

# MANUFACTURING MATTERS

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SIMTech



Materials Mag!c  
Hitachi Metals

**SIMTech-Hitachi Metals AM Lab**

## FEATURE METAL ADDITIVE MANUFACTURING JOINT LAB



**SUSTAINABILITY MATTERS**  
SILICON CARBIDE MEMBRANE  
FOR HIGHLY AGGRESSIVE  
WASTE WATER TREATMENT

**PRODUCTIVITY MATTERS**  
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PRODUCTIVITY

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NEW ADDITIVE MANUFACTURING  
APPROACH OVERCOMES TECHNIQUE  
LIMITATION

## NOTE FROM EDITOR...

Dear Friends and Industry Partners,

Additive Manufacturing (AM), also known as 3D Printing, has been identified as an essential enabler with the potential to positively impact industries such as aerospace, automotive, marine, oil & gas and medtech, among others, with its benefits.

To enable the widespread use of AM technology, various aspects need to be addressed. In the area of metals and metal alloys, there is a severe shortage of powders that have been validated for use with metal 3D printers, including laser, electron beam and binder-based AM processes. Although more than 1,000 steel alloys are commercially available for conventional casting, a minority have been verified for AM production by original equipment manufacturers (OEMs). The shortage limits the number of parts that can be made and companies that can benefit from the technology.

The relatively few metal AM powders that are available cost more than raw materials for other traditional forms of manufacturing. One of the ways to lower the barrier for AM mass adoption is to improve powder production methods and, possibly, formulate entirely new powders to get the most out of metal 3D printing (Source: University of Waterloo, Additive Manufacturing: Promises, Challenges and Opportunities, 2 August 2017).

This is exactly what the SIMTech-Hitachi Metals AM Joint Lab is set up to do for industry (See Feature in opposite page).

*Swee Heng*

*Editor, Manufacturing Matters*

*Email: shlee@SIMTech.a-star.edu.sg*



# METAL ADDITIVE MANUFACTURING JOINT LAB

Collaboration to develop innovation for industry's needs

An agreement was signed between A\*STAR's Singapore Institute of Manufacturing Technology (SIMTech) and Hitachi Metals, Ltd. (HML) to establish a joint research body dedicated to metal additive manufacturing on 19 July 2018.

SIMTech is actively collaborating with the research community and industry to broaden the application of 3D Additive Manufacturing (AM). Metal additive manufacturing R&D led by SIMTech is one of the areas of focus under this initiative.

HML is a materials company with a history of innovation in advanced metallurgical technology and development of high performance materials. The company is exploring new manufacturing technologies in 3D AM for their high performance powder materials and the manufacturing of their impeller products for the automotive market.

The SIMTech-Hitachi Metals Additive Manufacturing Joint Lab is to develop next-generation metal additive manufacturing technologies by combining SIMTech's world-leading metal additive manufacturing capabilities, and high-tech materials manufacturer HML's metal powder

“**With the combined expertise in SIMTech's manufacturing processes and Hitachi Metal's metal powder development know-how, the joint lab is expected to accelerate the adoption of 3D printing by overcoming the current constraints and maximise the potential of 3D printing for industry**”

Mr Kenichi Inoue, General Manager, Global Research & Innovative Technology Center "GRIT" Hitachi Metals, Ltd.



Dr Lim Ser Yong, Executive Director, SIMTech (right), and Dr Koji Sato, Vice President and Executive Officer, Hitachi Metals, Ltd. during the joint signing ceremony on 19 July 2018

development know-how. The new joint R&D body will further promote open innovation, and develop to market-leading products and solutions.

For the first-year project collaboration of the Joint Lab, HML identified a nickel-based superalloy (CM247LC) that is of interest to industry for its performance in the high temperature load-bearing environments in the aerospace and industrial gas turbine industry. In this project, both HML and SIMTech will work together to address processing challenges relating to additive manufacturing and post-machining. SIMTech will use Selective Laser Melting (SLM) and Electron Beam Melting (EBM) or Binder Jet Printing (BJP) Technologies to study the processability of this superalloy. This superalloy is known to exhibit poor weldability and has the tendency for cracking due to its sensitivity to high thermal gradients during processing.

#### R&D Journey with Hitachi Metals, Ltd.

The joint lab was preceded by a research collaboration project started

in April 2018 by HML and SIMTech to develop powder-bed metal additive manufacturing related processing technologies by using high quality gas atomised Alloy718 powder, developed by HML, to fabricate high performance industrial components. In this collaboration, SLM, EBM and BJP technologies were developed. Results revealed that HML's powder is suitable for powder-bed fusion additive manufacturing and the resultant microstructure and mechanical properties are comparable and even superior to that of the Original Equipment Manufacturer (OEM) powder. Finally, an industrial impeller fabricated by SLM and HML's powder with dimensional control and surface finishing of internal and external surfaces is developed by post-processing. The study revealed that the gas atomised Alloy718 powder from HML can be used to fabricate industrial components with complex geometry and good mechanical performance.

