KIST-HTWK Leipzig Conference 2022

Abstract Book

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Hosted by

KIST Institute of Advanced Composite Materials

HTWK Leipzig University of Applied Sciences

Institute of Advanced Composite Materials

HTWK
Leipzig University of Applied Sciences

KIST-HTWK Conference 2022

(11th Oct, 2022)

Moderator: Jun Yeon Hwang (KIST)

Korea Time	Conference Schedule	
14:00 – 14:10	Opening Remarks	HTWK Director KIST Director
14:10 – 14:15	Institute of Advanced Composite Materials in KIST: Open Another World with Composite Materials beyond the limit	Sungho Lee KIST
14:15 – 14:35	HTWK Leipzig – Introduction and materials science research	Robert Böhm HTWK
14:35 – 14:50	Ultralight multifunctional composite structures with integrated energy storage function	Robert Böhm HTWK
14:50 – 15:05	Engineering of multifunctional 2D materials via chemical functionalization	Jangyup son KIST
15:05 - 15:25	Identification of circular ecosystems for large-scale composite components based on a Multi-Tiered System of Recycling (MTS-R)	Philipp Johst HTWK
15:25 - 15:40	Design of Polymers with Dynamic Bonds and their Application to Composites	YongSeok Choi KIST
15:40 - 15:55	Breaking Time	-
15:55 - 16:10	Innovative metal-polymer hybrid 3D printing for composites and advanced applications	Jun Yeon Hwang KIST
16:10 - 16:30	Hybrid and additive manufacturing technologies at HTWK – people and projects	Peter Schulze HTWK
16:30 - 16:45	Acoustic emission analysis of carbon fiber-reinforced composite	Wonjin Na KIST
16:45 - 17:05	Materials research on martensitic stainless steels - current and future research topics	Paul Rosemann (Online) HTWK
17:05 - 17:10	Closing Remarks	HTWK Director KIST Director

Introduction & Vision of KIST Institute of Advanced Composite Materials: Open another world with composite materials beyond the limit

Jin Sang Kim

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KIST Jeonbuk Institute of Advanced Composite Materials was established with the mission to take the lead in the development of key materials closely associated with the region's strategic industries, which will contribute to the nation's international competitiveness and self-reliance in the composite materials industry. Since its establishment in 2007, we have led the development of the composite materials industry in Korea under the regional strategic industry growth initiatives. With the vision of opening another world with composite materials beyond the limit, we focuse on the development of high-performance functional composite materials, carbon composite materials, and structural composite materials. by understanding, controlling, and applying the microscopic phenomena within the materials for the purpose of leading the development of source technology and the commercialization of next generation materials. As the nation's center of composite materials research and development, we are dedicated to contributing to strengthening national competitiveness and laying foundations for expanding the domain of the novel composite materials industry.

Doctor Jin-Sang Kim, Director General of KIST Jeonbuk (Institute of Advanced Composite Materials). He received his Ph. D. from Seoul National University in 1993 and worked at RIKEN in Japan as Post-Doc. in 1999. He was the head of center for electronic materials in KIST from 2015 to 2017 and the head of R&D Group for on-site public security (PoliceLab) from 2019 to 2021. He currently leads Institute of Advanced Composite Materials in KIST since 2020

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HTWK Leipzig – Introduction and materials science research

Robert Böhm

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Leipzig University of Applied Sciences (HTWK Leipzig) is a young university in Saxony (Germany) with more than 7000 students and a unique research profile. With a long tradition originally starting as a School of Civil Engineering, faculties of Engineering, Economics, Cultural Sciences, Informatics, and Digital Transformation have been successfully established. In 2021, the Leipzig Center for Material Science was founded in order to initiate fundamental and applied material research as well as pure industrial R&D in the fields of novel materials for aerospace, automotive industry, construction industry and medical industry. The research covers material development, efficient manufacturing technologies, experimental and applied mechanics, virtual simulation technologies, LCA and recycling. HTWK Leipzig has a focus on applied sciences in order to develop scientific and industrial prototypes and to perform experiments on different length scales.

