# CFRP Grid Structures for Aerospace Applications

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**Abstract:** Lattice- or grid- structures are well suited to be made of unidirectional carbon fiber reinforced plastics (CFRP) composites and may be widely used in aerospace field. The rib components constituting the grids can be made of aligned fibers and thus can fully utilize the mechanical advantages of the CFRP. In this presentation, the overview of the challenges by the authors' group to improve the mechanical performances of the conventional grid structures is presented.

The major effort is made to improve the buckling behavior of cylindrical grid structure under compressive loading. One of the challenges is to eliminate the circumferential ribs from the conventional lattice configuration, reducing the total number of grid intersections. To replace the function of circumferential ribs, thin skin is added to the structure. This idea is based on the findings through the group's preliminary study indicating that the grid intersections are the critical points in terms of load carrying capability as well as manufacturing aspect. Further attempts are sought to completely remove these intersections by introducing the bonded type grid-like configuration. The results from analytical and experimental investigations show that these challenges are well effective. Another major approach to improve the mechanical capabilities is to alter the overall global shape from the cylinder to the bulged- or hourglass-type modified cylinders. Though the existing studies indicated that the hourglass modification improved the buckling strength of the homogeneous shell cylinders, adopting the bulged shape combined with the bonded-type lattice exhibited the superior results through analytical considerations. Shock responses are also investigated for the possible application for payload supporting structures of launch vehicles.

**Keyword**: Unidirectional composites; Lattice structure, Buckling; Grid intersection; Bulged cylinder, Shock response

**Brief CV of Reporter:**

Professor Takahira Aoki is currently Professor at the Department of Aeronautics and Astronautics, University of Tokyo. He received his PhD degree in Aerospace Engineering from University of Tokyo in 1988. He had served as a structures engineer at aircraft design section of Kawasaki Heavy Industries, Japan, between 1981 and 1983. He started his academic career as an Assistant Prof. at the Institute of Structural Mechanics, University of Tsukuba in 1988 and moved to University of Tokyo as an Associate Prof. in 1993. Prof. Aoki has served as the president of the Japan Society for Aeronautical and Space Sciences (JSASS) in 2015-2016, and the president of the Japan Society for Composite Materials in 2015-2017. He also acted as the project leader of the "Development of Creation and Processing Technologies for Next-Generation Structural Materials" Project (2016-2019), NEDO (New Energy and Industrial Development Organization, Japan). His current research interests are in the innovative aerospace structures including morphing wings of aircraft and advanced structural design of flight vehicles. He is also involved in the space structures research, including behavior of deployable space structures, and shape control of large space panels and membranes.

# Green Composites Development for Green Aviation, An Overview of the Sino-EU Joint Project ECO-COMPASS

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**Abstract:** Fibre reinforced polymers are important materials used in aviation due to their excellent specific properties enabling the reduction of fuel consumption. For example, carbon fibre reinforced epoxy resins are used in fuselage and wing structures. Glass fibre reinforced phenolic resins are mainly used for the interior panels due to their low weight and favourable fire properties. All these composite materials used in aviation have one thing in common: they are man-made. Renewable materials like bio-fibres and bio-resins are under investigation for a long time for composites but they did not made it into modern aircraft in high amounts yet.
The project ECO-COMPASS under Horizon 2020 aims to bundle the knowledge of 17 partners from China and Europe to develop ecological improved composites for the use in aircraft interior and secondary structures. Bio-based reinforcements, bio-sourced epoxy resin and sandwich cores are developed and improved for their application in aviation. Particularly in order to withstand the special stresses in aviation environment, protection technology to mitigate the risks of fire was under investigation. The presentation summarizes the entire project and the major accomplishment, and make an outlook in the future development of green composites.