SIMTech helped HML developed a new high temperature, high performance

material in Alloy718 for metal additive manufacturing (AM) and developed additive manufacturing processes and relevant post-processes for its key impeller product using powder-bed 3D printing technologies. As a HML partner, SIMTech helped the local 3D printing service bureau with qualified powder source to support end-users.

The project enabled HML to supply powder to AM service bureau with direct support from local engineering and R&D team. The OEMs and end-users now have options of local powder suppliers and enjoys direct local technical engagement in the early phase of product development. HML also can benefit from the early involvement in the product qualification of their AM powder with end-users, giving the company strategic heads-up in the later production scale-up.

The partnership resulted in a 3-year joint lab collaboration with over S\$1M in Industry R&D Spending by Hitachi Metals, Ltd. in 2018.

For enquiries, please contact

**Mr Tan Chee Tat**, Director, PE COI

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Web: [www.a-star.edu.sg/SIMTech-PECOI](http://www.a-star.edu.sg/SIMTech-PECOI)

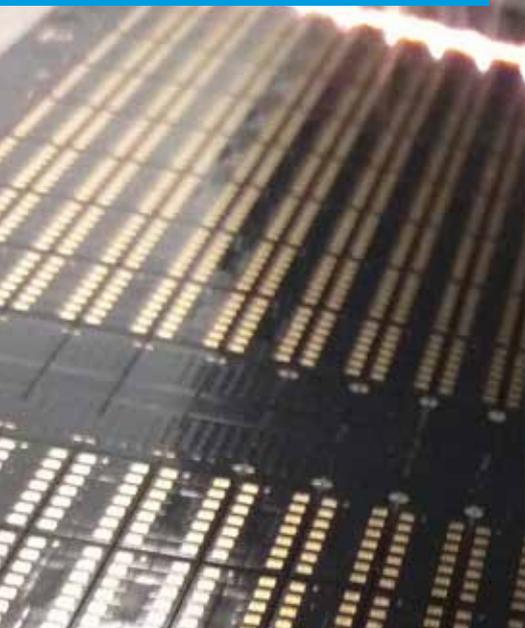
“**We are confident that the joint lab will create market-relevant innovations and solutions to diversify the use of 3D printing in parts that benefit industry**”

Mr Hiroo Kawabata, Managing Director, Hitachi Metals Singapore Pte. Ltd.

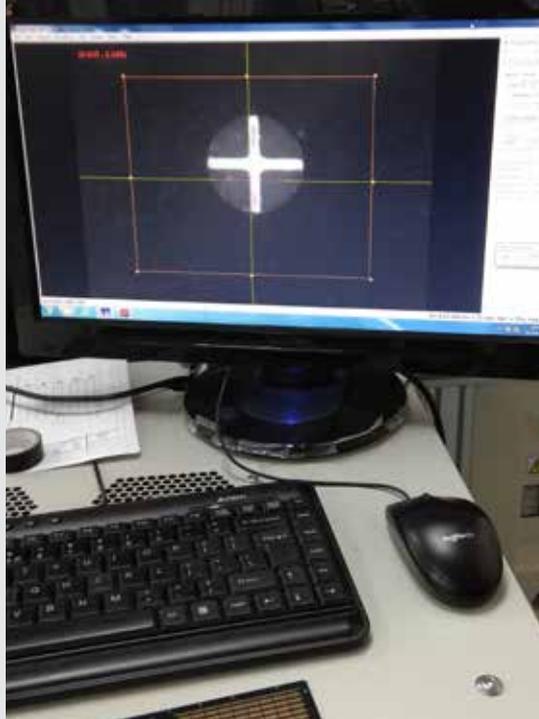
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Sustaining and Advancing PE Industry



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Centre of Innovation



**Speed.** Laser Singulation enables high productivity



**Precision.** Machine vision enables highly accurate laser singulation



**Quality.** Laser Singulation leaves the electronics package in pristine condition

## GENUINE SOLUTION FROM T-UP

### Laser-based Singulation process yields higher level of cleanliness

To meet a market need for a water-free, high speed and high precision singulation of electronic packages, a SIMTech researcher was seconded to Genuine Solutions Pte Ltd (GSP), a growing company that specialises in providing customised singulation solutions for semiconductor manufacturing customers globally.

The T-Up fused SIMTech's laser singulation technology with GSP's existing production strip handling and machine vision products and apply these technologies to fulfil the needs of a customer that manufactures components for high-end consumer electronics.

The rising demand for mobile devices and wearables creates a voracious need for singulation processes to have a high level of cleanliness. The mature technology in electronics singulation, using diamond singulation saws, does not maintain the standard of cleanliness needed. Singulation saws require the use of water as a coolant lubricant to ensure tool life and cutting quality. The presence of this coolant is problematic for many types of sensor packages as these have components that cannot be protected by the packages moulding compound and, are sensitive to coolant-borne contaminants. A laser-based process, on the other hand, is

completely dry and does not induce moisture, water marks, contamination and oxidation.