Prof. Robert Böhm, Professor for Lightweight Engineering with Composites. He received his PhD in Composite Material Science in 2008 from TU Dresden. After a Post-Doc period he habilitated in 2017 on damage tolerant design of composite structures. Since 2020 he is a full professor at HTWK Leipzig, Germany. He is Executive Board Member of the Lightweight Alliance Saxony and Member of several national and international research clusters. He received the IAAM Award „Advancement of Materials“ in 2020 and the Dresden Excellence Award in 2017. He is a co-founder of the “Leipzig Center for Material Science” in 2021. He works on multifunctional composites, experimental diagnostics of composites, modelling and simulation, and on the development of conventional and renewable, resource-efficient composite materials. He has written approx. 200 publications.

Web: https://www.htwk-leipzig.de/startseite/

Ultralight multifunctional composite structures with integrated energy storage function

Robert Böhm, Davood Peyrow Hedayati, Willi Zschiebsch, Michael Kucher

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Lightweight materials and energy storage are of particular importance in the development of electrically powered aircrafts. However, the current battery systems add significantly to the moving mass and thus reduce the achievable range or transport capacity. As a result, electric systems have yet to make a breakthrough in aviation. To make significant progress toward electric flying, the electrical storage systems can be improved using two methods: a higher specific energy density of the individual storage cells, and a targeted multifunctionalization of the composite materials and structures.

Both aspects have been investigated at HTWK Leipzig with particular emphasis on lightweight design. Firstly, multifunctional composite systems with combined structural load-bearing function and electrical energy storage (so-called “structural batteries”) have been developed and tested. This will result in tape-shaped composite semi-finished products with mechanically flexible components like cathode and anode which will be further processed to composite battery tapes. Secondly, solutions have been explored based on the combination of supercapacitors and composite materials (so-called “structural supercaps”). This concept of a structural supercap will open up a wide field of applications in diverse markets, not only for aircrafts but also for other electronic applications, such as laptops. Here, the casing acts as structural battery to store renewable energy. Similarly, structural supercaps, like car chassis, can be used for storing energy of fast-charging electric cars.

Prof. Robert Böhm, Professor for Lightweight Engineering with Composites. He received his PhD in Composite Material Science in 2008 from TU Dresden. After a Post-Doc period he habilitated in 2017 on damage tolerant design of composite structures. Since 2020 he is a full professor at HTWK Leipzig, Germany. He is Executive Board Member of the Lightweight Alliance Saxony and Member of several national and international research clusters. He received the IAAM Award „Advancement of Materials“ in 2020 and the Dresden Excellence Award in 2017. He is a co-founder of the “Leipzig Center for Material Science” in 2021. He works on multifunctional composites, experimental diagnostics of composites, modelling and simulation, and on the development of conventional and renewable, resource-efficient composite materials. He has written approx. 200 publications.

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Engineering of multifunctional 2D materials via chemical functionalization

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Over the last three decades, carbon (one of the most abundant materials found on earth) and carbon nanomaterials (carbon allotrope forms such as 0D fullerenes, 1D carbon nanotubes, and 2D graphene) have attracted significant attention due to their unique electronic, thermal, mechanical, and chemical properties. Recent advances in the synthesis and assembly techniques have renewed interest in employing carbon nanomaterials as the basis of electronic applications, and the flexibility and the low cost of these materials provide the opportunity for many applications such as wearable, disposable, and next-generation electronics. In addition, in these material systems, we can dramatically change their properties by engineering the surface, defect, phase, and interface.

In this talk, I will deliver the recent progress regarding the synthesis of carbon nanomaterials and provide related applications for multifunctional nanocomposite materials and electronic devices. Especially, this talk mainly affords studies on the chemical functionalization of 2D materials and introduces how to modify the surface and interface of 2D vdW heterostructures and control the defects for a broad range of practical applications such as electronics, spintronics, bio-sensors, and energy harvesting.

