and ultra high temperature.

Quad Engineering Inc.

Phone: +1-416-391-3755 www.quadeng.com

Quad Engineering is a well established company supplying engineering services and equipment for the metals industry, including the titanium industry. Quad provides process engineering for rolling of titanium shapes and flat product.

Quad designs and supplies rolling mill equipment for titanium production. This includes rolling mill stands and auxiliary equipment; roller tables; transfers; cut to length lines; induction heating lines. Quad also provides installation engineering services including foundations, buildings, piping.

Quebec Metallurgy Center



Phone: +1-819-376-8707 www.cmqtr.qc.ca

The Quebec Metallurgy Center is a technology transfer center located in Trois-Rivieres, Quebec, Canada. Our activities focus on supporting the technological development of manufacturing companies in the metallurgical sector. CMQ has developed a broad expertise on the transformation and development of advanced alloys such as titanium, zirconium, aluminum and nickel. Our semi-industrial metalworking facility is equipped for short series production with controlled atmosphere or vacuum melting; permanent mold, shell mold and sand mold casting; welding, thermal spraying, ultrasonic welding, LENS laser additive manufacturing, vacuum heat treating and hot isostatic pressing.

Reactive Metals Studio, Inc.

Phone: +1-928-634-3434 www.reactivemetals.com



Founded 1981, a supplier of exotic metals to include titanium and niobium to the jewelry and decorative arts market. We consult, teach and supply anodizing equipment. We supply jewelry components, chain and findings in titanium. We are small order specialists catering to the medical, crafts and arts community. RMS is the exclusive provider of MULTI-ETCH, a user friendly titanium etch. Multi Etch prepares medical components for bright smooth anodizing without the dangers of Hydrofluoric acids.

Realum Ind. Com. de Metais Puros e Ligas Ltda

Phone: +55 11 2343 2300 www.realum.com.br daniel.wolkind@realum.com.br

Established since 1984 in the branch of Titanium, and High Pure Metals Alloys, the REALUM specializes in the distribution of its products for applications in chemical, petrochemical, pulp and also in the medical field. Our proposed work is to provide our customers the materials based on specific standards of each product 4 years ago, the REALUM built his new home with 1,500 square feet, in order to specialize further in the segment of Titanium, winning international certifications, dividing the company into applications by type of metal, and expanding the diversity of products being offered.

ReMelt Scientific, Inc.

Phone: +1-330-440-0402 www.remeltinc.com sales@remelt.net

ReMelt Scientific is a global supplier of Titanium Chip Melt Preparation Systems and Weigh and Blend systems. We specialize in titanium and high temperature alloy chip crushing, centrifuging, aqueous wash and solvent cleaning, thermal drying, fines screening, and magnetic and gravimetric separation to prepare chips to for melting. We also specialize in Weigh and Blend systems that weigh and blend titanium chips, sponge, master alloys, aluminum, iron, and TiO² to achieve customer specified chemistry requirements.

Renton Coil Spring Company

Phone: +1-425-255-1453 www.rentoncoilspring.com info@rentoncoilspring.com

Renton Coil Spring Co. (RCS) is a world-class spring manufacturer for aerospace and performance markets and has been providing superior quality parts and performance since 1949. Design and material capabilities, along with complete performance solutions has lead RCS to become a top supplier of quality springs, wire forms, assemblies, and flat metal parts with thousands of applications across the world.

Retech Systems LLC Phone: +1 (707) 462-6522

www.retechsystemsllc.com

RETECH sales@retechsystemsllc.com



REX Heat Treat

Phone: +1-215-855-1131 www.rexht.com chris.constable@rexht.com

Rex Heat Treat is a family owned and operated business that was founded in 1938. We take pride in our ability to partner with our customers to gain insight regarding their future needs. We are a leader in customer service and quality for the heat treating industry. We have 3 locations in Eastern United States.

Roll Forming Corporation

Phone: +1-502-633-4435 www.rfcorp.com

Roll Forming Corporation's Aerospace division offers Inline custom welding solutions and advanced fabrication applications. RFC's highly skilled and experienced laser welding team is NADCAP approved for a range of aerospace welding and laser welding processes. Additionally RFC offers in house NDT, CWI and NADCAP accredited inspection.

Roll Forming Corporation has taken the initiative in technical development, and collaborating with our customers to find creative solutions to overcome many program hurdles. Our laser welders put us at the forefront of the Aerospace industry in-line laser welded fabrications, RFC continues to lead the way as our inline custom welding solutions, and advanced fabrication applications are RFC's core competencies. For more information call (502) 633-4435 ext. 338.

Rolled Alloys

Phone: +1-800-321-0909 www.rolledalloys.com

Rolled Alloys offers a full range of titanium products in plate, sheet and bar. In addition we forge material to customer specific dimensions and specifications. Our titanium grades are used in major aerospace applications around the world, and are extensively applied in the biomedical field. Rolled Alloys has many global inventory locations each equipped with state-of-the-art processing equipment, supporting just-in-time, cut-to-size contract requirements.

Roskill Information Services Ltd.

Phone: +44 (0)208 417 0087 www.roskill.com

Roskill global market reports include the latest information on supply, demand, end-use applications, trade and prices for a wide range of metals and minerals including titanium, molybdenum and vanadium. Roskill reports also provide informed forecasts of future trends.

Roskill's expert researchers make a thorough and objective analysis of all available data, from sources across the globe. This includes a large and invaluable network of contacts including the key industry players on these markets, making Roskill's research unrivalled in terms of breadth, depth, accuracy and expertise.

To build on this wealth of data, Roskill also offers bespoke consultancy services that can help to explore and understand any specific scenarios or analysis requirements you may have.

QUALITY AND COMPETENCE!



ZIROM offers high quality level titanium and titanium alloys ingots by VAR and EB melting and forged products using Free forging process. Our company is certified according to

international standards: AS 9100 / EN 9100, ISO 9001, ISO 14001.



From Zirom Romania to Titanium World!

Contact: Km 4 Sloboziei Road, Giurgiu, 080331, Romania Sales Department: Phone:+40 346 566 905, Fax:+40 372 870 586 E-mail: zirom@zirom.ro, www.zirom.ro



RTI Advanced Powder Materials Phone: +1-330-544-7626

www.rtiintl.com



RTI International

Metals, Inc.

RTI Advanced Powder Materials part of RTI International Metals, Inc manufactures high quality titanium, titanium alloy and titanium metal matrix composite (MMC) products. RTI APM can provide novel materials solutions to meet design requirements that can't be met by conventional titanium materials. These products are made by pressing and sintering of titanium and alloy powder metal (PM) as an alternative to conventionally processed material. Products are typically made to near-net shape, thereby reducing the input material and machining to manufacture finish parts (i.e. reduced buy-to-fly). The Company also developed new titanium alloys and CermeTi® MMC compositions that offer improved properties for titanium, such as increased wear resistance. Capabilities include custom manufactured titanium billet, bar, plate and tube from titanium powder from its specialty alloys as well as standard industry alloys. Markets for its material and products include military, industrial, medical and aerospace supplied to ASTM and customer-specific specifications.

RTI International Metals, Inc. 1-844-RTI-INTL

www.rtiintl.com

RTI International Metals, Inc. is a leading vertically integrated global supplier of advanced titanium and specialty metal products and services to commercial aerospace, defense, energy, medical device and other customers across the entire supply chain. For more than 60 years, RTI has been taking titanium further through advanced manufacturing and engineering processes. RTI delivers a full range of titanium mill products as well as other titanium and specialty metals products and services including extruded shapes, formed and 3D-printed parts, and precision engineered and machined components through our downstream integrated supply chain.

