

# MANUFACTURING MATTERS

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**FEATURE**

## ENVIRONMENTALLY-FRIENDLY COATING ENHANCES PRODUCTS

SUCCESS STORY  
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FOR MANUFACTURING

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SOURCE FOR INDUSTRY

## NOTE FROM EDITOR...

Dear Friends and Industry Partners,

The use of non-environmentally-friendly technology in manufacturing processes is not a sustainable option for companies. Take the case of hard chrome, a common engineering solution for corrosion issues, is known to be environmentally-unfriendly as fumes hazardous to the health of the operator is emitted during the plating process. Hard chrome plating is also a slow coating process. To build up a 100 micron thick coating on a component surface takes at least 8 hours. Including the cleaning, masking, demasking and other steps in the whole process typically requires 3 to 5 working days.

For environment-friendliness and to move up the value chain, greener technology such as thermal spray coating can be used effectively to achieve better product performance. O.E. Manufacturing is one such company that has successfully tapped on this technology to its advantage, in partnership with SIMTech and capability development grant support from SPRING Singapore. This research collaboration and the positive outcomes and results are detailed in the Feature opposite.

To know more, Dr Chen Wei Long at [wlchen@SIMTech.a-star.edu.sg](mailto:wlchen@SIMTech.a-star.edu.sg) will be most happy to answer your enquiries.

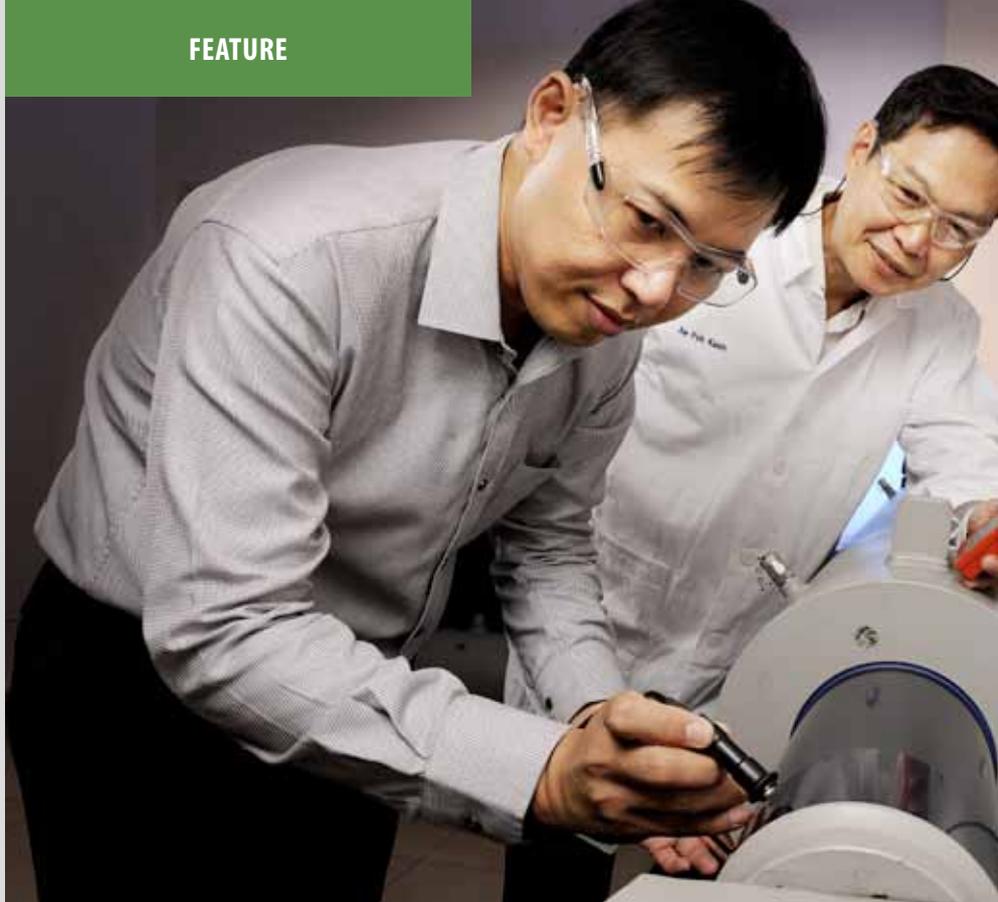
**WISHING OUR FRIENDS AND INDUSTRY PARTNERS A HAPPY AND PROSPEROUS LUNAR NEW YEAR**