Doctor Jangyup Son, Materials Science and Engineering Doctor (Ph.D.-engineering), is a Senior Researcher of Functional Composite Materials Research Center at Korea Institute of Science and Technology (KIST) and an Associate Professor (Division of Nano and Information technology, KIST School UST). He received his Ph. D. from Yonsei University in 2015. He studied 2D materials heterostructures at University of Illinois at Urbana-Champaign (UIUC) as a postdoctoral researcher from 2016 to 2019. Currently he researches advanced energy materials and devices as well as the surface chemistry of nanomaterials.

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Identification of circular ecosystems for large-scale composite components based on a Multi-Tiered System of Recycling (MTS-R)

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The demand for composites increased significantly over the last decades. This is due to the excellent properties of composites, especially low weight, corrosion resistance, and a high adaptability of the mechanical stiffness and strength according to the applied loads. Especially in wind energy and aeronautics industry, composites are often used because of these advantages.

However, composite components provide new obstacles for the circular economy. Acting in accordance with Green Deal of the European Commission, new pathways are required to ensure an effective and economic multiple use of end-of-life components.

We introduce a strategic approach for returning decommissioned composites back into the material chain with a particular focus on waste reduction, consequent energy, and emission savings. This Multi-Tiered System of Recycling (MTS-R) aims for sustainable methods in order to exploit numerous circular possibilities, consisting of: reuse, repair, refurbish, remanufacture, repurpose, and recycling.

Based on the proposed framework, circular ecosystems (eco-settings) with minimal entropy are identified and qualitatively defined. These eco-settings comprise closed loops, starting with sorting and dismantling of composites which helps to promote a cascade use of the products. Particularly, the interconnection between the various eco-settings and various R-strategies were described.

M. Eng. M. A. Philipp Johst, Research Associate for Lightweight Engineering with Composites. He received his master's degree in mechanical engineering and his master's degree in general management in 2021 from HTWK Leipzig, Germany. Since 2021 he is a research associate at HTWK Leipzig. He currently works on experimental analysis of impact problems in fiber composite structures. He is participating in the project European recycling and circularity in large composite components (EuReComp).

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Design of Polymers with Dynamic Bonds and their Application to Composites

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Carbon fiber-reinforced composites (CFRP) are of interest as a metal substitute to enable weight reduction because of their high strength and rigidity-to-weight ratio. In particular, the excellent physical properties of CFRP allow their application to models of mass transportation, such as aircraft, automobiles, high-speed trains, and boats. CFRP is generally manufactured using thermosetting resins as matrix materials because of their high mechanical and thermal stability, environmental resistance, and excellent interfacial properties (with carbon fibers). However, thermosetting materials have serious economic and physical drawbacks, such as yellowing and poor impact resistance, and their inability to reshape and recycle due to their crosslinked structures. Therefore, research is underway to replace the thermosetting resin within a CFRP with a thermoplastic resin.

This lecture introduces research conducted to replace conventional thermosetting epoxy resins with thermoplastic resins and non-trimers. PA12, which has formed a supramolecular structure by quadruple hydrogen bonding, exhibits excellent physical properties, demonstrating that it can be applied to CFRP. In addition, the dynamic covalent crosslinked structure prepared using the novel monomer having an imine group exhibited reprocessing and recycling properties, and carbon fibers could be easily recycled when applied to CFRP.

Doctor YongSeok Choi, is a Senior Researcher of Composite Materials Applications Research Center at Korea Institute of Science and Technology (KIST). He received his bachelor's and a doctoral degree from Seoul National University (Ph. D. degree in 2016). He researched superabsorbent polymers at LG Chem. as a Professional from 2016 to 2018. He currently researches polymer matrix with dynamic covalent bond for CFRP application as well as recyclable eco-friendly flame-retardant materials.