Headquartered in Pittsburgh, PA, RTI has locations in the United States, Canada, Europe, and Asia. To learn more about RTI International Metals, Inc., visit our website at www.rtiintl.com.

S. Letvin & Son, Inc.

Phone: +1-310-327-0590 www.titaniumscrap.com

S. Letvin & Son, Inc., specialists in processing high temperature scrap metals, has been in business since 1947. We prepare a high quality 6/4 titanium feedstock package that meets AMS 4928 Chemistry specifications. We have developed a unique and proprietary process to return mixed 6/4 titanium fasteners to specification 6/4 titanium. The final product is 6/4 titanium "Rotor Grade" feedstock; heavy, dense, clean and extremely consistent in chemistry and gases. Our 6/4 titanium feedstock package is approved and desired by most major titanium mills, as well as many smaller investment casters worldwide.

S+D Spezialstahl Handelsgesellschaft mbH

Phone: +49-211-230999-11 www.s-dspezialstahl.de

The S+D Speciality Metals Group is one of Europe's largest stockists for semi-finished high-performance materials like titanium and titanium alloys, special stainless steel for aviation and aerospace or nickel and nickel alloys.

We supply into the following markets:

Aviation and Aerospace / Motor Sports / Defence Technology / Medical Technology

Offshore / Petrochemical / Chemical and Process Engineering / Plant and Equipment Manufacturing / Electroplating / Turbine Manufacturing / Marine Engineering / Energy Industry / Automotive Industry / Universities and Research

Institutes

We deliver just in time: At S+D we are able to cut all our materials according to our customer's exact requirements utilising our "state of the art" Bar Saws and Plate Saw. We also offer precision water jet cutting. Our Just in time service provides our customers with cost savings and security of supply. S+D is Aerospace approved according to ASD EASE EN9120 and EN9120 and AS9120 Rev. A issued by ISOQAR.

Sandinox Comercio, Importação e Exportação LTDA

Phone: + 55 15 3335 3565 www.sandinox.com.br

Established in 1986, Sandinox is the largest medical distributor for the Brazilian market, offering a full range of products in titanium, cobalt, and stainless steel alloys for the medical industry. Our goal is the constant search for technologically advanced products and materials that will ensure quality and the desired satisfaction of our customers.

Sandvik Materials Technology Product Unit Special Metals Phone: +46-26-263741

www.smt.sandvik.com

Product Unit Special Metals with two manufacturing locations (Sweden and USA) belongs to Sandvik Materials Technology and is a long term experienced manufacturer of seamless tubes and complementary products in Titanium, Titanium alloys and Zirconium based materials for a broad range of industrial applications as well as applications within nuclear, aerospace and medical industries.

The full scale commercial manufacture, which started in 1964 is fully integrated from VAR-remelting of Titanium resp. Zirconium sponge up to finished product.

Sector3 Appraisals, Inc.

Phone: +1-718-268-4376 www.sector3appraisals.com

Sector3 Appraisals, Inc. is a metals and chemicals valuation company offering a complete portfolio of asset valuations and advisory services regarding inventory, machinery and equipment and risk management.
Service Steel Aerospace

Phone: +1-800-426-9794 www.ssa-corp.com sales@ssa-corp.com



Service Steel Aerospace is a customer oriented stocking distributor of high performance stainless steel, titanium, alloy steel, nickel based super alloy, and maraging steel. We are committed to providing quality products to the aerospace industry and other critical application industries throughout the world. SSA performs a wide array of value added processing services designed to meet the specific needs of our customers. Our commitment to the quality and service has made SSA the leader in the industry for over 40 years.

Sierra Alloys / TSI Titanium PRV Metals Companies

Phone: +1-626-969-6711 www.sierraalloys.com

Manufacture and supply forged and rolled products in Titanium alloys, nickel-cobalt base alloys, precipitation hardened stainless and high alloy steels from small rectangular and round bar to large section size open die forged bar and stock.

Signer Titanium

Phone: + 41 44 716 12 60 www.signer-titanium.com signertitanium@gmail.com

As a distributor for titanium, our 30-year success story of Signer Titanium is not a coincidence,

but the result of comprehensive understanding of the material and market. Thanks to specialization in the distribution of titanium, we exclusively successful, satisfied and loyal partner - to customers, such as on the manufacturing side. Apart from sound materialknowledge, we offer our customers a complete service range. Our partners are world leading processor and manufacturer of titanium.

Snappy Materials LLC

Phone: +1-203-949-1600 www.snappymaterials.com

Snappy Materials is a metal distribution center serving the International Aerospace, Defense, Electronic, Forgings, Industrial, Medical, and Petrochemical markets. Our extensive inventory includes a wide array of aluminum, copper, high temperature alloys, nickel alloys, stainless steel, and titanium products. Stocked shapes include bar (hex, rectangular, round and square), billet, extrusions, plate, sheet, tubing, and wire. Materials are prime and mill certified to applicable aerospace, federal, military, and/ or industrial specifications. Snappy Materials is an ISO 9001:2008 AS 9120:2009 registered company and a Pratt & Whitney LCS/MCS approved supplier. Controlled quality processes and systems assure our customers of full product traceability. Material test reports and Certificate of Conformance accompany all shipments. With warehouse locations in close proximity to major air and sea ports, Snappy Materials provides complete export documentation and region specific packaging to meet your international shipping needs.

Solar Atmospheres

Phone: +1-855-934-3284 www.solaratm.com info@solaratm.com



Solar Atmospheres provides vacuum thermal processing for titanium material, parts, forgings, and weldments. With the world's largest vacuum furnaces, 12, 24 and 36 feet long, Solar is capable of vacuum processing furnace loads of bar, billet, sheet, and plate up to 150,000 pounds under 1X10-6 torr vacuum levels. Specific heat treat services provided are: degassing, beta annealing, homogenizing, age hardening, creep forming, hydriding/dehydriding, stress relieving and Florescent Penetrant Inspection. Solar is Nadcap, ISO9001:2008 and AS9100C Registered and Boeing approved in heat treating, NDT (Non-destructive testing) services and BASCA (Beta Anneal Slow Cool Age). Solar Atmospheres serves customers with plants located in Pennsylvania, South Carolina, and California.

Solar Manufacturing, Inc.

Phone: +1-267-384-5040 www.solarmfg.com



Solar Manufacturing designs and manufactures all types of vacuum heat treating, sintering, carburizing, and nitriding furnaces, as well as offers replacement hot zones and spare parts for various vacuum furnace brands. Our vacuum heat treating furnaces are designed to be the most energy efficient, cost effective, highest performing and most technically advanced furnaces on the market. With models ranging from compact laboratory size furnaces to mid-size horizontal production furnaces to huge car-bottom vacuum furnaces, we design for heat treat processes such as hardening, annealing, sintering, stress relieving, normalizing, and tempering. Our furnaces feature improved graphite insulation materials, curved graphite heating elements, tapered gas nozzles, high velocity gas quench systems, SolarVac® 4000 and 5000 interactive control systems, and a ConserVac energy management system.

Specialty Metals Company

Phone: +32- 2645-7670

Specialty Metals Co is the major shareholder of UKTMP (Ust Kamenogorsk Ti Mg plant) located in Kazakhstan. UKTMP produces Ti sponge, CP and alloy ingots and slabs.

Specialty Metals Processing, Inc.

