HYPERION METALS

ASX RELEASE | ASX: HYM

10 June 2021

HYPERION EXPANDS PORTFOLIO OF TITANIUM METAL TECHNOLOGY

- Hyperion has secured the exclusive rights to the patented Granulation-Sintering-Deoxygenation ("GSD") technology developed by Dr. Z. Zak Fang for producing **zero carbon, low-cost spherical titanium powders**.
- GSD offers major advantages in the production of spherical titanium for use in 3D printing, including;
  - Production of titanium and titanium alloy powders with low oxygen, controllable particle size and excellent flowability
  - Higher manufacturing yields than current processes, leading to significantly lower costs
  - Energy efficient process leading to a zero carbon process when coupled with renewable power
  - Ability to utilize lower cost and sustainable feedstocks including recycled titanium metal powders/scrap or HAMR titanium powders
- The combination of producing titanium metal via the HAMR process followed by the production of titanium spherical powders via the GSD process has the potential to **substantially reduce the total cost of titanium powders for 3D printing**, opening up many potential new markets.
- The combination of these technologies has the potential to disrupt not just the high value titanium metals and powders market, but also the far larger aluminum and stainless-steel markets.
- Dr. Fang is a Professor of Metallurgy at the University of Utah. The HAMR and GSD technologies were developed, in part, with the financial support provided by the Advanced Research Project Agency-Energy (ARPA-E) of the US Department of Energy from 2014-2019:
  - Dr. Fang is a leader in global advanced materials and manufacturing technologies for energy production, storage, and efficiency applications and is the sole or co-inventor on more than 50 U.S. patents
  - ARPA-E has provided over US$2.6 billion in R&D funding for more than 1,000 potentially transformational energy technology projects
  - **ARPA-E analyzes and catalogues some of the Agency's most successful projects through its "Impact Sheets,"** which explore a range of individual projects and their achievements
  - The Impact Sheet for the HAMR and GSD technologies is available here: **https://arpa-e.energy.gov/impact-sheet/university-utah-metals** (Appendix II)
  - Further development and optimization of titanium products from the HAMR and GSD technologies has occurred subsequent to the ARPA-E funded activities
- The Company is making significant progress with Dr. Fang and his team in Utah on both the HAMR and GSD technologies and expects to make key updates, including:
  - HAMR powder production using the company's titanium minerals from the Titan project
  - Commencement of GSD powder production from HAMR titanium powders and/or titanium recycled scrap
  - Techno-economic assessment for the scale up of production of titanium metal and powders

Hyperion Metals Limited (ASX: HYM) ("Hyperion" or "the Company") is pleased to announce that it has entered into an agreement with Blacksand Technology, LLC ("Blacksand") to investigate the commercial development of spherical titanium metal powders using the GSD technology and an option to enter into an exclusive license agreement for the patents associated with the technology ("the Agreements").

This follows from the previous agreement with Blacksand for the HAMR technology (refer ASX announcement dated 15 February 2021) which when combined with GSD and Hyperion's Titan Project, has the potential to provide a sustainable, zero carbon, low-cost and fully integrated titanium spherical metal powder supply chain in the USA.

Commenting on the agreement, Mr. Anastasios Arima, CEO and MD of Hyperion Metals, said:

Titanium metal is the superior metal for a wide range of advanced applications, from aerospace to defense, and it should also be the logical choice for industrial and civilian applications. Titanium's widespread adoption has been held back in sectors such as consumer goods and electric vehicles due to its high cost.

The combination of the patented HAMR and GSD technologies together with advances in 3D printing offers a pathway to dramatically reduce the cost and carbon emissions of titanium metal components. Furthermore, recent studies by the Fraunhofer Institute have shown that the fabrication of titanium parts using laser powder-bed additive (a 3D printing technique), emits approximately 70% less CO_2 than equivalent production by traditional milling processes.

Hyperion's vision is to utilize these sustainable technologies and accelerate the rapid penetration of titanium in current and widespread applications in next generation mobility. The light weighting of trucks, trains, drones and electric vehicles will lead to a quantum leap in the energy efficiency of these vehicles and will be large, high growth new markets for titanium.

We aim to scale and commercialize these breakthrough technologies, make the US the global leader in titanium production and deliver technological leadership for in titanium applications for aerospace, space and defense."

Commenting on the agreement, Dr. Z. Zak Fang said:

We look forward to commercializing the HAMR and GSD technologies with Hyperion Metals. These technologies have produced titanium metal and powders that consistently met the purity requirements defined by industry standards and they have the potential to significantly lower the costs and carbon emissions of producing titanium metal and powders.

These technologies have the capacity to drastically alter the titanium, stainless steel and aluminum markets and increase the range of applications for high performance, lightweight and low-cost titanium parts."

This announcement has been authorized for release by the CEO and Managing Director.

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Titanium powders for 3D printing / additive manufacturing

Titanium has exceptional material properties including high strength, light weight, superior corrosion resistance and leading biocompatibility versus other metals.

Producing high quality spherical powders from titanium and titanium alloys is one of the critical building blocks for the rapidly growing, industrial scale, 3D printing / additive manufacturing sectors.