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Innovative metal-polymer hybrid 3D printing for composites and advanced applications

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The 3D printing (additive) process technology has the potential to be used in actual industry such as automotive, aerospace, aerospace, and medical care. In particular, the advantage of the 3D printing process, which is not constrained by shape, continues to give researchers a sense of purpose for the development of 3D printing technology. Currently, various 3D printing technologies that can reach the goals of these researchers are being introduced (SLA, FDM, SLS, MJT, etc.). Since there is a large difference in physical properties for each material, it is difficult to achieve complete 3D printing fused between metal-polymer, metal-composite with different physical properties unless the process is performed in an appropriate energy range. So, we studied a hybrid 3D printing technology in which a polymer layer is stacked on a metal (Aluminum) layer in one process using an SLS type 3D printer equipped with a heterogeneous laser (Fiber/CO2). In more detail, strong bonding was induced by optimizing the laser energy density at the interface between the Al and polymer layers. In this study, the limitations of heterogeneous material hybrid 3D printing with different characteristics were solved while utilizing the advantages of 3D printing process technology as it is. For this purpose, the polymer layer is possible when strong bonding between Al-polymer materials is achieved. Therefore, in order to induce strong bonding at the interface of Al and polymer, we focused on analyzing the morphology and chemical properties of the interface. Finally, by controlling the laser energy density for each layer, a 3D printed component was produced in sequence, and the improved bonding strength characteristics of the Al/polymer were numerically demonstrated. We believe that this study will serve as a cornerstone for the development of hybrid 3D printing technology for various heterogeneous materials.

Doctor Jun Yeon Hwang, received the Ph.D from Univ. of North Texas in 2007 at Mater. Sci & Eng. Dr. Hwang’s primary research is in the area of structure-property-processing relationships in materials with an emphasis on Composites and Metal alloys by 3D printing. The advanced characterization techniques involving transmission electron microscopy and X-ray microscopy are mainly used to correlate the physical and mechanical properties in these complex multi-phase, multi-component materials systems.
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Hybrid and additive manufacturing technologies at HTWK – people and projects

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The additive manufacturing group consists of: Dr.-Ing. Tobias Flath, Dipl.-Ing. Lukas Kube, Philipp Zimmermann, M. Eng., Robin Mäder, M. Eng., and Prof. Dr.-Ing. Peter Schulze. In our laboratories, there are optical 3D-scanning systems for the digitalization of complex construction components. Additionally, we develop different 3D printing systems (FLM, SLA and SLS). We use them in our scientific projects and during the practical teaching with the students. Our milling and drilling machines help us with subtractive processes.

Most of our scientific projects focus on 3D printing. For example, we optimized injection molding processes for industrial partners using 3D-printing. Another area of our scientific interest is the medical sector. We developed a human bone replacement material working together with pharmacists and biologists from Leipzig and Dresden. One example for this research was the PhD thesis of Dr. Flath, where he searched for the possibilities to mix biopolymers with active pharmaceutical ingredients during the FLM process.

Another material we process via 3D-printing are hydrogels. This medium can be potentially used to produce implants for nerve guide rails. Obviously the 3D-printing technologies provide numerous implementation options, so our team is constantly looking for and planning new projects.

Prof. Fritz Peter Schulze, Professor for Machine Tools and Fabrication. He received his PhD in printing process machines in 1993 from TH Leipzig. Since 1994 he is a full professor at HTWK Leipzig, Germany. He was head of the department and dean of the faculty machine building and energy environment between 1999 and 2003. He is a co-founder of the “building 3D e.V” (https://building-3d.de/) in Leipzig in 2019. He works on 3D printing projects, optimization of cast processes, 3D measurement methods for reverse engineering processes and on the development of subtractive and additive processes.