Phone: +1-330-656-2767 www.specialtymetalspro.com

A Toll Processor of special non-ferrous flat rolled material including sheet, plate, slab and coil. We specialize in assisting you with your most demanding surface applications for titanium; nickel-based alloys; stainless; high-temp alloys and aluminum. From.013" light gauge coil to 10" thick slabs, we have the largest abrasive belt grinding operation in the US. Make us your reliable source for polishing, precision grinding, surface finishing and reconditioning. We also offer cut-to-length, slitting, and coil grinding & buffing.

Features:

- With our large abrasive belt grinding capacity, we offer quick turnaround!
- Providing #3, #4, # 6 or custom matched finishes or an Ra /RMS range

- Ability to polish/grind/recondition up to 12' wide by 100' long
- Special packaging & PVC options available including export packaging
- Fast delivery on all processing
- Offering one stop shopping on many orders
- Same day quoting on most inquiries
- Servicing mills, service centers, distributors, end-users and fabricators

Spectore Corporation

Phone: +1-954-481-8422 www.spectore.com

Spectore Corporation was founded in 1983 to reinvigorate the 3,000 year-old traditions of the jewelry industry with its introduction of titanium as a new noble element. New technologies were perfected to manipulate this extremely tenacious and non-traditional metal. The company's ambitious designers and R&D team have persistently explored the potential of titanium to create truly unique collections. This resulted in being awarded the 2010 Titanium Development and Advancement Award by the ITA. Today Spectore remains dedicated to the development of new methodologies for the design, engineering and manufacturing of high-end consumer products made of titanium.

Spectore Corporation designs and manufactures for a range of world class brands focusing on consumer products from household, sporting, technology, apparel, corporate gifting and jewelry. Spectore Corporation has also developed their own in house designer brand, Edward Mirell which has won a wide range of national and internationally recognized design awards.

Spemet Company Limited

Phone: +1-886-225-857681 www.spemet.com.tw

Spemet was established since 1987. We emphasis on various usage of Titanium. We have all kinds of raw materials and parts on stock to supply customer's need. We respect each customer's need. Besides, cooperating with leading companies to develop superior products, we are also willing to work with customer to elaborate specific products. We believe that improving technology of production and quality is the way to face the challenges of the market.

Starrag USA Inc.

Phone: +1-859-534-5201 www.starrag.com

Starrag is a leading producer of machining centers for flexible machining concepts. The Starrag Group machining centers can fully machine a work piece on five sides using their four or five highly dynamically controlled axes. For very large and heavy work pieces, the Starrag Group can offer efficient machining solutions using portal-design and gantry-type machining centers. Starrag Group's comprehensive range of technologies give customers the ability to optimize each of their machines individually to the required process. Starrag is a publicly listed company located in Rorschacherberg Switzerland. Its shares are freely traded on Swiss stock exchange in Zurich.

S-Tech Corp.

Phone: +886-6-6235143 ext. 3100 www.s-tech.com.tw maggielee@gmtc.com.tw

STC is the only one non-ferro alloy manufacture in Taiwan, was beginning from the research team of Gloria Material Technology Corporation. Our main products are non-ferrous alloys which include titanium alloys, nickel alloys, and specialty alloys which strength widely used in a variety of application in key industries such as the chemical industry, aerospace industry, oil & gas Industry, medical industry and energy industry. In-house capability includes consist of forging, rolling, heat treating, finishing and supplying forged and machined components by customers' requirement . To reach your requirements, we put tremendous efforts on quality improvement and on-time delivery by 6-Sigma and lean manufacturing management. STC is your reliable partner for high performance specialty alloys needs. Certification System ISO 9001 / ISO 13485 / ISO 17025 / AS 9100 / NORSOK / PED / Baker / Westland / Hitachi / EGAT

Strohecker Incorporated

Phone: +1-330-426-9496 www.strohecker.com

Well-established specialist in the fabrication and repair of copper crucibles, hearths and related equipment used in VAR, ESR, EBM, PAM, as well as various similar processes. Serving producers of the reactive metals and alloys, nickel alloys, refractory metals, and steel alloys.

Sumitomo Corporation Of Americas

Phone: +1-847-384-5277 www.sumitomocorp.com

Sumitomo Corporation of Americas (SCOA) is a wholly-owned subsidiary of Sumitomo Corporation, which is one of the leading trading companies in Japan. SCOA is an integrated global trading firm with diversified investments in products and services.

TE Wire & Cable

Phone: +1-201-845-9400 or 1-888-4TE-WIRE www.tewire.com sales@tewire.com

TE Wire & Cable LLC, a Marmon Wire & Cable/Berkshire Hathaway Company, is a premier thermocouple and specialty wire and cable manufacturer that was formed from the Wire and Cable Division of the Thermo Electric Corporation. Since 1941, the company has been manufacturing high-quality wire and cable solutions for the thermo-sensing and temperature measurement markets. TE Wire & Cable manufactures a full line of thermocouple wire and cablefrom iron and nickel-based alloys to copper instrument and control cable. The company maintains an in-house ISO17025 Accredited laboratory directly certified by the National Institute of Standards and Technology (NIST), allowing it to calibrate its own wire. This results in a higher quality product at a lower cost and with improved performance. TE Wire & Cable is highly regarded as the industry leader and has maintained a reputation for providing high-quality temperature measurement wire and cable products with short lead times and competitive prices. TE Wire's thermocouple wire and

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thermocouple extension cable solutions can be used for several metallurgy applications, including heat treatment, component testing, furnace surveys and metals production.

The Council for Scientific and Industrial Research (CSIR)

Phone: +27-128412600 www.csir.co.za

The Council for Scientific and Industrial Research (CSIR) is South Africa's leading national research and development organization. The Titanium Centre of Competence (TiCoC) within the CSIR has a mandate to develop technology building blocks needed to establish a new South African titanium industry. The TiCoC is developing a suite of complementary technologies to add value to South Africa's vast resources of titanium. This programme primarily focuses on the development and commercialisation of cost-effective processes for primary titanium metal production and its conversion into finished and semi-finished products. The recently established Titanium Pilot Plant situated on the CSIR campus, is an important milestone in this entire process. Parallel to this the TiCoC is developing and adapting technologies to consolidate "low-cost" titanium powders into products. Formal collaboration agreements have been signed between the CSIR and global companies such as Boeing. Airbus and EADS. These mutually beneficial agreements support South Africa's long-term economic development goals that include the supply of titanium to many industries, including aerospace.

TiFast

Phone: +39 0744 736 307 www.tifast.com info@tifast.com

Tifast is a European producer of titanium ingots, slabs, billets, bars and wires for medical, aerospace and industrial markets worldwide. Tifast is fully integrated with a melting plant (3 furnaces including a new VAR), a rolling mill, a bars precision finishing shop, laboratories and R&D facilities.

Tifast can supply titanium medical grades (TI6AL4V ELI, Gr 2, Gr 4, TI67Nb) according medical specifications ASTM F136 and ISO 5832.3 and approved by majors medical end users.

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Timesavers International B.V.

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Manufacturer of wide-belt grinding and brushing machines for stainless steel sheet and coil finishing; lasercut, punched, routered and flame cut deburring and edge radiussing; cast iron, ferrous, nonferrous and titanium high precision calibration. Timesavers is based in Goes, The Netherlands, with regional offices around the globe in Shanghai (China), Taichung (Taiwan), Kuala Lumpur (Malaysia) an Timesavers Inc, in Minneapolis (USA). Worldwide the company has more than 200 employees supported by a network of local dealers and partners.

TIMET, Titanium Metals Corporation



Phone: +1 610 968 1300 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; Waunarlwydd, 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.

TIODIZE Company, Inc.