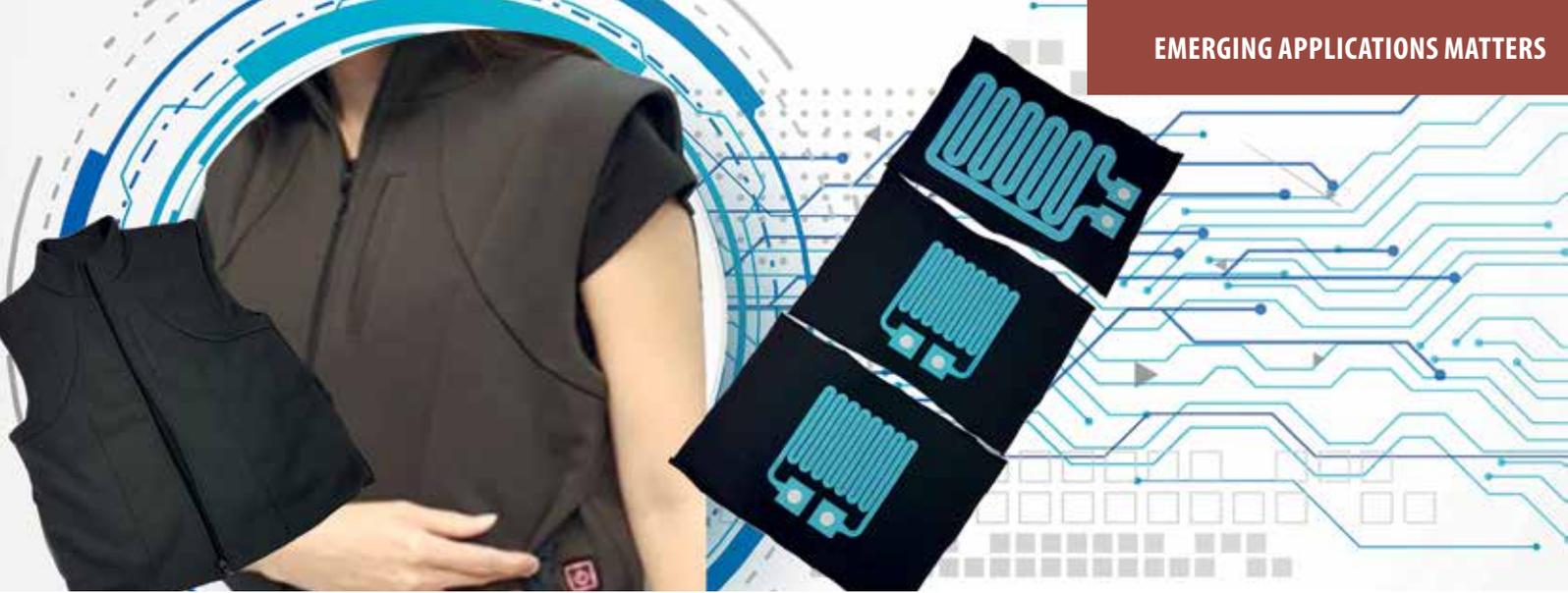
SIMTech's contributions during this T-Up include the transfer of laser singulation technology and extensive assistance in process development in consultation with both GSP and the end-customer. This project has created a new and marketable capability for GSP, solving the challenges associated with delivering high yield, affordable and low cost devices with increasing sensor capability.

**“This project for our first laser singulation customer was a culmination of months of hard work between SIMTech and GSP with a common objective to deliver expectations of end-customers. I'm glad that we made it and with the support of the T-Up programme, we have successfully transferred the solution to end- customers ,”**

Mr Sardjono Chainur, Director, Genuine Solutions Pte Ltd

*Note: The T-Up initiative, a multi-agency effort by A\*STAR, the Economic Development Board, SPRING Singapore (now Enterprise Singapore), IE Singapore (now Enterprise Singapore), and the Infocomm Development Authority (now Media Development Authority), involves seconding RSEs to local enterprises to access the pool of R&D talent in Research Institutes.*

For more information, please contact **Dr Chen Wei Long**, Director, Staff Development Office at [wlchen@SIMTech.a-star.edu.sg](mailto:wlchen@SIMTech.a-star.edu.sg)



## INCREASED PRODUCT RANGE AND STRONGER ECOSYSTEM

The commercialisation of Printed Heater Vest and ecosystem development for printed heater are outcomes of a Collaborative Industry Project

Lee Yin Apparel International, a participant of the SIMTech Collaborative Industry Project (CIP) on Smart Wearable Innovation Programme in February 2018, added printed heater vest to its wide range of apparel. Established in 1975, Lee Yin is a leading regional apparel manufacturer and exporter. It now has new capability to develop and produce a new range of winter wear with printed heater, transforming a traditional garment manufacturer to a smart wearable innovator and manufacturer of Printed Heater Wear.