Additive manufacturing with titanium can provide many benefits to the medical, aerospace, EV, space and defense sectors, including;

- Enhanced performance and sustainability by producing strong, lightweight parts that have high levels of corrosion resistance and are 100% recyclable
- Reduced production lead times through iterative, software led design and rapid printing
- Reduced waste and cost of producing a part - with scrap rates of less than 10% compared to over 90% for complex milled parts
- In medical applications, titanium powders allow the rapid production of made-to-measure medical implants that are strong, lightweight, and critically, biocompatible.

Figure 1: Titanium powder and 3D printed titanium parts

To realize the benefits of utilizing titanium powders, they need to meet very high chemical and physical standards. This not only relates to high titanium or titanium alloy purities with low oxygen and other deleterious elements but physical properties of high sphericity, specific particle size distribution and flowability. Hence, these powders are typically produced via complex, post processing techniques following on from the production of high purity titanium metal ingot or wire production.

Spherical titanium powder production challenges

The high cost of titanium spherical powders has curtailed its use in additive manufacturing for products that require its superior properties of strength-to-weight ratio, corrosion resistance and biocompatibility.

The price of titanium metal is approximately $8,500 per ton[1], with the price of titanium spherical powder suitable for 3D printing potentially over $300,000 per ton[1].

The current commercial processes for producing titanium spherical powders include gas atomization, plasma atomization and the plasma rotating electrode process.

Fine spherical powders can be produced with gas atomization and plasma atomization methods but, after size classification, the product yield is low. The plasma rotating electrode process produces titanium powder with good purity and excellent spherical shape, but the particle size is larger than required for many applications.

1 Roskill - Titanium Metal Outlook to 2030

The limiting factor in all three processes is low product yield for fine powder, which is one of the main technical reasons for the very high cost of titanium powder used in additive manufacturing.

GSD – Breakthrough spherical powder technology

Granulation-sintering-deoxygenation (GSD) is a thermochemical process for producing spherical titanium powders used in 3D printing and additive manufacturing and was invented by Dr. Z. Zak Fang and his team at the University of Utah.

The GSD technology significantly improves the yield, by up to 50%, and produces a spherical powder with low oxygen, controllable particle size and excellent flowability.

The GSD manufacturing process steps are:

1. Titanium metal or alloy is hydrogenated to make friable hydride and is then milled into fine particles
2. The fine hydride particles are granulated into spherical granules in the desired size range using spray-drying
3. The spherical granules are sintered to produce densified spherical titanium powder
4. The densified spherical titanium powder is deoxygenated with magnesium to reduce the oxygen content to product specifications

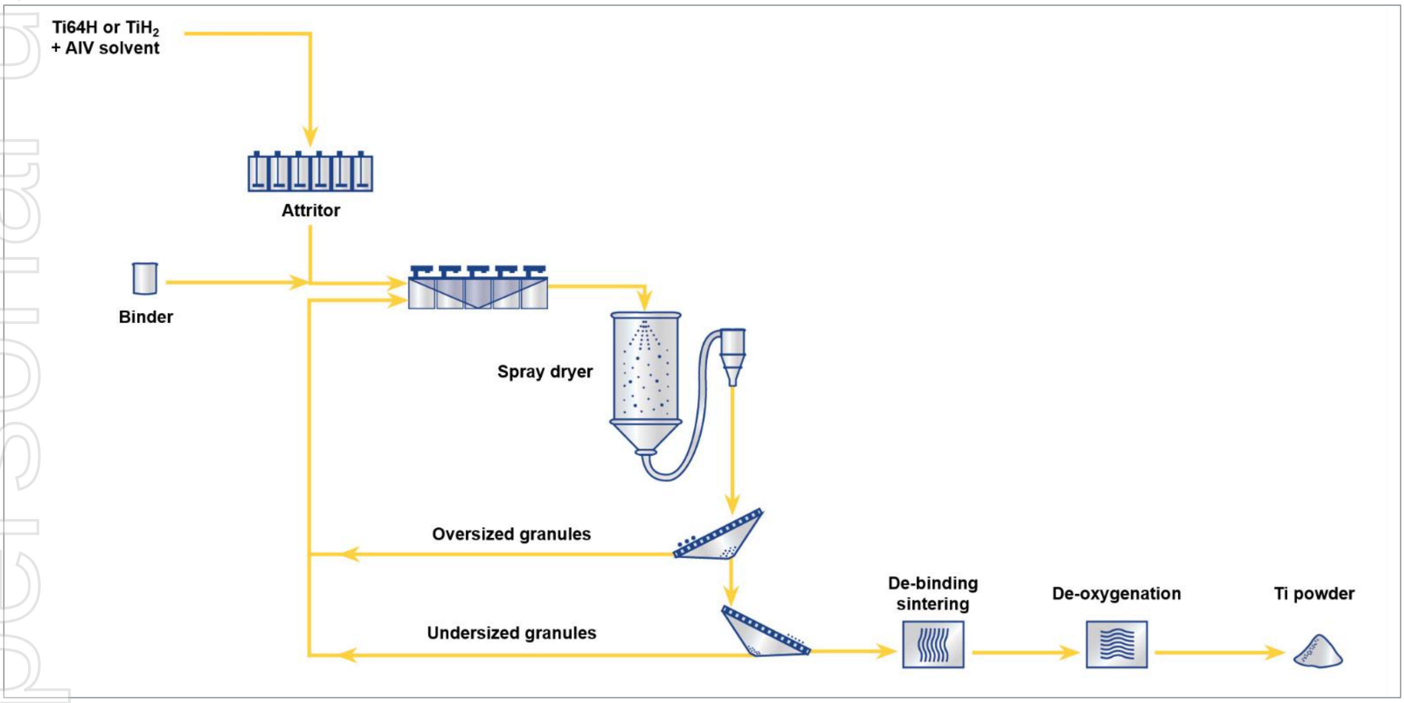

Figure 2: GSD manufacturing process steps

The GSD technology can also introduce desirable alloying ingredients with the titanium hydride powder made in Step 1 to make titanium alloys. For example, titanium hydride powder can be blended with aluminum and vanadium powders to create the widely used alloy Ti-6Al-4V. Other alloying elements for titanium include Fe, Nb, Zr and Mo.