**Swee Heng**

*Editor, Manufacturing Matters*

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## ENVIRONMENTALLY-FRIENDLY COATING ENHANCES PRODUCTS

### Thermal spray coating overcomes the challenges of hard chrome plating

Hard chrome plating is widely applied on the sliding rod surface of hydraulic cylinders. The plated rod surface provides the necessary lubricity to the interface between the cylinder rod surface and the seal which contains the high pressured hydraulic fluid in the cylinder. During operations, the cylinder rod surface will continuously rubbed against the seal and over time as corrosion set in, the rust developed rough surface will damage the seal. The damaged seal causes the hydraulic fluid to leak from the cylinder, resulting in operation failure and the discharged fluid pollutes the environment. Hard chrome plating process is also known to be environment unfriendly due to the toxic chemical used and disposal.

Considering these challenges, O.E. Manufacturing, a leading Singapore-based hydraulic cylinder manufacturer for the Marine & Offshore, Oil & Gas, Agriculture, Waste Management, Mobile and Transportation and other infrastructure sectors with established distributorships in Western Europe, Scandinavia, Middle East and South East Asia, has adopted thermal spray ceramic coating as an innovative approach to enhance its company products' performance.



### Thermal Spray Coating Development

This began with coating benchmarking study against hard chrome, powder materials evaluation and development as well as coating equipment supplier evaluation. The powders compositional development selects and optimises the suitable material composition for cylinder rod application. With the selection of the appropriate powder composition, a ceramic coating that has the desired hardness of hard chrome was developed.

**“ We are very happy to have a new product series with added reliability and quality that are truly Made in Singapore. O.E. Manufacturing is playing a role in contributing to a greener manufacturing environment as the newly developed products are completely hard chrome free. ”**

**With the new knowledge, we are in full control of the product design and production. In the past, with the outsourcing of the coating to a coating provider, there is no way of checking whether the received coating meets specifications. Now, we are able to instruct the coating provider exactly what to do and take full control in the product quality ”**

Mr James Wong, Managing Director, O.E. Manufacturing



Laboratory test in accordance to ASTM B117, an industry test standard by exposing the coating to continuous salt spray mist as a simulated marine environment, proved that ceramic coating has over 20 times higher corrosion resistance than hard chrome plating.

An impact test in accordance to ASTM D2794 was also conducted to address the concerns of potential coating damage arising from mishandling during installation. Positive test results showed only a dent on the spot of impact with no visible crack and coating delamination.

Coatings developed were qualified through various other laboratory tests which include hardness, microstructure analysis, chemical composition analysis,

simulated service environment tests in accordance to international test standards.

With the positive outcomes, O.E. Manufacturing set up a Quality Assurance and R&D laboratory to meet the demand and challenges from potential clients of various industries. Through the project, the engineer and production staff were trained and qualified for the production of the new coating. The validated results derived from the qualification testing established and enriched the engineering design database for hydraulic cylinder components through coatings performance tests and validation. The performance criteria are hardness, surface roughness, adhesion strength, impact resistance energy and corrosion protection rating.

For O. E. Manufacturing, this developed capability paves the way for non-conventional business opportunities as ceramic coating has many potential applications in the aerospace, automotive, electronics, medtech and energy sectors.

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## A MORE SUPERIOR PIPE TAGGING METHOD

PEC Ltd (PEC), an engineering specialist public-listed company provides project works and maintenance services to the oil and gas, petrochemical, oil and chemical terminals, and pharmaceutical industries, partnered SIMTech to develop a cost effective portable marking system that uses near-infrared fibre laser to tag its pipe products. This method is more superior than the traditional use of special tear and water-resistant paper and aluminium alloy plate which requires huge amount of preparation and consumables. This marking technology was subsequently licensed to PEC Ltd from ETPL, the commercialisation arm of A\*STAR.