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Acoustic emission analysis of carbon fiber-reinforced composite

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Carbon fiber-reinforced plastics (CFRPs) have a widespread usage since the 1940s due to their high specific modulus and strength. However, when manufacturing CFRP and applying it to specific applications (aircraft, automobile, wind turbine blade, etc.), the reliability of the structure is of great importance, induced by the presence of flaws in the manufacturing process. In addition to that, the brittle and low-elongation carbon fibers fail first even at lower stress than expected stress level (probability distribution) and it reaches another crack source. In this situation, reliable inspection techniques is attracting attention. So far, the ultrasonic technique and eddy current techniques have been mainstream, but there is a limit to their application to composite materials. Moreover, there is also a high demand for an in-situ technology for continuous condition monitoring with a post-mortem approach.

In this talk, the presenter would introduce an acoustic emission (AE) technology and its feasibility on CFRPs. In fundamental AE analysis of materials, the crack initiation and propagation behavior would be analyzed with the failure mechanics and real observations. From the analysis, a quantitative structural health monitoring technology which is named the b-value analysis would be introduced and applied to the CFRPs. The feasibility of b-value analysis would be discussed and optimized for CFRPs considering the vibration properties.

Doctor Wonjin Na, Materials Science and Engineering Doctor (Ph.D.-engineering), is a Senior Researcher of Composite Materials Applications Research Center at Korea Institute of Science and Technology (KIST). He received his bachelor's and a doctoral degree from Seoul National University (Ph. D. degree in 2016). He studied composite mechanics, failure mechanics, and weaving technology for high-performance composite materials. He researches advanced diagnostics technology on composite materials as well as the composite structure design and advanced manufacturing technologies including induction heating-assisted vacuum bagging process.

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Materials research on martensitic stainless steels - current and future research topics

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Hardness and corrosion resistance are the major quality criteria of cutlery, which are achieved by applying a heat treatment on the traditionally used martensitic stainless steel 1.4116 (X50CrMoV15). The established quality control method for the corrosion resistance of cutlery is an elaborate alternating immersion test showing a high deviation independent on the manufacturer. In the last year's new approaches for electrochemical corrosion testing of martensitic stainless steels were developed to connect the weak pitting corrosion resistance with the phenomenon of chromium depletion.

Currently the scientific and the industrial community assume that the main cause of chromium depletion is the heat treatment step of tempering. In case of cutlery the tempering temperatures are too low to explain the appearance of chromium depletion. For this reason, a systematic investigation of three different heat treatment parameters (duration of austenitization, cooling speed and tempering temperature) were performed to detect their contribution to chromium depletion. The method of electrochemical potentiodynamic reactivation (EPR), which is very sensitive to any change of the microstructure, was used to quantify the degree of chromium depletion. The results show a very small process window, which allows the production of cutlery with high corrosion resistance.

The addition of nitrogen is known to be beneficial for the pitting corrosion resistance of stainless steels. The substitution of carbon with nitrogen in martensitic stainless steel influences the precipitation behavior, heat treatment response and corrosion resistance of martensitic stainless steels. This field of research is currently studied by Prof. Rosemann at the HTWK Leipzig.

Prof. Dr.-Ing. Paul Rosemann is Professor for Material Sciences at the Leipzig University of Applied Science (HTWK). He received his PhD in Material Science in 2017 from Otto-von-Guericke-University Magdeburg. Since 2021 he is a full professor at HTWK Leipzig (Germany) in the Faculty of Engineering. He is an expert in the fields of materials engineering, metallurgy, heat treatment, materials testing, microstructure and corrosion of metallic materials. Prof. Rosemann is the author of around 50 publications. The majority of his research projects and publications dealt with the interaction between composition, microstructure, surface and corrosion resistance of stainless steels. Recent research focus on high nitrogen, austenitic, ferritic, martensitic and duplex stainless steels as well as biomedical CoCrMo alloys. He is a co-founder of the "Leipzig Center for Material Science" in 2021 an member of Deutsche Gesellschaft für Materialkunde e.V. (DGM) and the Gesellschaft für Korrosionsschutz e.V. (GfKORR).

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