The printed heater vest with various temperature settings and corresponding heating duration was developed within a year of the CIP. The beauty of it is that the smart winter wear with printed heater can convert energy from a power bank to heat. It will be launched by Lee Yin under the Coldwear brand soon.

In this product development, SIMTech developed the roll-to-roll manufacturing process of printed

heater to ensure manufacturability. Reliability test and field testing of printed heater jacket were also carried out to confirm product reliability and business viability.

To equip the local industry and create an ecosystem to be ready for the explosive growth in smart wearables, SIMTech launched the CIP on Smart Wearable Innovation Programme. It aims to develop capability in design, prototyping and manufacturing of printed electrodes, printed heater and printed electronic products for Smart Wearable Product Development.

Arising from this, supply chain partners for printed heater ecosystem for smart wearable product is established in Singapore. KPP Packaging Pte Ltd, a local paper-packaging provider, offset printer and manufacturer of packaging boxes, is a supply chain partner in this ecosystem. It acquired capability from SIMTech to print printed heater for Lee Yin's printed heater vest. With this acquired capabilities, KPP Packaging is

“ We are very pleased with the upcoming launch in our Coldwear stores, the first designed-in-Singapore Printed Heater Vest. This milestone comes from close partnership with SIMTech and KPP Packaging. We look forward to adding more innovative and smarter garments to the range, bolstering our apparel manufacturing and retail capabilities with leading-edge technology ”

Mr Clarence Lee, Chief Operating Officer,  
Lee Yin Apparel International

now able to provide functional printing of printed heater and electrodes for smart wearable with higher value-add.

For enquiries, please contact  
**Mr Rick Yeo**, Director, EAC  
Email: ricky@SIMTech.a-star.edu.sg  
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“ KPP Packaging is happy to be part of SIMTech Printed Electronics Ecosystem to develop new printing capabilities for printed heaters for smart apparel industry to expand our product portfolio to meet business challenges in our printing industry ”

Mr Melvin Yong, Business Development Manager, KPP Packaging

**EAC** Emerging Applications Centre  
Seeding and Growing Emerging Industries



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Overall Equipment Effectiveness Monitoring System was implemented on injection moulding machines



Real-time machine visibility provides live machine status updates through management dashboard

## DIGITALISATION IMPROVES PRODUCTIVITY

Racer Technology implemented Overall Equipment Effectiveness Monitoring System, Manufacturing Operations Management and Mobile Workflow for shopfloor productivity

To digitalise its operation, Racer Technology Pte Ltd, a medtech contract manufacturer, adopted a suite of technology and system from SIMTech.

Previously, Racer used a paper-based method to keep track of its machine operations. However, this manual method is time-consuming, prone to human error and not ideal for data collection and analysis to improve productivity.

To address this, Racer implemented the Overall Equipment Effectiveness Monitoring System (OEEMS) on its injection moulding machines to provide real-time machine visibility. The OEEMS provides live machine status updates through the dashboard, automatically capturing data on machine stoppages, analyse the cause and duration for each stoppage.

With this, Racer can now develop effective measures to reduce machine downtime and maximise machine utilisation. OEEMS improves machine utilisation by between 7 to 17 per cent and increase yield ranging from 19 to 21 per cent.

Mould set-up time was reduced 39 to 63 per cent through optimised set-up procedure.

SIMTech also implemented the Manufacturing Operations Management (MOM) solution, an integrated production planning and shopfloor tracking solution with raw material management, finished good management, delivery order generation and mobile shopfloor tracking for shopfloor productivity. Training on Manufacturing Operations Management system was also provided.

With this system in place, Racer reduced 75 per cent in report generation time; improved 69 per cent in data capture and production planning time and improved 75 per cent in shopfloor visibility.

SIMTech wfMOBILE™ Technology was applied for quality inspection and in-process quality control. The manual forms for these were converted to electronic forms for data capture for the sampling process, and reports are automated.

With the digital entry of quality data, the time taken to complete a quality data input is within 30 minutes versus previously unknown cycletime. The estimated paper reduction is 50 per cent. The time taken to search for

quality report is reduced from more than 30 minutes to 1 minute.

To enable its employees to use the digitalised technology and systems, Racer also sent 15 of its employees for Workforce Skills Qualifications (WSQ) courses conducted by SIMTech.

**“The collaborations with SIMTech helped Racer Technology to save on labour costs and improve efficiency in digitalisation. Its factory is able to produce the same output with fewer work shifts.”**

Mr Willy Koh, Chief Executive Officer, Racer Technology

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**Dr Tan Puay Siew**, Director, MPTC  
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**MPTC** Manufacturing Productivity Technology Centre  
 Enhancing Manufacturing Productivity



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High temperature furnace for pure silicon carbide membrane sintering

## SILICON CARBIDE MEMBRANE FOR HIGHLY AGGRESSIVE WASTE WATER TREATMENT

A cost effective manufacturing process developed to produce silicon carbide membrane

Increasingly more governments realise the importance of waste water treatment and have taken actions or regulations to improve their waste water treatment processes. Waste water treatment converts waste water from its unusable state into an effluent that can be either returned to the water cycle with minimal environmental issues or reused for another purpose.