**“ We are continuously exploring ways to tap on innovative use of technology to enhance our business while adhering to stringent safety and quality standards. After adopting this technology, we look forward to further collaborations with A\*STAR ”**

Mr Cheng Beng Kwang, Associate Director, Projects, PEC

This laser marking system can also be used directly to mark various steel pipe surfaces and allows the substitution of tag materials with cheaper options to improve cost savings. Its portability enables PEC to mark big and heavy parts located in different sites. Using this system, PEC achieved 75 per cent savings in manpower and materials. As such, the company is able to redeploy its excess manpower to work on other areas of production, thus increasing the company's throughput.

For more information, please contact **Dr Alex Thoe** at [tbthoe@SIMTech.a-star.edu.sg](mailto:tbthoe@SIMTech.a-star.edu.sg)



## OTR GROWS SME

XDel, a logistics company specialising in last mile deliveries, engaged Operation Technology Roadmapping (OTR) in 2015. The SIMTech team helped XDel create its roadmap by identifying its key external drivers, prioritising its future technology investments, and determining its future business direction.

With the completion of OTR, XDel was able to expand into higher value-added services which includes enhanced last mile fulfilment and e-Commerce delivery booking platform as well as international cross order services. Its 5-year strategic plan and roadmap have cemented its R&D direction and efforts with a next-generation Smart and Dynamic Route Optimisation system. In addition, XDel also commenced with the development of its mobile Apps and Software and these initiatives are expected to roll out progressively through 2017.

After the OTR, XDel embarked on a Feasibility Study of Vehicle Routing for Last Mile Logistic Planning with a research institute to analyse its system data and assist in the software development. During the same period, XDel also began enhancing and introduced advanced Mobile Tracking Initiative in line with its identified external drivers of Internet of Things and Smart Nation in the roadmap, allowing for live tracking of all deliveries. As such, up to four customer service headcount cost was saved due to less monitoring with real-time tracking and live updating by the ground staff, along with reduced human error and repetitive tasks that impede deliveries.

**“ OTR is an eye opener. Now, we do more with less. Our productivity gains are massive, and our couriers can do much more on the ground ”**

Mr Eddie Lee, Director, Sales & Marketing, XDel

For more information, please contact **Mr Jeff Pan** at [sppan@SIMTech.a-star.edu.sg](mailto:sppan@SIMTech.a-star.edu.sg)



Interior configuration of a powered caster wheel



Intuitive robot teaching for tool paths

# AUTOMATION TECHNOLOGY FOR MANUFACTURING

## Two Collaborative Industry Projects launched to speed up mass adoption

### CIP 1: SIMTech Scalable Mobile Platform

Mobility is a bottle-neck in material transfer on many manufacturing shop floors. Automated Guided Vehicles (AGVs) employed as an off-the-shelf component by system integrators cannot be customised easily for different applications.

In this CIP, we aim to allow companies explore a new platform technology called Scalable Mobile Platform (SMP). The SMP features powered caster wheel modules that enable the development of customised mobile platform for different needs. Together with the control software, the mobile platform can realise high mobility critical for easy manoeuvring in cramped spaces as well as for effective docking.

In two phases, the first phase trains companies with basic knowledge in mobile robotic technology and the requisites for effectively adopting the SMP technologies. The second phase provides the company with the opportunity to apply SMP to test out for its own application. The deliverables include a demonstration of the key required functionalities using SMP for

an identified application in a mock-up environment.

### CIP 2: PATH and PACE

A two-pronged approach is used to meet the needs of both SMEs and System Integrators (SIs) for improving productivity. For SMEs, a Process Automation Design Methodology (PATH) is introduced for assessing the manufacturing processes and proposed automation approach. For SIs, a Plug & Play Automation Control Engine (PACE) platform is used to facilitate the implementation of automation solution.

PATH is a process assessment tool to provide suitable automation means for a particular operation. In this CIP, learning sessions on robotics and automation basics will be conducted followed by a practice phase involving hot spots identification over an entire process chain provided by the company. The deliverables include the automation assessment result, automation concept and system implementation plan.

PACE provides a common platform for fast development and deployment of automation systems, which include key

components in robots and automation peripherals. In the PACE CIP, training for adoption of PACE control engine software toolkit will be a deliverable.