Importantly, the source material can also be recycled titanium scrap material. The manufacturing of titanium components and structures can generate a large amount of titanium machining chips (this 'scrap 'can be over 90% for complex traditionally milled parts). This scrap titanium can be sorted, cleaned, and prepared for processing as the source material in Step 1 above. This recycling pathway for the GSD technology can reduce costs and significantly improve the sustainability of titanium metal manufacturing.

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Process	Advantages	Disadvantages
Granulation-Sintering-Deoxygenation	• Controllable particle size • Low energy consumption • Very high powder yield / very low waste • A wide range of titanium alloys can easily be made • Excellent metallurgical quality • Excellent flowability	• Recently invented and patented • Pilot scale – requires commercial scale up
Gas Atomisation	• Excellent metallurgical quality • High powder flow rates • New and modified alloys can easily be made • Scalable technology: very high volumes available and can easily support AM growth • Large supply base	• Variability in powder properties between suppliers • Large number of suppliers and atomising technologies can be confusing • Reactive and high melting point alloys not available • Few companies currently atomising titanium • Low product yield • High cost
Plasma Atomisation	• Excellent metallurgical quality • Very high flow rates — near perfect spheres • Reactive and high melting point alloys can be made • Titanium alloys available	• Limited supply base • Only alloys available as wire can be made • Low product yield • High cost
Plasma Rotating Electrode Process	• Excellent metallurgical quality • Very high flow rates — perfect spheres • Reactive and high melting point alloys can be made • Titanium alloys available	• Limited supply base but growing • High quality bar needed as starting material • Low product yield • High cost

Table 1: Summary of powder characteristics by manufacturing process[2,3]

HAMR technology

Hyperion already holds an exclusive license for the patented HAMR technology that is a proven method for the production of titanium metal with significantly less energy than the current Kroll process. This technology was also developed by Professor Zak Fang and his team at the University of Utah with funding from the US Department of Energy.

The HAMR technology has successfully produced titanium metal at pilot plant scale at product qualities that exceed current industry standards. Detailed economic-energy analysis and process simulations indicate that the HAMR process uses ~50% less energy than the Kroll process, and offers a path to dropping the cost of titanium by approximately 50%. Using renewable electricity, it can produce zero carbon titanium metal.

The opportunity

The combination of the two patented technologies - GSD and HAMR - plus the advent of wide scale industrial 3D printing capabilities offers a compelling market opportunity.

2 Metal AM, An introduction to metal powders for AM: Manufacturing processes and properties, https://www.metal-am.com/articles/metal-powders-for-3d-printing-manufacturing-processes-and-properties/
3 Iver E. Anderson, Emma M.H. White, Ryan Dehoff, Feedstock powder processing research needs for additive manufacturing development, Current Opinion in Solid State and Materials Science, Volume 22, Issue 1, 2018, Pages 8-15

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The successful scale up of these technologies could potentially produce zero-carbon spherical titanium powders at a fraction of the cost, with economic modelling indicating a reduction in costs per ton of over 75%. Oak Ridge National Laboratories reports that 3D printing can cut down manufacturers' use of raw materials by up to 90%. This quantum of efficiency and cost reduction would not just disrupt the titanium market, but also the far larger aluminum and stainless steel markets.

Titanium competes with metals such as aluminum and stainless steel for strength, and corrosion resistance, and while there are several other metals with excellent properties in these applications, none have the same combined superior properties of strength, weight and corrosive resistance as titanium.

The size of the global titanium primary metal market is ~US$4.2bn pa[4]. The size of the manufactured titanium part market, which would be the relevant comparator for additive manufacturing with titanium powders, is a multiple of US$4.2bn pa. The global primary stainless steel market is ~US$115bn pa[5] and the aluminum market ~US$150bn pa[6,7].

Titanium is a superior metal for a wide range of high-performance applications in the aerospace, medical, space and defense sectors. It is only cost that has held it back from being used for its superior properties in larger consumer markets such as the global transportation industry.