Phone: +1-714-898-4377 www.tiodize.com

Titanium Anodize, Aluminum Anodize, Dry film Lubricants, Corrosion Coatings, Paints &Primers, Teflon Coatings, Manufacturers of Composite Parts (Carbon &Glass)

TiPro International Co. Ltd.

Phone: +86 29-89181603 www.tipro-international.com sales@tiprotitanium.com

ISO 13485; ASTM F136 F67,ISO 5823-3,ISO 5832-2; ISO 5832-11. 6AL-4V ELI Size : Dia 0.8mm -- 120.0 mm Microstruchture: Preparetion according to ETTC8. Conditioning: Anneald ,Pickling ,Grind ground.

TITANIUM Consulting & Trading S.r.l.

Phone: +39-055-642543 www.tct.it

Based in Florence with a distribution centre in Milan, affiliated company in Germany and Great Britain, is a privately owned stockiest/distributor of titanium mill products with nearly 20 years experience. We can guarantee prompt delivery of a wide range of titanium and titanium alloys mill products melted and certified in

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Medical devices/implant is one of our core businesses and we are operating in the Italian and European markets as well as service center and stockiest of a wide range of material, guaranteeing quick response to customers' requirements.

We are certified UNI EN ISO9001:2008 and UNI EN 9120:2010 and Our Company's commitment is supplying the industry with the <u>4 O's</u>: <u>qualified</u> Staff able to provide satisfactory answers to specific requirements; <u>quality</u> of material from certified origins with full traceability; <u>quantity</u> required with no minimum order and with just in time deliveries; <u>quotation</u> always competitive. We provide" the best source, service and supply of product, allied to first class technical advice and support, to ensure total satisfaction for our customers.

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Titanium Industries, Inc. (T.I.)

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Titanium Industries, Inc. (T.I.) is the global leader in performance metal solutions for the aerospace, medical, industrial and oil & gas markets. Holding the world's most complete inventory of performance metals across a global service center network. T.I. delivers supply chain solutions through its Materials Management brand at all levels of sophistication and complexity. With a globally experienced and technically driven team that now includes wholly owned subsidiary Pierce Spafford Metals, Inc. T.I. has been providing dependable, quality driven solutions to customers since 1972. www.titanium.com

Titanium International Group SRL

Phone: +39-051-6814893 www.titanium.it tig@titanium.it



We are a service provider for Aerospace, defense, automotive, medical, racing, packaging and special applications. We store and sell titanium, nickel, steel & cobalt alloys and services. We have water-jet machines and more than 30 cutting centers.We offer a wide range of product forms full size, cut to size and tailored services. We can also machine and heat treat your items. We are EN9100 & EN9120 approved. Our job is to supply standard and non- standard materials and solutions, on spot and contract businesses, integrating all your non-core activities.

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Phone: +1-888-771-9449 www.titaniumprocessingcenter.com

Titanium Processing Center is a stocked supplier and distributor of a wide range of titanium products, from bars and billets to sheets and plugs. We're focused on providing high-quality products and services on top of fast turnaround and delivery.

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"Titanium Valley" Special Economic Zone OJSC Phone: +7-343-378-45-83

ritanium-valley.com welcome@titanium-valley.com

Titanium valley is the special economic zone (SEZ), based in Russia, Sverdlovsk region, where unique conditions for production organization and development are created. The territory of the SEZ is located close to the OJSC "VSMPO-Avisma" Corporation", the world's largest titanium producer, supplier of raw materials, forgings and finished production for Boeing, Airbus, Rolls Royce, Goodrich, Embraer, GE. Thus, the territory is known after the name "Titanium Valley". The companies investing in the SEZ get prepared sites with all the necessary utilities. Moreover, they are exempted from customs duty on import of capital goods, VAT as well as from the corporate profit for the first 10 years. The total area of the territory of a special economic zone "Titanium Valley" is more than 580 hectares. The main object of the SEZ is investors' attracting whose purpose is manufacturing of value-added and high technology products.

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TMS Titanium

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TMS Titanium is a leading supplier and stocking distributor of titanium mill products to a variety of industries including, aerospace, medical, racing and commercial. By combining product and industry knowledge, commitment to specialty industries, access to titanium and reliable inventory, TMS is able to consistently provide titanium to its customers in order to keep their production moving forward. TMS works with their trusted network of suppliers, finishers and fabrications to fulfill their customers' specific titanium needs, while producing the best quality products available.

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Phone: +81 467 87 7023 www.toho-titanium.co.jp

Toho Titanium Company, Ltd. manufactures titanium metals such as premium quality titanium sponge for aerospace and other applications, titanium ingot (CP and Alloy), high purity titanium ingot/ billet for semiconductor industry and electronic materials including high purity titanium dioxide and ultra-fine nickel powder etc.

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Torresin Titanio s.r.l is a leading Stockist and Service Center of Titanium and Nickel Alloys semi-finished mill products. We stock plates, sheets, wire, bars, coils, tubes, pipe and fittings. All material is according to ASTM, ASME and NORSOK standards. Our Service Center is equipped with 4 water jet cutting machines, saw cutting, guillotine and slitters. ISO 9001:2008 certified company.

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Phone: +1-618-877-0585 www.tmrusa.com

Totall Metal Recycling is an ISO 9001:2000, ISO 14001:2004,OHSAS 18001 & R2 (E-Scrap) certified scrap metal processing facility located just east of St. Louis, Missouri in Granite City, Illinois. Totall Metal Recycling specializes in the processing and recycling of various types of scrap materials including nonferrous metals, ferrous metals, hitemp alloys, titanium, precious metals scrap, and turnings &residues of all types of metals as well.

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Tricor Metals for Corrosion applications and Tricor Alloys for Aerospace & Medical applications



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Tricor Alloys California Div. (www.tricoralloys.com) : supplies welding wires; titanium, nickel, cobalt, aluminum, stainless steel and magnesium to AMS/AWS/OMAT specifications, DFARS-compliant materials, and other customer-specific specifications. Tricor UltraGrade[™] wire cleaning and packaging options. Aerospace grade titanium mill products including; plate, sheet, strip, bar and billet.

ASME code shops in Ohio and Texas we build custom process equipment; tanks, towers, pressure vessels, pipe spools, shell & tube heat exchangers, plate and frame heat exchangers, and custom welded parts. We specialize in corrosion resistant applications fabricating with; titanium, tantalum, zirconium, niobium, nickel alloys, duplex stainless and stainless steel. Field weld repairs crews mobilized globally.

Tzimet Titanium & Alloys s.r.l.

Phone: +39-0382-914401 www.tzimet.it oreglia@titanium.tzimet.it

Tzimet Titanium & Alloys srl, is an Italian private Company specialized in the PROCESSING & PREPARATION of reactive and refractory metal scraps: Titanium and its Alloys, Zirconium, Niobium and Tantalum. These scraps, of different alloys, are dedicated after preparation, to be remelt in vacuum process from our customer:

Titanium CP Gr. 1-2-3-4, 6 Al-4 V, 6 Al-4 V eli, Ti Pd (Gr. 7-11-16-17), Ti Gr. 12, IMI 367 (Ti 6 Al 7 Nb), Ti 15-3-3-3, Zirconium, Niobium, Tantalum

Tzimet Titanium & Alloys buy and sell these scraps: Titanium and Titanium Alloys, Zirconium, Niobium, Tantalum. Tzimet Titanium & Alloys has acquired in August 2014 the Certification ISO 9001:2008

Tzimet Titanium & Alloys srl is supplier of scrap for domestic market normally Ti CP and foreign market (USA, Germany, Russia, England), the material supplied is used for production of ingots Ti and its alloys and Fe-Ti for: Petro-chemical application (Ti CP, Ti Gr.12, Grade 7-11-16-17), Surgical application (Ti 6AI 4 Veli, IMI 367), Fe-Ti (steelfactory)

TZMI, Inc.