With the acquired knowledge, SMEs can tap the robotics and automation technologies effectively for productivity improvements. For SIs, new business opportunities emerged as a result of the collaboration with companies and SIMTech.

Target companies of the CIPs are in the sectors of Precision Engineering, Aerospace, Marine & Offshore, Logistics, Service and Food Manufacturing, as well as SIs who are interested to partner with SIMTech to adopt the robotics and automation technologies needed by the end users.

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[cttan@SIMTech.a-star.edu.sg](mailto:cttan@SIMTech.a-star.edu.sg) for SMP CIP

**Mr Foo Yeong Han** at  
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# GENERATING VALUE FOR PE INDUSTRY IN LAB-ON-A-CHIP

Multinational Corporations (MNCs) and Small and Medium Enterprises (SMEs) are participating in Collaborative Industry Project (CIP) to build capabilities

The demand for Lab-on-a-Chip (LOC) products is growing rapidly worldwide opening opportunities as well as challenges to the precision engineering (PE) and MedTech industries. A LOC device integrates one or several laboratory functions on a microfluidic chip to achieve automation and high-throughput screening. LOC technology is becoming an important part of efforts to improve global health, particularly through the development of point-of-care (POC) testing devices and systems. A typical LOC product consists of microfluidic device in the form of chip, cassette or cartridge, and a system

which manipulates the microfluidic device and analyses the reaction results.

Specific knowledge, skill and know-hows are required to cope with the design and manufacturing of the LOC devices and systems. Help is now available through the CIP for companies to extend their business into Point-of-Care (POC) and in-vitro diagnostics (IVD). SIMTech has been developing the capabilities for LOC design and development since 2007 to become the only research organisation in this region that specialises in providing manufacturing solutions for polymer microfluidic devices.

In this CIP, SIMTech works with the 14 participating companies to develop up-to-date knowledge about the LOC product design and system integration. Its scope covers the LOC technology overview, the analysis of key functions such as microfluidics flow manipulation and optical detection, LOC product design, as well as the MedTech product regulation and quality management system. Eligible participating companies can tap on SPRING Innovation Credit Voucher for SMEs, e2i grant for both MNCs and SMEs, IRAS Productivity and Innovation Credits for both MNCs and SMEs.

**On CIP completion, participating companies are expected to benefit from upgraded competence on LOC device design and system integration; expand business with wider product range and gain business in LOC product development and manufacturing**

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# SETTING UP NEW CAPABILITIES FOR INDUSTRY NEEDS

## Timely move to address gap in Photochemical Etching

In response to industry demand, SIMTech initiated a Collaborative Industry Project (CIP) to develop manufacturing capability on photochemical etching. Several multinational companies (MNCs) in Singapore require local manufacturing support with Photochemical Etching (PCE) processes for their precision parts used in analytical tools, medical devices, and vacuum process related machineries. These products are typically of high value, but low in volume and high mix in variety. The MNCs are keen to develop local suppliers with the aim of localising their product manufacturing.

To assist industry in this CIP, a shared facility will be set up in SIMTech with researchers working alongside engineers from participating companies to develop basic PCE process capabilities, enabling participants to embark on supplier qualifications as required by the MNCs. Interested

MNCs support the project by providing product specifications and qualify potential suppliers. SPRING Singapore provides funding under the Capability Development Grant scheme to eligible participating Small and Medium Enterprises (SMEs).

SIMTech's contributions to this CIP are to adapt to PCE product quality and requirements by MNCs, transfer knowledge and provide training to operate a PCE manufacturing line.

In this CIP, participants acquire expertise in PCE process optimisation with the fabrication line. With reference to technical specifications of a typical part from one of the participating MNCs, a PCE process will be optimised to produce acceptable parts with Stainless Steel substrates. From one reference part shown by a MNC, the dimensional accuracy to be achieved will be in the range of  $\pm 0.1$  mm for a beam of 0.8 mm. Process control parameters of

**The participating PE suppliers would take on the know-how through SIMTech and eventually acquire the product qualification approvals by MNCs to secure mass manufacturing**

all the steps will be established and documented with a production yield of more than 90 per cent.