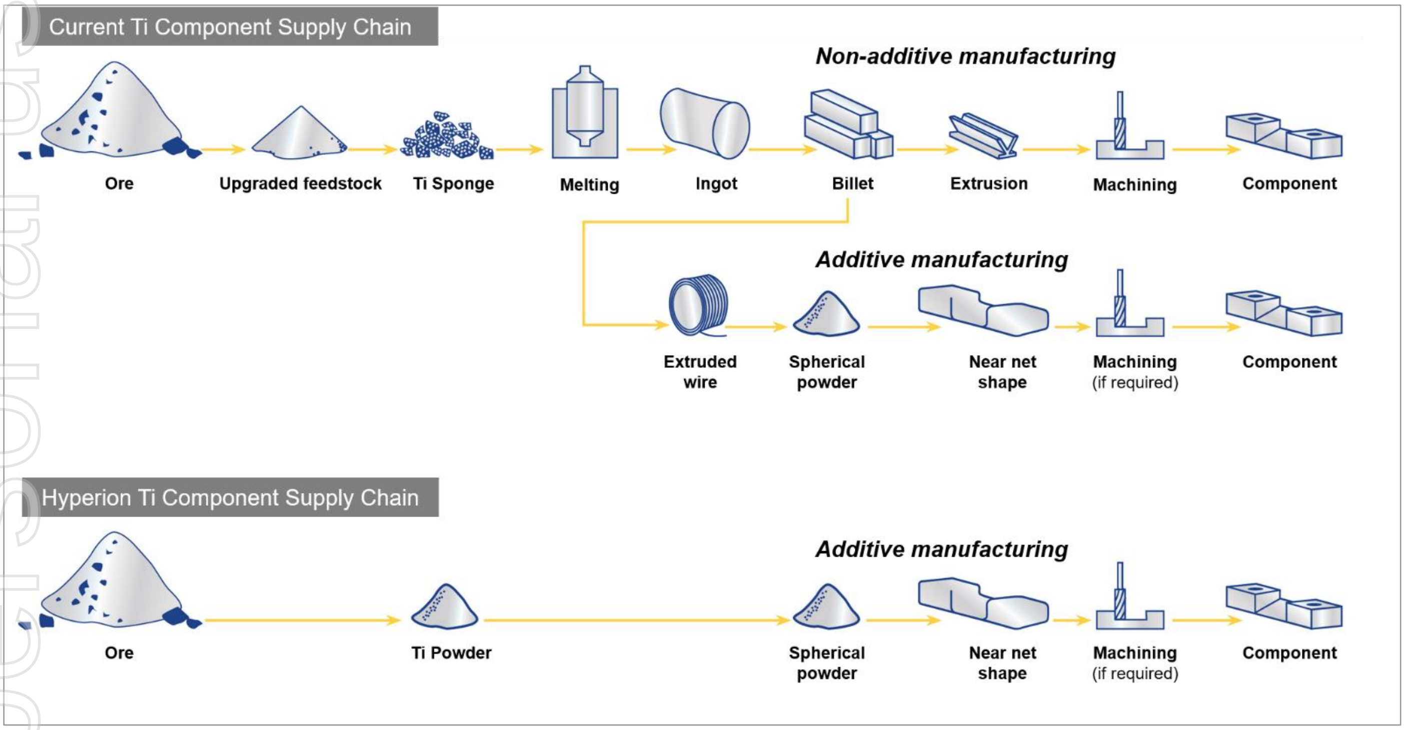

Figure 3: Current Ti supply chain vs. potential Ti supply chain utilizing HAMR & GSD technologies

The patented HAMR and GSD technologies have the potential to provide a step change in the titanium supply chain process through eliminating process stages, reducing energy consumption, reducing carbon emissions and significantly cutting costs. Hyperion believes these breakthrough technologies offer a pathway to create the lowest cost, lowest carbon titanium components globally.

Next steps

- Q3 2021: Produce titanium powders at the Blacksand Technology's production facility in Salt Lake City, Utah, for customer and partner testing
- Q3 2021: Commence techno-economic studies for the scale up of the HAMR and GSD titanium metals and powders production facility

4 Roskill Titanium Metal 10th Edition Update 1 – November 2020
5 Alcoa Corporation Investor Presentation, May 2021
6 Outokumpu, https://www.outokumpu.com/en/investors/outokumpu-as-an-investment/operating-environment
7 MEPS, https://www.meps.co.uk/gb/en/products/world-stainless-steel-prices

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- Q4 2021: Bulk sample from Titan project converted into titanium metal and powders using HAMR and GSD technologies
- H1 2022: Completion of techno-economic studies and FID for production scale HAMR and GSD plant

Dr. Z. Zak Fang Biography

Dr. Zak Fang currently serves as a Program Director at the Advanced Research Projects Agency-Energy (ARPA-E). His focus at ARPA-E is on advanced materials and manufacturing technologies for energy production, storage, and efficiency applications.

Prior to joining ARPA-E, Fang served as a Professor in Metallurgical Engineering at the University of Utah. There, he led a number of innovative research projects and was recognized with an R&D 100 Award for his efforts. He is also a serial inventor and entrepreneur. He has founded two small technology businesses and is the sole or co-inventor on more than 50 U.S. patents. Prior to joining the faculty at the University of Utah, he held various technical and management positions in a number of industrial corporations, including Smith International.

Dr. Fang earned a B.S. and M.S. in Materials Science and Engineering from the University of Science and Technology Beijing and a PhD in Materials Science and Engineering from the University of Alabama at Birmingham. He is also a Fellow of the National Academy of Inventors, ASM International, and APMI International.

Further information for Dr. Fang can be found at the University of Utah's website: (https://faculty.utah.edu/u0320607-ZHIGANG_ZAK_FANG/hm/index.hml)

Dr. Fang is the founder and Chief Technology Officer of Blacksand Technologies, LLC.