Phone: +1 281 956 2500 www.tzmi.com houston@tzmi.com

TZMI is an independent consulting company that works with a wide range of global clients to provide insight and expert advice on opaque mineral, metal and chemical sectors. Our uniqueness is that TZMI contains technical and operational experience, together with strategic and commercial competency, to provide a full service offering to our clients.

As trusted advisors, our reputation is underpinned by having an experienced cross-section of technical specialists around the globe. TZMI partners with clients from the private and public sectors to provide bespoke solutions across markets and strategic services; and also technical and engineering services. Our clients range from the world's 500 largest companies through to mid-sized companies and small businesses.

TZMI regularly releases market reports and periodicals on relevant subject matters which support the consulting activities and ensure up-to-date, high quality and comprehensive data, analysis and information is provided. TZMI annually hosts the largest titanium and zircon industry conference. Email: Houston@tzmi.com

Ulbrich Stainless Steels & Special Metals, Inc.





Phone: +1-203-239-4481 www.ulbrich.com information@ulbrich.com

Ulbrich Stainless Steels & Special Metals, Inc., is a leading processor of a variety of different alloys including, but not limited to: stainless steels, PH grades, nickel and nickel alloys, cobalt alloys, niobium, zirconium, titanium and titanium alloys. Commercially Pure Titanium: Grade 1, Grade 2, Grade 3, Grade 4, and Titanium Alloys: Grade 9 (Ti 3-2.5), Ti 15.3.3.3 and 21s (Ti Beta21s), as well as the aforementioned metals are available in strip, foil, flat, round and shaped wire. Nitinol, Grade 5 (Ti 6-4) and Ti 6.2.4.2. are available in limited widths at Ulbrich. Please inquire for more detail on all of our product offerings.

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Phone: +1-323-235-2156 www.uametals.com

United Alloys & Metals is one of the world's leading processors of all grades and forms of Titanium Scrap for all Titanium applications. Both our Los Angeles and Columbus, OH plants have full processing capabilities and are certified to ISO 9001:2000 standards.

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Phone: +1-412-424-0440 www.uniti-titanium.com

Uniti Titanium brings together two major global titanium producers with complimentary manufacturing and technical capabilities, Allegheny Technologies Incorporated (ATI) of the United States, and VSMPO-Avisma from Russia, to create a joint venture focused on titanium mill products for industrial and other non-aerospace,

non-military and non-medical markets. Uniti Titanium integrates the synergistic use of raw material, melting, hot rolling, finishing, research and technology resources of the two companies.

Universal Technical Resource Services, Inc.

Phone: +1-856-667-6770 www.utrs.com

Engineering services company, primarily focused on delivering services to the US Government. UTRS maintains a research and development facility working with material science projects, specifically with titanium and titanium alloys.

University of Northern Iowa

Phone: +1-319-273-7085 www.mcc.uni.edu

UNI's metal Casting Center, established in 1989, has achieved unique stature as the premiere not-for-profit US research and development facility specializing in manufacturing technologies and materials for the metal casting industry. The MCC testing laboratory and pilot-plant demonstration facility are the most advanced of their kind. The center's primary mission is to assist the foundry industry by developing technical solutions to keep this primary industry competitive in a global economy.

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VSMPO-AVISMA, the world's largest producer of titanium, holds more than 300 international quality certifications and approvals at major aerospace OEMs and medical device companies. VSMPO-Tirus operations in the US, the UK, Germany and China provide regional sales, distribution and service center processing.

VSMPO - Tirus China Ltd. XVSMPO TIRUS Phone: +86 10 8455 4688



VSMPO-Tirus China ltd. is the Chinese sales and distribution division of VSMPO-AVISMA, the world's largest producer of titanium, holding more than 300 international quality certifications. VSMPO-Tirus China distributes ingot, slab, sheet, plate, bar and billet to the aerospace, medical, and consumer products industries.

VSMPO - Tirus, US

Phone: +1-720-746-1023 www.vsmpo-tirus.com



VSMPO-Tirus, US is the North American sales and distribution division of VSMPO-AVISMA, the world's largest producer of titanium, holding more than 300 international quality certifications. VSMPO-Tirus US distributes ingot, forgings, slab, sheet, plate, bar, and billet to the aerospace, medical, and consumer products industries. VSMPO-Tirus US also manufactures small diameter bar and coil for medical and aerospace fastener applications.

VSMPO TiRus GmbH

Phone: +0049 69 905477-25 www.vsmpo.de



VSMPO TiRus GmbH is responsible for the sales and distribution of titanium semi-finished products in Europe (except the UK), Brazil and Israel to the aerospace, medical and automotive industries. The company was established in 1999 in Frankfurt/Main. The German affiliate of the largest vertically integrated international titanium producer VSMPO-AVISMA offers optimum service, including custom-made processing of semi-finished products as well as a comprehensive transport service. We offer cut-to-size material (bars, billets, sheets and plates) to meet our customers' individual operational needs. TiRus GmbH also distributes electrodes, ingots, rolled rings and different types of forgings.

VSMPO Tirus UK Ltd. Phone: +(0) 1527 514111



VSMPO Tirus UK Ltd. is the UK's sales and distribution division of VSMPO-AVISMA, the world's largest producer of titanium, holding more than 300 international quality certifications. Tirus UK distributes ingot, forgings, sheet, plate, bar, and billet to the aerospace, medical, and consumer products industries.

VSMPO Titan Ukraine Ltd.

Phone: +380 562 313092 www.tw-vsmpoavisma.com



VSMPO Titan Ukraine Ltd. is fabricator of seamless tubular products from titanium and its alloys. It is a part of the world's largest producer of semi-products and finished titanium products - JSC Corporation VSMPO-AVISMA (Russia) which supplies billets and bars to the plant. It is guarantee of quality competitiveness of manufactured production for the customers. Annual production capabilities of the enterprise is 700 tons of cold-finished titanium tubes (diameter 3-134 mm and wall thickness 0,2-9 mm), and in cooperation additionally 200 tons of hot-finished titanium tubes (outside diameter 169-325 mm and wall thickness 7-30 mm). Engineers and technical specialists are developing new technologies of titanium tubes production and new types of products. For example, octahedral and ribbed tubes, special kind of thin tubes for silphons, technologies of longlength tubes production, etc. VSMPO Titan Ukraine Ltd. has all equipment necessary for different tests and QA inspections. It allows manufacturing not only according to the international and national standards, but meeting any customer's requirements.

Vulcanium Metals International

Phone: +1-888-326-7556 www.vulcanium.com titanium@vulcanium.com



Vulcanium Metals International, a leading distributor and processor of titanium and high performance alloys, serves global aerospace, medical device and industrial markets. VMI's fully operational facilities in the US and UK carry a complete line of inventories in titanium sheet, coil, plate, bar and forged block products of CP, Ti-6AL-4V and Ti-6AL-4V Eli grades as well as CCM and 316L stainless round bar. FIRSTCUT+® services offer a comprehensive suite of first-stage processing including precision shearing and sawing, machining, chamfering and facing, deburring and finishing, leveling, slitting, and laser and water jet cutting. VMI also offers inventory management solutions to save its customers supply chain costs and reduce manufacturing bottle-necks. Vulcanium is a specialty division of United Performance Metals, one of more than a dozen companies comprising O'Neal Industries, Inc. (onealind.com), parent company of the USA's largest, family-owned group of metal service centers. AS9100 & ISO 9001 LEAN Quality Management

Webco Industries

Phone: +1-918-245-2211 www.webcotube.com heat_exchanger@webcotube.com

Webco delivers North America's widest range of tubular products, rapidly fulfilling urgent orders and helping customers avoid costly unscheduled shutdowns and production delays. Customers in the aerospace, automotive, chemical processing, industrial, oil & gas, power generation and other industries, rely on Webco's strength, agility, and innovation to deliver solutions for their most challenging requirements. In fact, Webco manufactures and distributes millions of feet quality tubing made to meet today's most demanding specifications.