For enquiries, please contact  
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Tray Return System @ Timbre+

# FOOD ATRIUM GOES HIGH-TECH

## RFID technology boosts tray return

Labour shortage is a challenge in Singapore. Hawker centres are not spared, lacking cleaners to clear and collect used food trays. Although many measures were taken to encourage diners to return the used trays after meals, these are not effective. Timbre+ food atrium, facing a similar challenge, approached SIMTech as recommended by SPRING Singapore and Infocomm Development Authority with requirements for a solution to improve the tray return and to reduce the manpower needed to clean the food atrium.

With the requirements of Timbre+, SIMTech worked with Tunity, a



RFID-tagged trays

“ More enquiries were received as interests for implementation of such a system grows ”

Ms Lim Peck Hui, Managing Director,  
Tunity Technologies Pte Ltd

technology partner of SIMTech specialising in RF and RFID technology, to design and develop the RFID-based Tray Return System. Conceptual design, detailed design, exception handling, prototype and testing for both hardware and software were involved. Through licensing SIMTech technology, Tunity implemented and deployed the system in the Timbre+ food court.

With the jointly developed innovative RFID-based tray return system, diners are encouraged to return the trays after meals. Diners pay a \$1 deposit for a RFID-tagged tray at a food stall and, when they have completed their meals, they drop it off at a conveyor belt equipped with an RFID reader.

When the reader detects that a tray has been returned, a machine returns the deposit, and the tray carries on towards a washing station.

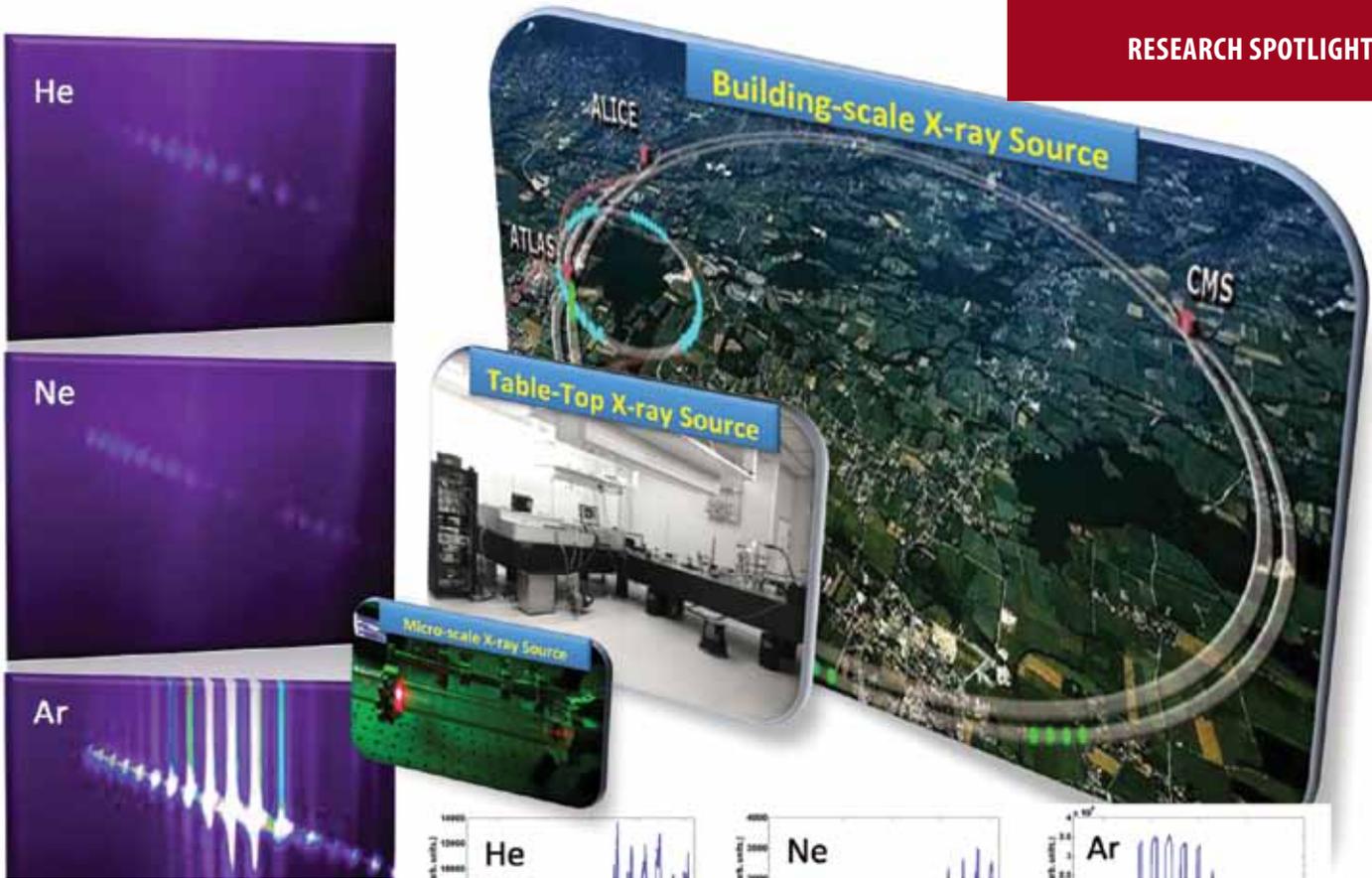
Over 95 per cent of the diners return their trays after meals, reducing the efforts of 8 cleaners to 3 to do this work, helping to resolve the labour shortage especially cleaners in food atriums and also enforce the habit of diners to return the trays after meals. It results in a cleaner and happier public meal environment. Timbre+ becomes the model that other food courts and hawker centres can emulate.