**Keyword**：Composite, bio-sourced, epoxy, ramie, fire retardant

**Brief CV of Reporter**：

Prof. Xiaosu YI received a Dipl.-Ing. (M.S.) 1982 and Dr.-Ing. (Ph.D.) degree 1986 in Material Engineering at University of Paderborn, Germany, respectively. He became full professor in Polymer Materials and Technology 1988-1998 at Zhejiang University. He joined Beijing Institute of Aeronautical Materials (BIAM) from 1998 to 2011, then AVIC Composite Center (ACC) since 2010, and now he is LDS Chair Professor of the University of Nottingham Ningbo China (UNNC) since 2017. Prof. YI is Global President and Fellow of SAMPE (F. SAMPE), Academician of APAM (Asia-Pacific Academy of Materials), Fellow of Aviation Industry of China (AVIC). He published over 400 papers, 10 books or book chapters, and awarded over 60 Chinese and international patents. His research interests in structural composites, polymer materials, functional composites, process engineering, materials modeling and surface technology.

# Fracture behavior of a unidirectional CFRP under biaxial tensile loading

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**Abstract**: In order to clarify bi-axial fracture behavior of a unidirectional CFRP monolayer, 0°/90° bi-axial tensile loading test of a cruciform specimen with symmetric two concave parts in the thickness direction was carried out. There were three fracture modes in the fractured specimens. First one is a mode of transverse crack (TC), and second one is a fibers-break (FB) mode. Third is a mixture of TC and FB modes. According to the strain measurement result, regardless of the magnitude of the strain occurring in 0° direction, TC mode and TC & FB mode occurred when the strain occurring in 90° direction was positive, and FB mode occurred when the 90° strain was negative. The fracture load in 0° direction was larger when a load was applied in 90° direction at the same time than when it was applied independently to 0° direction. The fracture load in 90° direction was also larger with an applied load in 0° direction. Similar behavior was confirmed in FEM analysis (ANSYS) results. Finally, Hoffman's and Tsai-Wu's failure criterions under bi-axial stress states were applied to the experimental data. The latter criterion is expressed with a larger rotation angle in the ellipse equation, so that it fitted more accurately to the data.

Key-words: Unidirectional CFRP, Bi-axial test, Transverse crack, Fibers break, Failure criterion

**Brief CV of Reporter:**

Prof. Koichi Goda received his PhD degree in Mechanical Engineering from Hiroshima University, Japan in 1989. He is currently a Professor and Chair in the Department of Mechanical Engineering at Yamaguchi University, Japan. He was awarded Young Scientist Awards of JSME (1992) and JSMS (1996). He was also awarded Best Paper Awards of JSMS (1998), JCOM (2009) and JSCM (2013). Some of his academic articles have more than 200 citations. In addition to these achievements, Meritorious Contribution Award of JCOM (2018) was given for his contribution to JCOM. His researchinterests include damage process simulation and probabilistic modeling of metal-matrix
and polymer-matrix composites. Recently, he is also focusing on researches on production, experimental evaluation and probabilistic modeling of natural fiber green composites

JSME: The Japan Society of Mechanical Engineers, JSMS: The Society of Materials Science, Japan, JCOM: JSMS Committee on Composite Materials, JSCM: Japan Society for Composite Materials

# Bacterial cellulose based composites for various applications

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## Abstract:

Bacterial cellulose (BC), with the same chemical structure as plant cellulose, is a kind of pure cellulose bio-synthesized by some certain microorganisms. The main advantages of BC as a composite substrate are its renewability, biodegradability, biocompatibility, and large specific surface area, and ultrafine fiber. In addition, the porous network structure is conducive to the infiltration and combination of active materials on BC to form functional composite materials for various applications. BC based composites have become one of the most prominent materials for biomedical utilization, and they can be formed with different functional materials for tissue engineering, wound dressing and drug delivery. Multifunctional adsorbent based on metal-organic framework modified bacterial cellulose/chitosan composite aerogel for high efficient removal of heavy metal ion and organic pollutant is also an example of the BC based composite used in enviornmental protection. As a natural biomass, BC plays an important role in the development of new generation wearable electronics. Herein, three construction strategies of BC-based functional composites including in-situ biosynthesized method, physical method, and chemical modification are briefly introduced. Finally, an outlook of the future prospects for developing BC-based functional composites is presented.