Links

- https://arpa-e.energy.gov/impact-sheet/university-utah-metals
- https://blacksandtechllc.com/spherical-refractory-metal-alloy-powders/
- https://powder.metallurgy.utah.edu/research/sphericaltitanium.php
- https://powder.metallurgy.utah.edu/research/hamr.php

Key Patents and References

- Z. Zak Fang et al., Powder metallurgy methods for the production of fine and ultrafine grain Ti and Ti alloys, US patent 9,816,157 B2
- Z. Zak Fang et al., Methods of producing a titanium product, US Patent App. 14/935,245
- Ying Zhang et al., Methods of deoxygenating metals having oxygen dissolved therein in a solid solution, US Patent 9,669,464
- Z. Zak Fang et al., Production of Substantially Spherical Metal Powders, US Patent 9,421,612
- Ying Zhang et al., Methods of deoxygenating metals having oxygen dissolved therein in a solid solution, US Patent 9,669,464
- Pei Sun et al., A Novel Method for Production of Spherical Ti-6Al-4V for Additive Manufacturing, Powder Technology, 301(2016):331-335.
- Ying Zhang et al., Thermodynamic destabilization of Ti-O solid solution by H2 and de-oxygenation of Ti using Mg, Journal of the American Chemical Society, 138(2016):6916-6919.

About Blacksand

Blacksand Technology LLC is located in Salt Lake City, Utah, and is a materials innovation company founded in 2013 by Dr. Z. Zak Fang, Professor of Materials Science and Engineering of the University of Utah.

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Blacksand is the worldwide exclusive licensee from the University of Utah for proprietary & patented technologies to produce low-cost powders for use in additive manufacturing and near net shape manufacturing of metal parts.

Blacksand's patented technologies produce spherical and non-spherical titanium and its alloys, stainless-steel powders, and refractory metal alloy powders. Core competencies of Blacksand Technology include expertise on metallic materials manufacturing processes, metal powders synthesis, characterization, processing, sintering, and mechanical properties. Blacksand Technology's expertise covers titanium, refractory metals, hard materials, and other specialty alloys

Blacksand's manufacturing and testing facilities in Salt Lake City can produce spherical titanium and titanium metal alloy powders. Testing capabilities include particle size and shape distribution characterization, chemical compositions, microstructure characterization using optical microscope and scanning electron microscopy, and the mechanical and erosion testing of metal parts.

About Hyperion Metals

Hyperion's mission is to be the leading developer of zero carbon, sustainable, critical material supply chains for advanced American industries including space, aerospace, electric vehicles and 3D printing.

The Company holds a 100% interest in the Titan Project, covering nearly 6,000 acres of titanium, rare earth minerals, high grade silica sand and zircon rich mineral sands properties in Tennessee, USA. The Titan Project is strategically located in the southeast of the USA, with low-cost road, rail and water logistics connecting it to world class manufacturing industries.

Hyperion has secured options for the exclusive license to produce low carbon titanium metal and spherical powers using the breakthrough HAMR & GSD technologies. The HAMR & GSD technologies were invented by Dr. Z. Zak Fang and his team at the University of Utah with government funding from ARPA-E.

The HAMR technology has demonstrated the potential to produce titanium powders with low-to-zero carbon intensity, significantly lower energy consumption, significantly lower cost and at product qualities which exceed current industry standards. The GSD technology is a thermochemical process combining low cost feedstock material with high yield production, and can produce spherical titanium and titanium alloy powders at a fraction of the cost of comparable commercial powders.

Hyperion also has signed an MOU to establish a partnership with Energy Fuels (NYSE:UUUU) that aims to build an integrated, all-American rare earths supply chain. The MOU will evaluate the potential supply of rare earth minerals from Hyperion's Titan Project to Energy Fuels for value added processing at Energy Fuels ' White Mesa Mill. Rare earths are highly valued as critical materials for magnet production essential for wind turbines, EVs, consumer electronics and military applications.

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Appendix I: Key Terms of the Agreements

- The Company has entered into an agreement with Blacksand to provide services to investigate the scale up and commercialization of the GSD technology, utilizing titanium feedstocks produced and sourced by the Company (“Commercial Development Agreement”).

- The Commercial Development Agreement comprises a master services agreement and a new statement of work which outlines the terms of the services to be provided by Blacksand. The total cost of the services to be provided is US$1,200,000 ("Payment Amount") over the term of the Commercial Development Agreement.

- The term of the Commercial Development Agreement ends on the earlier of the master services agreement being terminated, completion of the program or 2 years after the effective date. The Commercial Development Agreement may be terminated by the Company for any or no reason upon 90 days’ prior written notice to Blacksand.

- The Commercial Development Agreement provides the Company with an option to enter into an exclusive license agreement with Blacksand over a suite of patents comprising the GSD technology and related products to be used for the processing of titanium feedstocks and the production of spherical titanium metal powders, as set out in a separate option for exclusive license agreement (“License Agreement”).

- The option is exercisable by the Company provided it has paid to Blacksand of the balance of the Payment Amount which has not already been paid to Blacksand under the Commercial Development Agreement.

- Upon exercise of the option, the Company will pay total license fees to Blacksand of US$3 million over a two-year period. From the third anniversary of the option exercise the Company will pay Blacksand the greater of the minimum annual license payment (between US$250,000 and US$500,000) and a royalty of 5% of the net value of licensed product sold.

- The term of the exclusive license continues as long as the Company continues to pay all amounts due to Blacksand under the License Agreement. The License Agreement may be terminated by Blacksand if the Company breaches the License Agreement. The Company may terminate the License Agreement it the licensed patents are ruled to be not patentable by relevant authorities or by the Company providing 90 days written notice to Blacksand.