Presently, ceramic membrane filtration technologies, such as ultra-filtration, micro-filtration, nano-filtration, and others are used due to the growth in the manufacturing sector. However, in extreme conditions, where the pH value in the waste water is higher than 14 or lower than 0, the common oxide ceramic membranes are not robust enough for chemical resistance. The

waste treatment industry is looking for new materials and processes to cope with extremely harsh waste water directly. Silicon carbide (SiC) membrane is a more suitable ceramic membrane for such application.

SIMTech developed a cost effective manufacturing process in producing pure SiC membrane. In this process, an additive was selected to enhance the SiC sintering mechanism and achieve comparable strength and chemical resistance at sintering temperature below 2000°C. One-step sintering process was also developed to further reduce production cost. The produced SiC membrane consists of average pore size of 5~10µm and porosity of 40 per cent and SiC functional layer with controlled pore size of 0.1~1µm.

Due to the nature of the material, the produced SiC membrane has excellent chemical resistance over the whole pH range and is inert to chemical cleaning. Furthermore, the membrane has good stability at high temperature, suitable for treating aggressive hot waste water and exhaust gas. The hydrophilic nature of SiC makes the membrane suitable for water-oil separation.

**The porous silicon carbide ceramic membrane is potentially attractive for use in waste water treatment, waste gas treatment, desalination, bio-medicine, food processing, energy, chemical and other fields**

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Pure silicon carbide membrane and microstructure



# NEW COURSE IN INDUSTRIAL ROBOTICS AND AUTOMATION

Diploma course fills skills gap to meet manufacturing industry needs using Learn-Practise-Implement model

With the growing need to boost productivity to be competitive, more skilled engineers are in demand for effective adoption of robots and automation technology. These engineers must be able to assess the manufacturing processes, identify the hot spots, plan and implement suitable automation technology.

To this end, SIMTech is launching a new course in industrial robotics and automation. Known as **Graduate Diploma in Industrial Automation**, the course aims to fill the gaps in knowledge and skills for the manufacturing industry in the areas of robotics, material handling, automation system control, design and simulation.

The participants will be taught by SIMTech trainers, who developed the course based on numerous robotics and automation projects they executed, through practical automation with industry.

In five modules, the course with hands-on sessions covers the following key capabilities:

- **Apply robotics for manufacturing automation** – Understanding the

fundamentals of robotics and how industrial robots can be used for manufacturing process automation

- **Automation components and systems** – Application of part handling systems for loading and unloading, and material transferring within work cells and among the machineries on the factory floor
- **Control in automation systems** – Selection of the state-of-the-art automation control systems for equipment and automation line control
- **Automation design and simulation** – Assessment of manufacturing process for implementation of automation systems using design and simulation tools
- **Plan and manage project for Implementation** – Application of methods for planning, executing and managing projects for developing technology, products and processes

The course is for Professionals, Managers, Engineers and Technicians (PMETs) who have a degree in engineering, or have a diploma with

several years of work experience in equipment and automation system operation, maintenance and development.

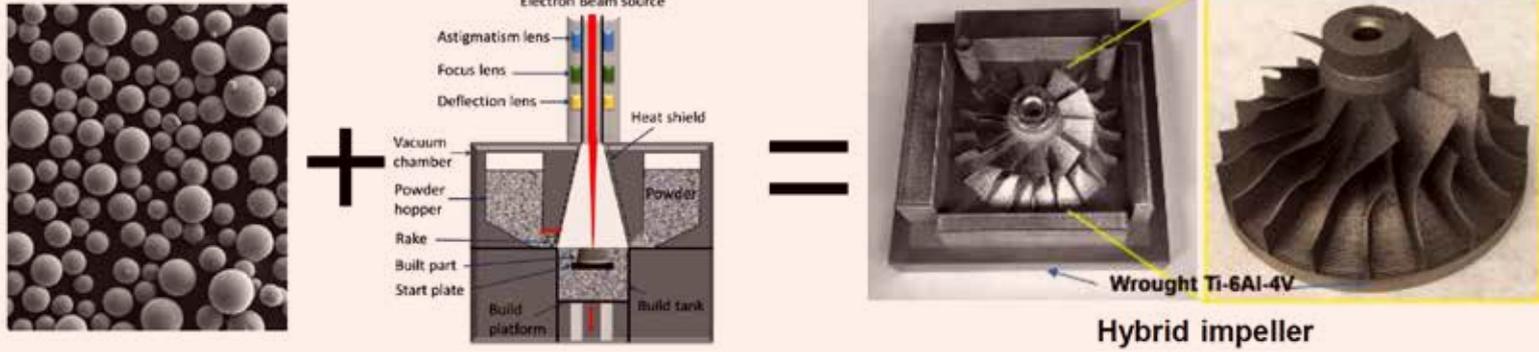
The first module on Apply Robotics for Manufacturing Automation starts in July 2019.