**Keywords**：bacterial cellulose; functional composites; biomedical; sensors

**Invited speaker**：

Dr. Qufu Wei, professor of Textile Science and Engineering in the School of Textile Science and Engineering at Jiangnan University, earned his Ph.D. in Textile Science and Engineering from Heriot-Watt University in the UK. He currently serves as Director of the Key Laboratory of Eco-textiles within the Ministry of Education of P.R. China at Jiangnan University. He was an Area Editor of Journal of Engineered Fibers and Fabrics.

Prof. Qufu Wei is a recipient of the 2006 Award for New Century Excellent Talents in Universities from the Chinese Ministry of Education. His research interests lie in the surfaces and interfaces of functional textiles, nanostructured textile materials and smart textiles. His research has been funded by the National Key Research and Development Plan, the National High-tech Research Plan (863), the National Natural Science Foundation of China and Jiangsu Department of Science and Technology. He has also be awarded a Second Prize of the Natural Science Award of Ministry of Education and the First Prize of the Science and Technology Award by China General Chamber of Commerce. He has authored two books, "Surface Modification of Textiles" (2009) and "Functional Nanofibers and Their Applications" (2012) which have been published by Woodhead Publishing. He has also published more than 400 articles in the international peer-reviewed journals. He has over 50 patent applications in which 30 National Invention Patents have been granted.

# Electromagnetic Shielding Applications of Multi-functional Nanocomposites and CFRP Composite Structures

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**Abstract:** The carbon-based materials have attracted great attention in various fields. Here, several nanocomposites and CFRP composite structures were developed for electromagnetic shielding applications. High performance of shielding effect (SE) was obtained by developing dielectric particles combining with carbon nanotubes. EMI shielding anisotropy of CFRP composites is found. The electrical conductivity of unidirectional CFRP composites was identified and the obvious EMI shielding anisotropy of unidirectional CFRP composites was clarified by free-space measurement. The prediction formula is proposed with a good agreement with the experimental results. Furthermore, a new nondestructive method based on electromagnetic wave (EMW-NDT) is proposed and confirmed being effective in detecting damages such as delamination, crack and so on in CFRP composites.

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**Keyword**： Nanocomposites, CFRP composites, Electromagnetic wave, Anisotropic electromagnetic shielding

**Brief CV of Reporter：**

Prof. Qing-Qing NI

He got his PhD in Kyoto Institute of Technology, Japan, in 1993. He worked with Kyoto Institute of Technology as a lecturer from 1993, then became an associate professor in 1999. He moved to Shinshu University as a full professor in 2005, and became an academician of Japan Academic Engineering in 2019. Prof. Ni has served as the president of the JSMS Committee on Composite Materials (Japan) in 2010-2012, the president of the JSMS Hokuriku-shinetsu Branch in 2012-2014 and Councilor and/or Director of Japan Society for Composite Materials. His research interests are composite engineering including nano/macro materials innovation, mechanical analysis, smart materials, sensing and actuation, health monitoring and so on. He has published more than 400 journal papers and 20 book chapters.

# 高性能复合材料在奇瑞新能源汽车上的应用与研究

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**摘　要:** 随着汽车工业的飞速发展，安全、节能、环保日益成为当今世界汽车界的研究热点，汽车轻量化无疑是解决这些问题的最佳途径。轻量化技术应用是新能源汽车未来发展方向，而铝合金+复合材料为轻量化提供有效的解决技术方案。

奇瑞新能源作为国内最早开发新能源汽车的公司，一直践行总书记的指导精神，坚持做汽车绿色革命的领导者。奇瑞新能源“铝基轻量化新能源乘用车短流程研发制造关键技术及装备”项目，获得2020年度“中国汽车工业科技进步奖”一等奖。项目首创封闭截面多腔铝型材的车身骨架和可拆卸式的高性能复合材料车身外饰件的电动汽车新型结构，攻克了新材料应用难题，率先在国内实现产业化，并作为典型案例写入《节能与新能源汽车技术路线图年度评估报告2019》。奇瑞新能源承接国家863项目、04专项等各项课题均按期完成并顺利验收。

**关键词：** 轻量化、复合材料

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