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# AFFORDABLE TABLE-TOP X-RAY SOURCE FOR INDUSTRY

High order Harmonic Generation from gas atoms is the approach

Coherent extreme ultraviolet (EUV) / soft X-ray light source is the core equipment for next generation integrated circuit nano-lithography, nano-resolution microscopy and ultra-high accuracy chemical and biological analysis. The EUV soft X-ray light source, at wavelength from 1 to 100 nm, allows scientists and engineers to “see” smaller features and “write” smaller patterns than would be possible with visible light. Also, it is able to generate the “camera flash” thousand times faster than any visible equivalent to capture the motion of electrons. As such, dozens of synchrotrons, the only facility able to generate EUV X-ray light source, is constructed globally. However, the extremely high cost and the building-size scale synchrotron make it only affordable at the national level, limiting its use. For example, the most famous particle accelerator, Large Hadron Collider (LHC) near Geneva, has a circumference of 27-kilometre with a construction cost of €7.5 billion.

High order harmonic generation (HHG) from gas atoms is an alternative approach to generate EUV soft X-ray source. Intense laser light is focused into rare gas. The light intensity is so strong that it is able to rip some electrons from the atoms. The electron will be accelerated by the surrounding laser field and oscillate strenuously in light speed. When such high speed electrons collide with nearby ion, EUV soft X-ray emits. As the whole process is driven by the same laser, the emitted EUV soft X-ray is a fully coherent and laser-like beam. Compared with particle accelerator, the high order harmonic system can be very compact, of table-top size and comparatively low cost of few hundreds of thousands. This makes it affordable for companies or organisations for industrial use instead of academic purpose only.

Dr Li Hao from SIMTech, working in collaboration with Professor Wang Qijie from Nanyang Technological University,

has successfully built a table-top HHG based EUV soft X-ray source platform in SIMTech. The system is able to provide coherent broadband EUV beam with cut-off frequency of around 100 eV which is important for the fabrication of feature sizes of 10 nm on integrated-circuit.

**The researchers are now focusing on improving the cut-off frequency to provide a true nano-scale imaging, ablation and fabrication tool for industry and even personal use in future**

For more information, please contact **Dr Li Hao** at [hli@SIMTech.a-star.edu.sg](mailto:hli@SIMTech.a-star.edu.sg)

A number of events were organised in 2016 to engage the industry and forge partnerships

## MPTC Annual Conference 2016 , 12 Oct

This yearly event shared productivity improvements by local enterprises through the use of technology and innovation attracted 266 representatives from industry. With the theme, "Productivity Transformation through Innovation", it focused on value creation and generating new business opportunities.