Our welded and seamless titanium tube products are available in variety of grades and sizes, standard/off-the-shelf or tailored to meet customers' unique requirements.

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Weber Metals, Inc. specializes in Aluminum and Titanium open and closed die forgings for the Commercial and Military Airframe, Air and Land Turbine, Nuclear and Semiconductor industries. Our press sizes range in size from 1200 to 33,000 tons. We have capabilities to perform heat treatment, non-destructive and destructive testing in house. Our forgings range in size from 1 pound to 11,000 pounds. Our aluminum stress relieved forgings are some of the most stable products in the industry for machining.

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WPI s.r.l. is a leading manufacturer of welded pipes OD 6" to 82" and wall thickness up to 60mm, pipe spools and vessels in special materials like Titanium, Nickel Alloys, Duplex, Superduplex, SM0254 and 904L. NORSOK approved manufacturer.

Wellmet International Inc

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We supply and distribute Titanium Sponge and Titanium Powder. We represent the largest Titanium sponge and powder producers in China. We can also supply other non-ferrous metals which are of Chinese origin with approved quality. The Titanium Sponge producer is ISO9001:2008 certified and sponge quality is approved by world main consumers.

West Penn Testing Group

Phone: +1-724-334-1900 www.westpenntesting.com

West Penn Testing Group is a full-service, independent testing

laboratory with diverse inspection and testing capabilities since 1952. They provide an extensive array of non-destructive, chemical, metallographic, failure analysis and mechanical evaluation services, serving customers in these industries: aerospace, medical, power generation, commercial, military, raw materials, refractories, oil and gas, and the automotive industry. They have three locations in New Kensington, Pennsylvania and Richburg, South Carolina and perform testing nationally and internationally. Their 79,000 sq. ft. facilities accommodate parts up to 20,000 lbs. www.westpenntesting.com

Western Smelting & Metals, Inc.

Phone: +1-503-623-8341

Western Superconducting Technologies Co. Ltd.

Phone: +86-29-8651-4505 www.c-wst.com than@c-wst.com

Western Superconducting Technologies Co., Ltd. (WST), located in Xi'an, the capital city of Shaanxi Province, China, is a leading corporation for the production, R&D, and marketing of titanium ingot, billet, bar, wire, slab, plate, etc. Especially from the ingot to bar and wire, WST has the most advanced and integrated production line and quality assurance system in the world. The production capacity for bars is 4000 tons per year, and 6000 tons for ingots. WST is an ISO 9001:2008, AS 9100C and Nadcap approved company and the products are widely used in the aerospace, medical, offshore, sporting, car and petroleum chemical market.

Westmoreland Mechanical Testing & Research Inc.

Phone: +1-724-537-3131 www.wmtr.com us.sales@wmtr.com

us.sales@wmtr.com Westmoreland Mechanical Testing & Research is a world leader in materials testing. Founded in 1967, WMT&R serves a broad range of industries including aerospace, automotive, medical, and nuclear. We support our customers with our highly-skilled staff and advanced facilities. Our turnaround time is unrivaled, and with over 150,000 square feet of accredited production and testing space, we have the capacity and equipment to handle any materials testing project. WMT&R is organized into the following specialized testing groups: Mechanical, Composites, Fatigue, Stress Rupture and Creep, Fracture Mechanics, Metallography, Chemical/Analytical Laboratory, and Mechanical Engineering. For more information, please visit www.

VMT&R

Xi'an Metals & Minerals Import & Export Co., Ltd. Phone: +0086-29-88210716

wmtr.com or email us.sales@wmtr.com.

www.tiwmo.com

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 Titanium industry. We supply Titanium and its alloys in various forms as per ASTM, AMS and other main internationally recognized specifications. Our advantage is the most competitive

prices as well as guaranteed high quality! Our products are exported worldwide, and gained high reputation because of their excellent performance.

Yunnan Titanium Industry Co., Ltd.

Phone: +86 13888217035 www.ytico.com.cn

Yunnan Titanium Industry Co., Ltd (Yunti) is specialized in the production and processing of titanium strip and coil and dedicated to technology research of titanium industry in China, which has manufactured ability from titanium slab to cold rolled titanium strip and coil with minimum thickness of 0.5 mm, Yunti has rich technical resources and innovation ability, Yunti has established the standard quality management system, Occupational Health and Safety & Environment management and systems based upon international standards. Yunti has a production capacity of 5,000 tons titanium coils per year.

Its products range from 800 ~ 1400 mm in width, 0.5 ~ 10 mm in thickness, 2000kg - 8000kg in weight, the quality and performance of titanium strip is stable. The surface is of good consistency, and mainly used for the manufacturing of titanium welded pipe, anodizing plate, plate heat exchanger etc.

Zak, Incorporated

Phone: +1-518-273-3912 www.zakinc.com



Zak Incorporated is a fully integrated design, fabrication, machine, and test facility. We engineer, manufacture, and refurbish crucibles, liners, molds, and accessories for the remelting and production of specialty metals. Our manufacturing and consulting experience has contributed significantly to the VAR, ESR, Plasma, EB, C.C., and EBPVD processing industries. This experience, along with our precision CNC machining capabilities, will extend your product life cycles and improve the reliability of your process. Our ISO 9001-2008 certified services include a full range of dual pallet, multiaxis CNC machining centers with live tooling; MIG, TIG, and stick welding of copper and other dissimilar metals; hydro, helium, X-ray and other available NDT services. For more information about Zak Incorporated, please visit us at www.zakinc.com

ZIROM S.A.

+40 246 216666 www.zirom.ro



Zirom SA is an European manufacturer, founded in 1991. ZIROM offers high quality level titanium and titanium alloys ingots by VAR and EB melting and forged products using Free forging process, for application in the aircraft, automotive, petrochemical, medical and other industries. Our company is certified according to international standards: AS 9100 / EN 9100, ISO 9001, ISO 14001.

Zirom SA can also provide a series of services like melting the secondary materials – scrap, machining/grinding the surface of products, cutting top/bottom of products, chamfering the edges, full chemical analyses, LP, US+ Eddy testing.

ZTMC Zaporozhye Titanium & Magnesium Combine Phone: + 38 067 466 5791

www.ztmc.zp.ua

Zaporozhye Titanium-Magnesium Combine (ZTMC) located in Zaporozhye city industrial zone, Ukraine, is one of the first in the work and unique in Europe titanium sponge manufacturer. It works since 1956. During this period production facilities were modernized and rebuilt more than once, which allowed to modernize technological processes and to increase titanium sponge production volume. ZTMC as a reknowned sponge manufacturer has been investing in the new technologies to increase both its capacity and allow us to supply high quality sponge to various customers around the globe. The wide range of ZTMC products are represented by titanium sponge, titanium ingots, titanium casting, refined titanium tetrachloride, ferrotitanium, titanium slag, casting. The quality of ZTMC products is guaranteed by a certified quality management system in accordance with the requirements of the International Standard ISO 9001:2008. Currently works underway to create and implement the requirements of the management system for Aviation standard EN 9100.