For enrolment details and course fees, please visit <https://www.a-star.edu.sg/kto/Courses/Graduate-Diplomas>

Funding is available for Singaporeans and Permanent Residents to cover up to 95 per cent of the course fee. For details, please contact KTO-enquiry@SIMTech.a-star.edu.sg

**Based on practical case-studies, the course contents are industry-relevant**

For more information, please contact:  
**Dr Lin Wei** at  
[wlin@SIMTech.a-star.edu.sg](mailto:wlin@SIMTech.a-star.edu.sg)



Process flow for hybrid components fabricated by Electron Beam Melting

# NEW ADDITIVE MANUFACTURING APPROACH OVERCOMES TECHNIQUE LIMITATION

Solution is in the direct fabrication of part on a wrought plate

Electron Beam Melting (EBM), one of the powder bed-based additive manufacturing processes that is able to produce complex geometrical metal parts directly, has many application possibilities in various fields. However, when the scanning line is longer than 100 mm during fabrication using EBM, the lack of energy results in poor material fusion. This degrades the mechanical properties of the printed part dramatically.

To overcome this, SIMTech developed an approach to replace the long scanning length section by wrought counterpart via a direct building of a Ti-6Al-4V part onto a wrought plate using EBM.

Experimental studies by SIMTech researchers reveal that the complex geometrical component can be

successfully fabricated and the finished component has a combination of wrought base plate and EBM-built section. This part has comparable tensile properties to that of the wrought and annealed Ti-6Al-4V. A good fusion without defect is observed along the fusion zone which is also confirmed by the tensile results.

This approach can also be used to repair parts. When the part is worn or is beyond the designed life, it can be cut off. A new feature can be designed and built on the existing part.

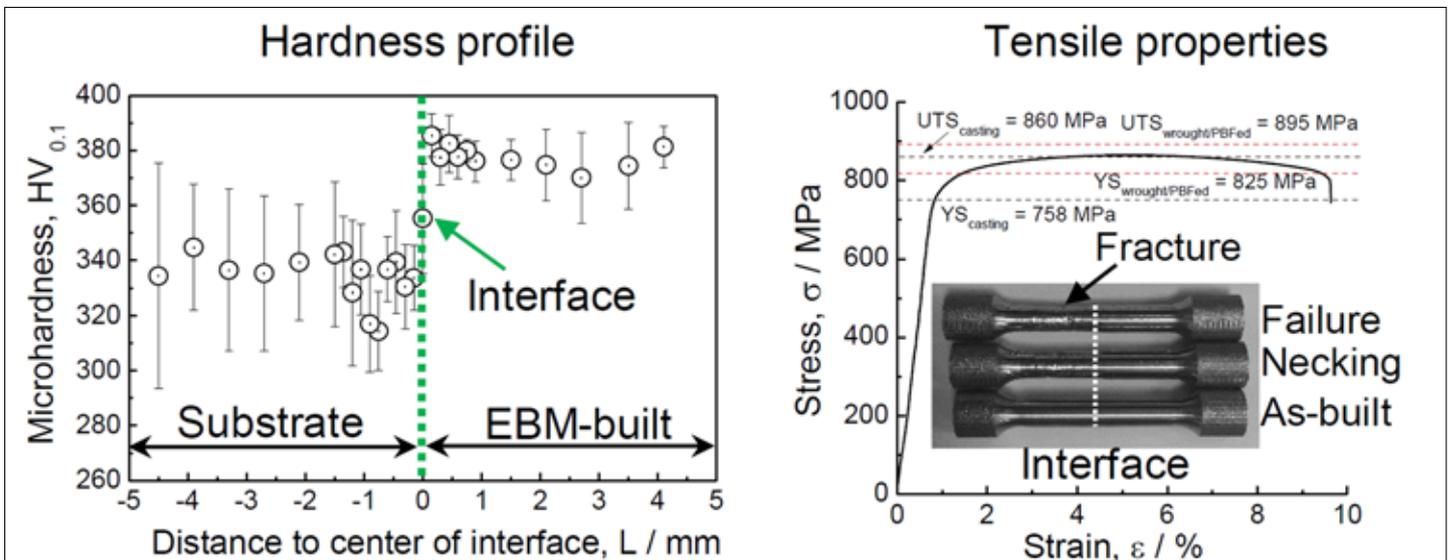
The EBM's advantage of low buy-to-fly ratio and the ability of printing complex parts have been combined with the conventional processing methods (such as forging and machining parts with relatively simple geometry), the total cost

**Hybrid 3D manufacturing could offer a new method of building medium volume components as well as repairing parts that would benefit the aerospace industry**

and lead-time for such hybrid fabrication approach could be significantly reduced.

This technology also includes customised process parameters to tailor the mechanical properties of the complex geometrical part to meet the requirements of specific industrial demands.