Ms Jenny Teng, Vice President/Board of Director from Toshiba TEC Singapore presented the Journey of Toshiba TEC Business Transformation. Mr Sacca Chong, CEO of Wing Tuck Engineering Pte Ltd, highlighted the Productivity Gain with Field Workers Identification and Tracking. A & One's Lean Thinking Cultural Transformation was demonstrated by Ms Lim Sock Siang, Senior Manager. Supporting Industry Transformation through the MCT™ Learning Factory was shared by Dr Tan Puay Siew, Programme Manager of Manufacturing Control Tower, SIMTech.



Two parallel technical sessions in Engineer Value Innovation and Enhance Efficiency/Ensure Effectiveness were organised. Productivity 1-1 Discussion Sessions to discuss on productivity challenges and solutions were also provided.

Co-located with MPTC Annual Conference 2016 was Manufacturing Solutions Expo (MSE) 2016 of Singapore Manufacturing Federation (SMF). It showcased innovative solutions, cost effective technologies and products to improve business productivity and efficiency within and beyond manufacturing.

At the event, 23 companies from industry received the Productivity Partners Recognition Award from Minister of State for Trade & Industry and National Development, Dr Koh Poh Koon. A Memorandum of Understanding was signed between SMF and SIMTech in using innovation to improve manufacturing productivity. A Partnership Agreement was also sealed between SIMTech and NTUC LearningHub as well as Workforce Advancement Federation to enable more companies to acquire know-how to boost productivity and nurture in-house productivity champions.

MPTC Annual Conference 2016 was organised by SIMTech in partnership with Employment & Employability Institute, SMF and SPRING Singapore.

## SMC Annual Conference and Technology Exhibition 2016, 3 Nov

This event aimed to help local companies utilise fewer resources and optimise their use. It was attended by 200 industry professionals.

Professor Christoph Herrmann, Director of the Institute of Machine Tools and Production (Germany) shared a comprehensive review on how life-cycle engineering is an indispensable tool for sustainability issues in manufacturing. Materials Informatics and the availability of a variety of inexpensive tools, apps and methodology coupled with the knowledge of diverse manufacturing processes and materials enable resources productivity, process efficiency, environmental performance of products and, zero waste was presented by Dr Seeram Ramakrishna, Professor, Materials Engineering, National University of Singapore. Mr Satish Lele,



Senior Vice-President of Frost & Sullivan (Singapore) provided the market and industry landscape of resource efficiency, from the local and regional perspectives.

The event was co-organised by the Singapore Business Federation and supported by the Employment and Employability Institute, Waste Management and Recycling Association of Singapore and the Singapore Green Building Council.

Collaborative Industry Projects (CIPs) are cost-effective R&D platforms, where companies facing similar issues work jointly with SIMTech, to develop manpower and technology

## 3D Additive Manufacturing Capabilities of Metal and Polymer Parts

Call for Participation

This CIP aims to demonstrate 3D Additive Manufacturing process capability from design to process optimisation, material preparation and handling, product processing to secondary operations. Companies can use this platform for quicker adoption of 3D AM technology by leveraging on SIMTech's know-how and facilities.

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

## Advanced Machining Techniques

Call for Participation

This CIP aims to improve the productivity and surface quality in precision machining (milling and turning) via Quick Milling Vibration Solver which helps eliminate machining chatter and improve surface finishing of machined parts caused by vibration.

For enquiries, please contact **Dr Mehrdad Zarinejad** at [mehrdad@SIMTech.a-star.edu.sg](mailto:mehrdad@SIMTech.a-star.edu.sg)

## Feasibility Study of Antimicrobial (AMB) Easy Clean Coatings for Child-care Centres

Call for Participation

This project aims to also incorporate chemical additives for hydrophobic easy-to-clean properties for easy removal of Hand Foot Mouth (HFM) virus in addition to the AMB properties.

For enquiries, please contact **Mr John Lim** at [kylim@SIMTech.a-star.edu.sg](mailto:kylim@SIMTech.a-star.edu.sg)

## Functional Coating

Call for Participation

This CIP aims to develop and apply advanced surface coating processes via sol-gel materials formulation. This might include the incorporation of nanomaterials and special additives, combining UV curable or ambient curable technologies to create new desired surface functionalities and/or achieve improvement of existing functional performance applicable for products.