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BANNER MEDICAL is an ISO 13485 certified supplier providing custom tailored and single source supply chain solutions for raw material and value added services required by the medical industry. Banner provides medical grade raw materials, machining, and value added services to the following market segments within the orthopedic and dental industries: Orthopedic Market Segments: Hips, Knees, Extremities, Fracture Repair, Arthroscopy/Soft Tissue Repair, Spinal Implants, Instruments for all orthopedic segments Dental Market Segments: Implant, Instruments. Banner Medical offers the following services to our customers: Centerless Grinding, Turning, Straightening, Chamfering, Cut-to-Size, Plating/Surface Treatments, Nondestructive Testing, Heat Treating, Line Marking, Small run and production run machining, Near Net/Fully Machined Components, Passivation, **On-Site Materials Management**, 510K Support/FDA Compliance, Rapid Prototyping, Complete Material Traceability Contact our office to see how we can help your next endeavor 800-323-9732.

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SC ZIROM produces a diverse range of titanium and titanium alloys, including ingots, and from this year, free forging products. The Company practices a modern production technology (VAR and EB) according to different quality international standards. Technical and qualitative parameters of products meet the most stringent quality requirements and can be used in different applications.

SUPPLY OF PEELING AND OTHER COLD FINISHING EQUIPMENT FOR TITANIUM PROCESSING.

Danieli Centro Maskin, the cold finishing division of the multinational DANIELI group, design and manufacture a wide range of equipment that cover the processes of peeling, drawing, cut to length, straightening, chamfering, packaging and all associated equipment. Enquiries for individual machines and/ or complete cold finishing plants are welcome. For USA enquiries contact Danieli Corporation USA (Bob Smith Tel: (724) 778 5448; r.smith@danielicorp. com). For all other enquiries contact Danieli headquarters in Italy (Kristiaan van Teutem, Tel: +39 04321957295; k.vanteutem@danieli.it)

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Following courses are eligible: Manufacturing, Mechanical, Aerospace, Industrial, Design, Electrical, Mining, Material Science, Quality Assurance.

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ADMINISTRATIVE MANAGER *Plymouth Engineered Shapes Hopkinsville, Kentucky USA*

Hopkinsville began operating in 1980 & produces near net shapes by extrusion in titanium, stainless, carbon and alloy steels in a 130,000 square foot plant. Responsibilities include: Plans, directs and controls the administration groups of the organization. This position oversees such functions as Accounting, Information Systems, Purchasing, and Shipping activities of the company. The objective of this role is to manage the administrative functions as they support the operational units within the company and satisfy the external requirements related to the Legal and Governmental mandates. For detailed information visit: http://www.plymouth.com/employment/

ADVANCED/ADDITIVE MANUFACTURING ENGINEER RTI Niles Plant Niles, Ohio USA

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The primary function of the Advanced/ Additive Manufacturing Engineer is to lead development and continuous improvement activities within our 3D printing and Advanced Powered Metals groups. The position will work to partner with customers to provide cost effective solutions on their next generation platforms. Responsible for optimization of Additive Manufacturing processes focused on Advanced Powder Technology and 3D printing, delivering cost reductions & design improvements. Establish collaboration with universities, consortia, and government to drive RTI priorities and leverage R&D investment. Develop and maintain a database for mechanical properties and capabilities delivered via additive processes. Implement and support company wide value added initiatives and programs. Provide insight in the improvement of the complete value stream associated with the development and production of our products. Drive improved product quality by identifying manufacturing issues, developing advanced manufacturing cost-effective solutions, and overseeing

successful implementation of Additive Manufacturing into production. Supports the creation of new business opportunities through developing advancements in additive manufacturing and building relationships with clients in the industry. For detailed information visit: www.rtiintl.com

AEROSPACE ENGINEER HIGH TEMPERATURE ALLOY SPECIALIST Research & Development / Technology Business Unit Group, Alcoa Technical Center, PA USA

The position is responsible for participating in, defining and executing alloy and process development projects targeted for high-performance high temperature alloys and to create growth opportunities for Alcoa through the introduction of new products. The individual will be an on-site technical leader for high temperature alloys and will interface with plant engineers, application engineers, technology managers and commercial managers across Alcoa, including Alcoa Technical Center, Alcoa Power & Propulsion, Alcoa Forgings and Extrusions, Alcoa Fastening Systems, and other businesses within Alcoa's EPS Business group. This position requires a fundamental understanding of Ti, Ni, Co or Mo alloys, including fundamental and applied metallurgical knowledge, experience in alloy design, knowledge of structureprocessing-property relationships in high temperature alloys, thermal process development, working knowledge of various manufacturing technologies for cast and wrought products, and experience in material selection for new product design. For detailed information visit: www.alcoa.com

ASSOCIATE TECHNICAL SALES REP -BAHCO® BAND SAW SPECIALIST Snap-on Industrial Los Angeles, California USA

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This outside sales position will assist in working with industrial distributors, manufacturing reps and agencies and/ or direct sales to identify and evaluate production end users and stimulate additional product demand with current accounts and develop new customer accounts. This position will create band saw performance tests at customer sites, record and document and assist the lead sales person in presentations to customers. Working with company support to help "close the sale", and grow the territory are key objectives. The assigned territory will cover the California, Arizona and Nevada saw industry markets with an emphasis on the greater Los Angeles area. Overnight travel of about 50% required. As the band saw industry changes, the territory assigned may be modified to meet growing demand. Must be mechanically inclined and capable of operating and adjusting machines. For detailed information

visit: https://ch.tbe.taleo.net/ CH01/ats/careers/requisition. jsp?org=SNAPON&cws=1&rid=3483

ENVIRONMENTAL ENGINEER -WATER SYSTEMS - (PCC-US 178526) *TIMET, Titanium Metals Corporation*

Henderson, Nevada USA

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TIMET offers a full range of titanium products, including ingot and slab, forging billet and mill forms. TIMET is vertically integrated, capable of making its own titanium sponge Provide leadership and technical support to address water systems throughout the facility including; Water Conservation Facility, storm water, sanitary sewer, groundwater, potable and non-potable water and evaporation ponds. Assist with the development and corporate-wide integration of sustainability initiatives related to water and the environment. Manage and coordinate sustainability efforts to reduce TIMET's environmental impacts. Establish, maintain and report progress on sustainability metrics. Drive improvements within the company and communicate efforts and results to stakeholders. For detailed information visit: www.timet.com

GENERAL FOREMAN - ROTATING SHIFTS

Dynamet, a subsidiary of Carpenter Technology Corporation Washington, Pennsylvania USA

Main Responsibilities Include: Leads and directs the activities of production personnel engages in all facets of the manufacturing function with no authority for personnel actions. Oversees all phases of the department's operation (three shift rotation) to ensure materials are produced to meet customer specifications and established company standards. Expedites the operations of the department in order to meet production schedules. Ensures all operators have the necessary supplies and PPE to complete jobs. Updates load sheets in Foreman's log and completes necessary production sheets for shift. Ensures safety compliance and other policies and reports violations to Coordinator, HR or GM. Presents counseling necessary under the direction of Foreman - Coordinator, HR or GM. Completes Report Off Reports. Conducts safety meetings and ensures safety inspections are completed including logs on respective shift as required. Oversees and expedites incoming and outgoing shipments. Perform all other duties and special projects as assigned. For detailed information visit: www.cartech.com/ dvnamet