For more information, please contact **Dr Wang Pan**, Forming Technology Group at [wangp@SIMTech.a-star.edu.sg](mailto:wangp@SIMTech.a-star.edu.sg)



Mechanical properties of EBM-built hybrid samples

## A number of events were organised in 2019 to engage the industry and forge partnerships



### SIMTech Partnership Night 2019, 13 February

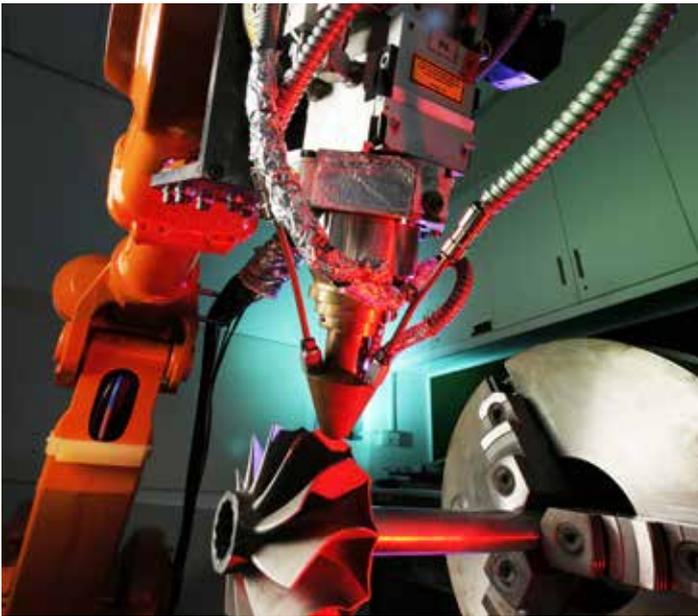
SIMTech ushered in the Lunar New Year together with more than 260 industry partners, representatives from trade associations and government agencies. Reinforcing the commitment for closer collaboration, industry leaders from Singapore Precision Engineering and Technology Association; Print and Media Association Singapore; SEMI Southeast Asia; Association of Aerospace Industries; Singapore Association of Ship Suppliers and Services; Singapore Glass Association; Singapore Industrial Automation Association; Singapore Manufacturing Federation; Singapore Semiconductor Industry Association; Textile and Fashion Federation and representatives from SIMTech, A\*STAR, Economic Development Board, Employment and Employability Institute, Enterprise Singapore, Skillsfuture Singapore and Workforce Singapore turned up in full force to network. SIMTech Partnership Night is also an opportunity to update the guests on the institute's activities, initiatives and upcoming events.



### Visit of Delegates from Free State of Saxony, Germany, 15 March

Exploring opportunities to collaborate in industry partnerships and research, a group of Chief Executive Officers, Directors and Professors from leading companies, research institutes and universities in the Free State of Saxony, Germany visited SIMTech Valley Block. The delegation was coordinated by Prof Christoph Leyens, the Managing Director of Fraunhofer Institute of Materials and Beam Technology (IWS). The visitors were given an overview of SIMTech and insight of the research activities in 3D additive manufacturing technologies and forming technologies during their tour of the research facilities.

Collaborative Industry Projects (CIPs), initiatives, programmes and ready-to-go technologies are available to assist industry



## Large Format 3D Printing with Laser Aided Additive Manufacturing (LAAM)

This programme uses LAAM technology which utilises high energy laser beam for material deposition to enable 3D additive manufacturing, surface modification and repair with high flexibility to achieve good mechanical properties, wear and corrosion resistance.

For enquiries, please contact **Mr Tan Lye King** at [tanlk@SIMTech.a-star.edu.sg](mailto:tanlk@SIMTech.a-star.edu.sg)

## SIMTech Scalable Mobile Platform (SMP) Programme

This programme aims to enable the development of customised mobile platform to suit different industry needs, and to realise high mobility critical for easy manoeuvring in cramped spaces and for effective docking.

For enquiries, please contact **Mr Tan Chee Tat** at [cttan@SIMTech.a-star.edu.sg](mailto:cttan@SIMTech.a-star.edu.sg)

## Protective Coating and Corrosion Assessment

This programme aims to develop and apply advanced surface coating processes via Physical Vapour Deposition coating, Thermal Spray coating, Electrochemical processes, anodising, electroplating, conversion coatings, etc, to create new desired surface protection and/or to improve existing protective performance pertaining to surface quality and morphology.

For enquiries, please contact **Mr Goh Chee Chien** at [gohcc@SIMTech.a-star.edu.sg](mailto:gohcc@SIMTech.a-star.edu.sg)



## Real-Time Dashboard

Connect to multiple data sources to transform real-time data into business insights; allowing business owners to make timely fact-based decisions for unrivalled business performance. Easy to use with alerts and drill-down capabilities, the web-based real-time dashboard is fully customisable to suit company needs.

For enquiries, please contact **Mr Gary Kwok** at [gary\\_kwok@SIMTech.a-star.edu.sg](mailto:gary_kwok@SIMTech.a-star.edu.sg)

## Maintenance Management System

A system to help companies to digitise and manage their activities from preventive maintenance, ad-hoc repairs, spares checking to report generation.