- The aim of the GSD development program is to produce significant quantities of spherical titanium metal powder to additive manufacturing customers to begin a supplier qualification process.

- Blacksand will supply Ti6Al-4V powder for a 2-year period produced using the GSD technology, with the production of powder to meet widely accepted specification (ASTM F2924 and AMS 4998), or customized to meet end user specifications based on direction by Hyperion.

CHANGING WHAT'S POSSIBLE

PROJECT IMPACT SHEET

ARPA-E PROGRAM

A THERMAL PATHWAY TO LOW COST TITANIUM POWDER

UPDATED: FEBRUARY 6, 2017

PROJECT TITLE: A Novel Chemical Pathway for Ti Production to Drastically Reduce Cost
PROGRAM: Modern Electro/Thermochemical Advances in Light Metals Systems (METALS)
AWARD: $3,593,494
PROJECT TEAM: University of Utah, Arconic (formerly Alcoa) and Boeing
PROJECT TERM: February 2014 – February 2017
PRINCIPAL INVESTIGATOR (PI): Dr. Z. Zak Fang

TECHNICAL CHALLENGE

Reducing the weight of vehicles through the use of lightweight metals in place of steel is important for reducing energy consumption and emissions in the transportation sector. Unfortunately, the production of light metals is expensive and energy intensive. For example, titanium (Ti) production via the standard Kroll process consumes 100 kWh/kg, emits 36 kg CO_2/kg, and results in Ti costs of $9-10/kg before alloying or processing for parts. As a result, the use of Ti has been limited primarily to aerospace applications with very specific, high value, performance-critical parts that cannot use other, cheaper metals. Most of the cost and energy intensity associated with Ti production is associated with the difficulty in removing oxygen from the ore, and the subsequent propensity of purified Ti metal to rapidly pick up oxygen and other impurities. In the standard Kroll process, these challenges are addressed by converting Ti ore (an oxide) into $TiCl_4$, and then reducing the chloride to Ti metal with Mg. This process is both capital- and energy-intensive, as the Ti metal coming out of the reduction step must be held for over a week under a high temperature vacuum distillation, and the regeneration of Mg from the $MgCl_2$ by-product is also energy-intensive.

TECHNICAL OPPORTUNITY

With auto and aircraft manufacturers revisiting all light weighting options to improve fuel efficiency, and with the advent of 3D printing and powder manufacturing techniques for complex parts, there is a large and growing potential market for Ti powder. To meet this demand, a low energy, cost-effective means is required to produce Ti metal or manufacture Ti parts for high-volume applications. An alternative pathway that avoids chlorination of titanium oxide (TiO_2) could offer dramatically lower energy input and cost for Ti production, and potentially could expand the use of Ti into higher volume applications.

INNOVATION DEMONSTRATION

The University of Utah (Utah) project's goal was to develop a novel thermochemical process to extract Ti metal from ore that substantially reduces the cost, energy consumption, and emissions of Ti metal production. Utah's approach uses their new chemical process, which they named "hydrogen assisted magnesiothermic reduction" (HAMR). Mg has been known to be a reducing agent for TiO_2 to Ti metal. However, the equilibrium oxygen content in the Ti metal from Mg reduced TiO_2 is typically higher than 1%, depending on the temperature used, which is unacceptable for industrial applications. This is because Ti-O solid solutions can be more stable than MgO. In order to further reduce the oxygen content in Ti, Utah discovered that Ti-O can be destabilized using hydrogen[1], making it possible to turn the reduction of TiO_2 with Mg from thermodynamically impossible to thermodynamically favored. This allows TiO_2 to be reduced and deoxygenated directly by Mg to form TiH_2, with low oxygen levels that can meet the needs of the industry. TiH_2 can be further processed to Ti metal through industry standard approaches. Utah also developed a two-step technique, which is designed to overcome kinetic barriers and engineering issues. The first step of this technique is the reduction that converts TiO_2 to Ti-O solid solutions. The second step is the deoxygenation that refines Ti-O solid solutions to Ti metal with ultra-low oxygen content. The output of the process is HAMR TiH_2 powder, shown in Figure 1. This powder contains a range of particle sizes and shapes, and is suitable for subsequent sintering or other powder applications. The team reliably produced small amounts (0.2-1 kg) of the HAMR TiH_2 powder in a batch and then dehydrogenated it by heating above 400 °C in a vacuum or inert atmosphere to produce commercially pure Ti powder (CP-Ti), and tested its purity against the industry standard for general purpose Ti composition (ASTM B299-13), as shown in Table 1. The HAMR Ti powder

[1]Zhang, Y. Fang, Z. Z., Sun, P., Zhang, T,, Xia, Y., et al. (2016). Thermodynamic destabilization of Ti-O solid solution by H_2 and deoxygenation of Ti using Mg. *Journal of the American Chemical Society*, 2016, *138*: 6916-6919.

produced from the HAMR TiH_2 powder has consistently met the purity requirements defined by the industry standard and the Utah team has developed a reliable recipe for lab-scale production of HAMR Ti powder. A 10 kg batch was produced for further testing at Utah's commercial partners, Arconic (formerly Alcoa) and Boeing.