For enquiries, please contact **Dr Mehrdad Zarinejad** at [mehrdad@SIMTech.a-star.edu.sg](mailto:mehrdad@SIMTech.a-star.edu.sg)

## PATH and PACE for Mass Adoption of Automation and Robotics Technologies

Call for Participation

This CIP aims to prepare the industry for adopting robotics and automation solutions for their challenging manufacturing processes. A two-pronged approach is used for meeting the needs of both SMEs and the System Integrators (SIs). For SMEs, a Process Automation Design Methodology (PATH) is introduced for assessing the manufacturing processes and proposed automation approach. For SIs, a Plug & Play Automation Control (PACE) platform is introduced to facilitate the implementation of automation solution (See page 5 for more details).

For enquiries, please contact **Mr Foo Yeong Han** at [yhfoo@SIMTech.a-star.edu.sg](mailto:yhfoo@SIMTech.a-star.edu.sg)

## Scalable Mobility Platform (SMP) for Mobile Robots

Call for Participation

This CIP aims to promote the adoption of mobile robot for automating the material transfer through a platform technology. Such platform technology features modular powered caster wheels that enable the development of customised mobile platform to cater for different needs. This CIP allows SIs as well as SMEs to understand such technology and to prepare them for developing the mobile robots with desired specification requirements (See page 5 for more details).

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

Call for Participation

This CIP 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 **Dr Mehrdad Zarinejad** at [mehrdad@SIMTech.a-star.edu.sg](mailto:mehrdad@SIMTech.a-star.edu.sg)

## SIMTech Membership Networking Night 2017

8 February 2017 | 6.00pm - 10.00pm | Holiday Inn Singapore Atrium

This annual dinner brings SIMTech's industry partners, trade associations, and government agencies together for networking and Lunar New Year celebration. At the event, SIMTech will share the upcoming activities, latest technologies, as well as updates to bring more value to you and manufacturing in Singapore.

For enquiries, please contact **Mr Cedric Yon** at [xyyon@SIMTech.a-star.edu.sg](mailto:xyyon@SIMTech.a-star.edu.sg)



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## PE WSQ Graduate Diploma in Advanced Welding Technologies

**Module 4: Adopt Friction Stir Welding and Diffusion Bonding**

17 January 2017 | 6.30pm - 9.30pm, Fusionopolis Two

## PE WSQ Review Heat Treatment Process for Metals

7 February 2017 | 6.30pm - 9.30pm, NTU Valley Block

## PE WSQ Graduate Diploma in Precision Measurement Characterisation (PMC)

**Module 4: Image Processing and Industrial Vision Inspection**

7 March 2017 | 6.30pm - 9.30pm, Fusionopolis Two

## PE WSQ Graduate Diploma in Metal Manufacturing Processes

**Module 1: Evaluate Advanced Metal Machining Techniques**

7 March 2017 | 6.30pm - 9.30pm, NTU Valley Block

## PE WSQ Graduate Diploma in Precision Measurement Characterisation (PMC)

**Module 5: Materials Characterisation**

9 March 2017 | 6.30pm - 9.30pm, NTU Valley Block

## PE WSQ Programme in Integrated Carbon Footprint Assessment Reporting Essentials

20 March 2017 | 6.30pm - 9.30pm, Fusionopolis Two

## PE WSQ Graduate Diploma in Advanced Welding Technologies

**Module 5: Evaluate Advanced Brazing**

21 March 2017 | 6.30pm - 9.30pm, Fusionopolis Two

## PE WSQ Course in Productivity Improvement through Energy Usage Pattern Monitoring and Analysis

3 April 2017 | 6.30pm - 9.30pm, e2i

## PE WSQ Graduate Diploma in Mechatronics

**Module 2: Enhance Control Performance of Precision Machines**

10 April 2017 | 6.30pm - 9.30pm, Fusionopolis Two

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

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Tel: 6501 1800 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 400 researchers, we are committed to serving the manufacturing industry to develop the human, intellectual, and industrial capital in Singapore.