INTERNATIONAL CUSTOMER SERVICE ASSOCIATES Ft. Wayne Metals

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We are looking for an International Customer Service Representative to assist our customers. Must be fluent in Mandarin, as well as English. Main Responsibility: Perform sales and customer service functions for new and existing accounts for assigned international geographic zones. For detailed information visit: http://www. fwmetals.com/people/join-our-team/

MAINTENANCE PLANNER ATI Flat Rolled Products (ALC) Brackenridge, Pennsylvania USA

ATI Flat Rolled Products produces and markets a wide range of specialty metals, including stainless steel, nickel alloys, and titanium to end use markets such as aerospace, power generation, automotive, and housing. We deliver exceptional products and services to customers around the world. We are currently seeking a Maintenance Planner for the Hot Rolling Processing Facility in Brackenridge, PA. Responsibilities include: Plan, organize and schedule all necessary resources required to accomplish maintenance activities. Prepare and issue the maintenance activity work schedule. Prepare and coordinate contractor activities and work schedule. Prepare detailed critical path plans including equipment and materials for major jobs such as planned shutdowns. Ensure that equipment and material are available when required. Assist storeroom in parts procurement, repair and identification. Issue and follow up on preventative/predictive maintenance inspections and procedures. Ensure that necessary work history and documentation are organized and inputted. Attend daily meetings with operations and maintenance representatives. Prepare summary and exception reports. Prepare long-term plans and schedules for review and approval by management. For detailed information visit: www.atimetals.com

MECHANICAL ENGINEER ATI

Latrobe, Pennsylvania USA

ATI Flat Rolled Products, an operating company of Allegheny Technologies (NYSE: ATI), manufactures and markets a wide range of flat rolled specialty metals, including stainless steel, nickel alloys, titanium and electrical steels to global end use markets such as aerospace, power generation, automotive and housing. Our goal is to safely deliver exceptional value to our customers, suppliers, employees and shareholders.

We are seeking a Mechanical Engineer for melt shop in Latrobe, PA. For detailed information visit: www.atimetals.com **Operations Planning Analyst** Dynamet, a subsidiary of Carpenter Technology Corporation Washington, Pennsylvania USA Responsible for application of material. Also interface between Sales, PA Manufacturing, Technical and Development, Quality and Raw Material Purchasing and has a detailed understanding of customer's requirements and specifications. Responsible for application of material. Also interface between Sales, PA Manufacturing, Technical and Development, Quality and Raw Material Purchasing and has a detailed understanding of customer's requirements and specifications. Track raw material at the various stages of the process. Work with the various manufacturing groups to understand breakdowns, personnel issues, constraints or other issues that can impact throughput and delivery. Adjust scheduling plan and/or provide visibility to upper management when these events can affect customer deliveries. Quote deliveries for products based upon available production capacities and inventory with the goal of on time delivery to customer. Research, facilitate discussions, recommend and respond to questions from customers (via Sales) regarding capacity and delivery. Lead weekly production meeting. Review load and schedules looking for conflicts or abnormalities and providing possible solutions when necessary. Create material work orders and planning intermediate material for supply. Participate in various MRP focus/improvement projects. Review and disposition fallout and slow moving inventory. Hot Roll Planning for intermediate material requirements. Work with Technical Development, Manufacturing and Sales team members on developmental process improvements, new product development and capacity increases. Part number, router and work order creation and maintenance. Perform all other duties and special projects as

assigned. For detailed information visit: www.cartech.com/dynamet

PLANT MANAGER Caledonian Alloys

Huntington, West Virginia USA

Responsible for managing, planning, directing, organizing, and developing strategic manufacturing capabilities and executing a strategic plan for manufacturing excellence. Main Duties & Responsibilities include: Oversees all manufacturing operations, gives direction, resolves problems, sets deadlines to assure that all company manufacturing objectives are met. Supervises, directs, evaluates the job performance of all direct reports within the manufacturing organization. Monitors production schedules and production process to assure customer delivery dates are met. Identifies, analyzes, and plans for plant capital needs and completes capital requests in accordance with corporate requirements. Assists in developing and implementing manufacturing labor policies. Directs the workforce to meet company labor objectives. Assures company compliance with all established company and corporate policies, procedures, and governmental regulations pertaining to plant safety or environmental issues. Reviews financial and budgetary reports, cost data, to assure plant operations meet company profitability and financial objectives. Makes presentations, conducts meetings, and communicates with all levels of the corporation pertaining to manufacturing related activities. Perform other duties as assigned. For detailed information visit www.precast.com.

R&D BUILDING ADMINISTRATOR Cristal Metals

Lincolnshire-Stallingborough-Laporte Road United Kingdom

An exciting opportunity has arisen for a well organized individual to join Cristal's Stallingborough site as our Research & Development building administrator. In this role the R&D building administrator is responsible for supervising contractors working in the R&D building, providing guidance and expertise to explain the utilities and history of the buildings, construction work and maintenance while maintaining a safe working environment; developing and tracking the performance of projects in the building including budgets and ensuring that the projects are completed on time, within cost, and that resources are effectively utilized; working with the Product R&D team and with other functional groups to advance Product R&D goals and objectives. Coordinating R&D activities in support of Technical Services, Sales, & Marketing, and product-related manufacturing. Work with the "Technology Leader -Analytical", other R&D laboratories, and Manufacturing to ensure that best practices are consistently employed in our Analytical methods. Overseeing routine safety audits in the building and monitoring and tracking safety objectives for the building. For detailed information visit: www.cristalmetals.com

SALES DIRECTOR – PCC REVERT GROUP

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Precision Castparts Charlotte, North Carolina USA

The Revert Group is comprised of 3 businesses; Caledonian Alloys, SOS Metals and Greenville Metals Inc. specializing in recycling nickel, cobalt and titanium super alloys. They deliver revert management solutions for leading aerospace, gas turbine & oil patch industry manufacturers and their supplychains. Revert has a global network of 34 facilities. Locations include the following: Charlotte, NC, Monroe, NC, Transfer, PA (Greenville Metals Inc.), Huntington, WV, Gardena, CA, and Livingston, Scotland, Portland, OR, Hereford, England and Wichita, KS to name a few. This candidate will be reporting directly to the General Manager of the PCC Revert Group, the Sales Director will be responsible for managing, planning, directing, organizing, and implementing a global strategy for continued company

growth through the securing of long term agreements (LTA's) and Key Accounts with customers of strategic importance, and/ or high revert potential. The Sales Director will collaborate across worldwide locations and functions to develop organization sales structure, sales forecasting tools and resource allocation to optimize business performance. He/ She will provide leadership to sales staff; develop, recruit, direct and mentor. For detailed information visit: www.precast.com.

TECHNICAL SALES REPRESENTATIVE - BAHCO® BAND SAW SPECIALIST

Snap-on Industrial Los Angeles, California USA

This outside sales position will work with industrial distributors, manufacturing reps and agencies and/or direct sales to identify and evaluate production end users and stimulate additional product demand with current accounts and develop new customer accounts. Working with company support to help "close the sale", and grow the territory are key objectives. The assigned territory will cover the California saw industry markets with an emphasis on the greater Los Angeles area. As the band saw industry changes, the territory assigned may be modified to meet growing demand. BA Degree in business, marketing or equivalent sales experience required as well as prior technical training in metals, metallurgy, cutting tools. Must have a minimum of 3-5 years outside sales experience in an Industrial environment and with distributors and/or agency reps. For detailed information visit: https://ch.tbe. taleo.net/CH01/ats/careers/requisition. jsp?org=SNAPON&cws=1&rid=3484

WELDER / FABRICATOR *Retech Systems LLC*

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