	O	C	N	Al*	Fe	Mg	Si
HAMR	0.098	0.009	0.011	0.100	0.045	0.071	0.037
ASTM B299-13	<0.15	<0.03	<0.02	<0.04	<0.15	<0.5	<0.04

Table 1: HAMR Ti powder composition against industry standard, average of three batches (*: Al is higher than the standard, however, Ti is almost always alloyed with Al so this is not a concern.)

The deoxygenation process that Utah invented has also enabled a new means to produce high quality spherical powders of Ti and Ti-alloys, a critical and high-value feedstock for additive manufacturing ("3D printing"). Today's processes to produce spherical powders use plasmas or high temperature gases to atomize a Ti wire or rod. These processes are very expensive (>$200/kg) because the cost of the Ti wire or rod input is high, and the powder yield is low (only 20-30%, due to the wide distribution of particle size). Using Utah's new deoxygenation approach, it is now possible to form Ti spheres at about tens of micron in size by agglomerating, sintering, and then de-oxygenating smaller Ti particles (a process called granulation, sintering, and deoxygenation, or GSD). GSD can be applied to commercial TiH_2 pigment powder, or to finely ground powder from HAMR or Kroll. GSD can also use recycled Ti alloys as the raw material. Figure 1 contrasts HAMR non-spherical TiH_2 particles versus GSD spherical Ti-6Al-4V powder. The GSD process produces high quality spherical powder with a nearly monodisperse particle size distribution, suitable to feed a 3D printer. The properties of GSD powder relative to the existing industry standard are highlighted in Table 2.

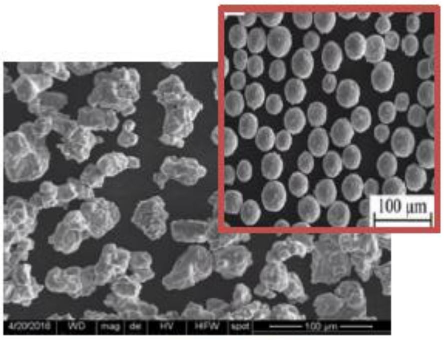

Figure 1: Non-spherical HAMR TiH_2 powder vs. spherical GSD powder.

	Density (g/cc)	O (%)	N (%)	C (%)	Al (%)	V (%)	Fe (%)	Yield (MPa)	UTS (MPa)
GSD	4.419	0.171	0.047	0.075	5.92	4.48	0.33	1059	1105
Commercial powder for Selective Laser Melting (SLM)	4.414	0.204	0.087	0.016	6.38	4.52	0.47	1074	1132
ASTM F2924	--	<0.20	<0.05	<0.08	5.50-6.75	3.50-4.50	<0.30	825	895

Table 2: GSD powder alloy composition and properties against industry standard and incumbent technology (laser-sintered) (UTS: Ultimate tensile strength)

To assess the commercial viability of the HAMR process, Utah performed a techno-economic analysis and a full process simulation in ExtendSim (a well-known chemical processing simulation software) to estimate the energy consumption, emissions, and cost at mass production. The modeling effort included the feed materials, reaction conditions (temperature and pressure), and side processes (pretreatment of the feed materials and post-treatment of the products). As shown in Figure 2, the HAMR process is 50% less energy intensive and generates 30% less emissions than the Kroll process, even after accounting for an additional purification step of the TiO_2 feed prior to the HAMR process. The bulk of the energy and emissions savings comes through eliminating the need to chlorinate TiO_2 to make $TiCl_4$, and vacuum distillation after the reduction of $TiCl_4$. For the GSD process, the improved yields from this new pathway allows for production to occur at more than 50% lower cost, dramatically lowering the potential price point of high quality Ti powder while keeping energy usage and emissions comparable to the state of practice.

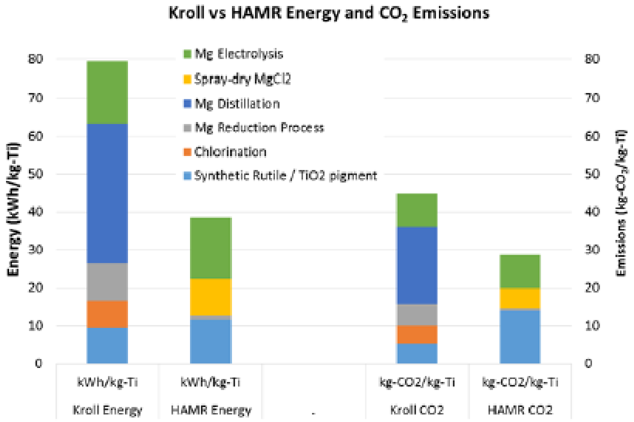

Figure 2: Energy and CO_2 benefits of HAMR vs. Current Ti Production Processes

PATHWAY TO ECONOMIC IMPACT

The key challenge for moving forward is scaling up the HAMR and GSD processes from lab-scale demos (~kg batches) to commercial-scale production (thousands or tens of thousands of tons annually). In scale-up there will be many engineering issues in thermal management, reactor design, and system integration that must be overcome and optimized. In addition to obtaining industrial validation of the Ti powders, more samples and parts of much larger sizes must be demonstrated and tested. Utah is working with its partners, Boeing and Arconic, to design new scope and testing protocols that will allow the team to fully scale and validate their products over the next two years. Their goal is to improve their HAMR process for higher volume production of CP-Ti for higher volume markets.