For enquiries, please contact **Mr Wong Ming Mao** at [mmwong@SIMTech.a-star.edu.sg](mailto:mmwong@SIMTech.a-star.edu.sg)

## Project Resource Management System

A system to help companies better manage projects by tracking actual resources as well as calibration and inspection of safety equipment.

For enquiries, please contact **Mr Wong Ming Mao** at [mmwong@SIMTech.a-star.edu.sg](mailto:mmwong@SIMTech.a-star.edu.sg)

## Mobile Workflow – wfMobile™

A platform for mobile workforce to perform user-configurable business / operational transactions using Android devices.

For enquiries, please contact **Dr Justin Lim** at [limkm@SIMTech.a-star.edu.sg](mailto:limkm@SIMTech.a-star.edu.sg)

## PE COI Annual Conference 2019

8 May 2019 | 8.00am-5.30pm | Matrix @ Biopolis, Level 4, Breakthrough & Discovery Theatres

The theme of **PE COI Annual Conference 2019**, organised by SIMTech in collaboration with Singapore Precision Engineering and Technology Association (SPETA), is **Beyond 10 Years Supporting the PE Industry – on Internationalisation** to help PE companies understand the needs and challenges when undertaking international business operations.

At this conference, you learn more about how PE companies can leverage on the existing PE Industry Transformation Map (PE ITM). Divided into four sessions, each session is aligned to topics specific to a PE ITM pillar – Internationalisation, Innovation, Productivity and Jobs and Skills. Mr Kenichi Inoue, General Manager of Global Research & Innovative Technology Center (GRIT), Hitachi Metals, Ltd. is invited to share the advanced metal powder opportunities and the manufacturing technologies in the application space of a wide variety of industries.

For enquiries, please contact **Ms Nadia Chandra Sekar** at [sekarn@SIMTech.a-star.edu.sg](mailto:sekarn@SIMTech.a-star.edu.sg)



Scan for more events

### PE WSQ Graduate Diploma in Advanced Welding Technologies

**Module 4: Review Welding Operation & Quality Control**

25 April 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### PE WSQ Graduate Diploma in Additive Manufacturing

**Module 3: High Speed Additive Manufacturing Processes for Metallic Components**

25 April 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### PE WSQ OMNI Programme

29 April 2019 | 8.30am - 12.30pm | Fusionopolis 2

### Master Class in Mastering Sales and Operations Planning (S&OP) Process to Align Strategies for Operational Excellence

6 - 7 May 2019 | 8.30am - 5.30pm | Fusionopolis 2

### Fast Value from I4.0 Data Analytics - A Master Class in Digital Transformation

15 - 16 May 2019 | 9.00am - 5.30pm | Fusionopolis 2

### PE WSQ Plan and Manage Project for Implementation

22 May 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### Understanding & Derive Impacts of Industry 4.0 - A Master Class in Digital Transformation

23 - 24 May 2019 | 9.00am - 5.30pm | Fusionopolis 2

### Master Class in Supply Chain Analytics – Descriptive, Predictive & Prescriptive Analytics

17 - 18 June 2019 | 8.30am - 5.30pm | Fusionopolis 2

### PE WSQ Dimensional Measurements and Metrology

1 July 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### PE WSQ Graduate Diploma in Additive Manufacturing

**Module 4: Polymer-based Additive Manufacturing Processes for Flexible Mass Customisation**

2 July 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### PE WSQ Graduate Diploma in Mechatronics

**Module 3: Develop Machine Health Monitoring Techniques and Vibration Control**

2 July 2019 | 6.30pm - 9.30pm | Fusionopolis 2

### Greater Benefits When Lean Meets I4.0 - A Master Class in Digital Transformation

10 - 11 July 2019 | 9.00am - 5.30pm | Fusionopolis 2

### Responsive I4.0-enabled Logistics & Supply Chain - A Master Class in Digital Transformation

17 - 18 July 2019 | 9.00am - 5.30pm | Fusionopolis 2

For course details and registration, please visit <http://KTO.SIMTech.a-star.edu.sg>

For general enquiries, please contact

Tel: 6590 3193 or email: [KTO-enquiry@SIMTech.a-star.edu.sg](mailto:KTO-enquiry@SIMTech.a-star.edu.sg)



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#### About SIMTech

The Singapore Institute of Manufacturing Technology (SIMTech) develops high-value manufacturing technology and human capital to enhance the competitiveness of Singapore's manufacturing industry. It collaborates with multinational and local companies in the precision engineering, medtech, aerospace, automotive, marine, oil & gas, electronics, semiconductor, logistics, and other sectors.

SIMTech is a research institute of the Agency for Science, Technology and Research (A\*STAR). With a pool of more than 450 researchers, we are committed to serving the manufacturing industry to develop the human, intellectual, and industrial capital in Singapore.



**SIMTech**

for Industry