Utah's success with the GSD process for spherical powders offers an ideal first market, with a high-value product for the rapidly growing additive manufacturing industry. The GSD process offers a fast path to scale for this market, and the unique ability to produce custom alloys in small batches for customers to test and improve their 3D printing performance. Utah has spun out a small company, FTP Technologies, to pursue this market. The market size for spherical Ti is expected to reach 2,000 tons in ten years, but faster growth is possible with the lower cost feedstock and improved performance of alloys from the GSD process.

LONG-TERM IMPACTS

Ultimately, if the HAMR process proves to be scalable, it is projected to reduce the price of Ti parts by 50% or more. It is too soon to determine whether HAMR could drive the price of Ti low enough to displace steel for widespread use in high volume automotive applications, but it does show the promise to dramatically alter the Ti market and increase the range of applications for high performance, lightweight Ti parts. The team projects that its HAMR process could generate billets for automotive and other large scale use at a scale of around a million tons per year, potentially displacing millions of tons of heavier stainless steel products over time.

INTELLECTUAL PROPERTY AND PUBLICATIONS

As of December 2016, Utah has generated two invention disclosures to ARPA-E, two U.S. Patent and Trademark Office (PTO) patent applications, and one patent.

Patents

Zhigang Zak Fang, Yang Xia, Pei Sun, Ying Zhang. Production of substantially spherical metal powders, US patent 9,421,612 B2.

Publications

Utah has also published the scientific underpinnings of this technology extensively in the open literature. A list of publications is provided below:

Zhang, Y., Fang, Z. Z., Xia, Y., Sun, P., Van Devener, B., Free, M., Lefler, H. & Zheng, S. (2017). Hydrogen assisted magnesiothermic reduction of TiO_2. Chemical Engineering Journal, 308, 299-310.

Sun, P., Fang, Z. Z., Xia, Y., Zhang, Y., & Zhou, C. (2016). A novel method for production of spherical Ti-6Al-4V powder for additive manufacturing. Powder Technology, 301, 331-335.

Zhang, Y., Fang, Z. Z., Sun, P., Zhang, T., Xia, Y., Zhou, C., & Huang, Z. (2016). Thermodynamic Destabilization of Ti-O Solid Solution by H2 and Deoxygenation of Ti Using Mg. Journal of the American Chemical Society, 138(22), 6916-6919.

Zhang, Y., Fang, Z. Z., Xia, Y., Huang, Z., Lefler, H., Zhang, T., Sun, P., Free, M.L. & Guo, J. (2016). A novel chemical pathway for energy efficient production of Ti metal from upgraded titanium slag. Chemical Engineering Journal, 286, 517-527.

Cho, J., Roy, S., Sathyapalan, A., Free, M. L., Fang, Z. Z., & Zeng, W. (2016). Purification of reduced upgraded titania slag by iron removal using mild acids. Hydrometallurgy, 161, 7-13.

Forward looking statements

Information included in this release constitutes forward-looking statements. Often, but not always, forward looking statements can generally be identified by the use of forward-looking words such as may", will", expect", intend", plan", estimate", anticipate", continue", and guidance", or other similar words and may include, without limitation, statements regarding plans, strategies and objectives of management, anticipated production or construction commencement dates and expected costs or production outputs.

Forward looking statements inherently involve known and unknown risks, uncertainties and other factors that may cause the Company s actual results, performance, and achievements to differ materially from any future results, performance or achievements. Relevant factors may include, but are not limited to, changes in commodity prices, foreign exchange fluctuations and general economic conditions, increased costs and demand for production inputs, the speculative nature of exploration and project development, including the risks of obtaining necessary licenses and permits and diminishing quantities or grades of reserves, political and social risks, changes to the regulatory framework within which the company operates or may in the future operate, environmental conditions including extreme weather conditions, recruitment and retention of personnel, industrial relations issues and litigation.

Forward looking statements are based on the Company and its management s good faith assumptions relating to the financial, market, regulatory and other relevant environments that will exist and affect the Company s business and operations in the future. The Company does not give any assurance that the assumptions on which forward looking statements are based will prove to be correct, or that the Company s business or operations will not be affected in any material manner by these or other factors not foreseen or foreseeable by the Company or management or beyond the Company s control.

Although the Company attempts and has attempted to identify factors that would cause actual actions, events or results to differ materially from those disclosed in forward looking statements, there may be other factors that could cause actual results, performance, achievements or events not to be as anticipated, estimated or intended, and many events are beyond the reasonable control of the Company. Accordingly, readers are cautioned not to place undue reliance on forward looking statements. Forward looking statements in these materials speak only at the date of issue. Subject to any continuing obligations under applicable law or any relevant stock exchange listing rules, in providing this information the company does not undertake any obligation to publicly update or revise any of the forward-looking statements or to advise of any change in events, conditions or circumstances on which any such statement is based.

Competent Persons Statement

The information in this announcement that relates to the Titan Project Exploration Results is extracted from Hyperion s ASX Announcements dated 6 May 2021, 10 March 2021 and 7 January 2021 (Original ASX Announcements") which are available to view at Hyperion s website at www.hyperionmetals.us. *Hyperion confirms that a) it is not aware of any new information or data that materially affects the information included in the Original ASX Announcements; b) all material assumptions included in the Original ASX Announcements continue to apply and have not materially changed; and c) the form and context in which the relevant Competent Persons findings are presented in this report have not been materially changed from the Original ASX Announcements*

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