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EDITORIAL

What's next toward the bio-design and manufacturing field?

Academic and humanistic interactions echo each other in BDMC2023

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This report provides a highlight of the third International Conference on Biomaterials, Bio-Design and Manufacturing (BDMC2023). BDMC2023, based on the journal of *Bio-Design and Manufacturing* (*BDM*) founded by Zhejiang University, was successfully held in Singapore on August 6–8, 2023.

The chairperson of this conference, academician from the Chinese Academy of Engineering, Professor Huayong Yang from the School of Mechanical Engineering, Zhejiang University, invited fellow of Singapore Academy of Engineering, Professor Sam Shuzhi Ge from the National University of Singapore (NUS), executive director of the Singapore Centre for 3D Printing, Professor Paulo Bartolo from Nanyang Technological University (NTU) in Singapore, fellow of Royal Academy of Engineering, Professor Zhanfeng Cui from the University of Oxford in UK, and Professor Chee Kai Chua from the Singapore University of Technology and Design (SUTD) as co-chairs of this conference.

This conference was hosted by Zhejiang University and *BDM* journal and received strong support from the co-organizers from National University of Singapore, Nanyang Technological University, and *International Journal of Bioprinting* (*IJB*). The participants came from 12 countries (Singapore, China, the USA, the UK, India, Portugal, Germany, Saudi Arabia, the United Arab Emirates, Austria, Poland, and New Zealand), and more than 160 experts and scholars as well as young postdoctoral and doctoral students in the interdisciplinary field of biomanufacturing from 64 universities and research institutes as well as hospitals attended this conference (Fig. 1).

The participants were excited and joyful during the two-day intense academic information bomb. People discussed the future of biodesign and manufacturing in both technological and industrial aspects. It seemed that they were all melted by the rich academic feast and cultural atmosphere of BDMC2023. This atmosphere lasted until the last moment of the closing ceremony at 6:00 p.m. on August 8.

Plenary talk as an academic feast

To improve the global impact of BDMC2023, the conference organization committee invited the most prestigious investigators in the biodesign and manufacturing field all over the world (Fig. 2).

The first plenary speaker was Professor James J. Yoo, former president of the International Society of Biofabrication, from Wake Forest Institute for Regenerative Medicine, Wake Forest University, USA. The title of the first plenary talk was "Support technologies that enhance clinical translation," which provided a detailed introduction to the research team's application of bioprinting and bioreactor technologies in clinical translation research [1, 2]. Aligned with the goals of tissue engineering, they followed a strategy that involves the use of biocompatible matrices, either with or without cells. The matrices are either used as a cell delivery vehicle or scaffolds to promote and enhance tissue regeneration. This strategy has been successfully applied to many tissue and organ systems in the clinic.

Subsequently, the conference chair, Professor Huayong Yang, gave a wonderful talk titled "Biomanufacturing of functional tissues and organs: exploration and progress," which presented a systematic view of biomanufacturing research progress at Zhejiang University from

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Fig. 1 Group photograph of BDMC2023

Fig. 2 Plenary speakers on August 7. **a** James J. Yoo, **b** Huayong Yang, **c** Tim Woodfield, **d** Chee Kai Chua, **e** João F. Mano, **f** Zhanfeng Cui, **g** Xiaodong Chen, **h** Yong Huang, and **i** Bin Liu

several aspects: developing novel strategies for the modeling of macro- and microstructures of complex heterogenetic tissues and organs; designing and formulating multiple crosslinking bioinks, revealing the formation mechanism of non-Newtonian fluids and precisely controlling the microenvironment of cells; and designing and manufacturing high-resolution multimaterial printing systems with multi-integrated printing methods, including microextrusion, inkjet, and stereolithography, with parallel and concurrent printing abilities [3]. Based on the above concepts, many research activities have focused on fabricating functionalized human functional organs, including skin, blood vessels, liver, and tumor tissues, as well as tissues with complex surfaces including corneas [4] and nerve conduits.

The third plenary talk was given by Professor Tim Woodfield from the University of Otago, New Zealand, who is the present president of the International Society for Biofabrication. The report was titled "Engineering cell-instructive microenvironments across multiple biofabrication technologies." This talk mainly discussed alternative strategies to engineer highly tunable hydrogel platforms that promote a specific cell-instructive niche using light-activated crosslinking in gelatin-based bioinks, bioresins, and high-throughput modular spheroids [5, 6]. These biomaterials are printable across multiple biofabrication technologies, including extrusion-bioprinting, lithography-bioprinting, and microfluidic-based bioprinting. With these cell-instructive platforms, biofabrication technologies can be further applied to regenerative medicine and clinical translation.

The fourth plenary talk in the morning was brought by Professor Chee Kai Chua, who is the editor-in-chief of *IJB*. This talk titled "3D food printing: the next frontier of additive manufacturing" provided us with a detailed description of the current progress and wonderful prospects of 3D-printed food. The enormous industry market of 3D-printed food is expected to be approximately 1 billion USD by 2027, and the main driving force is the rising demand for customized food. He emphasized that the 3D food printing industry is still in its infancy and faces problems such as insufficient institutionalization and limitations of standardized food materials for 3D food printing [7, 8]. After solving these issues, the growth potential of this novel industry can be highly expected.

The first speaker of the afternoon session was Professor João F. Mano from the University of Aveiro, Portugal. Professor Mano is an internationally renowned biomaterial expert and the editor-in-chief of *Materials Today Bio*. He delivered a talk titled "Human derived proteins to be used in regenerative medicine and 3D cell culture: from macromolecular design up to the biofabrication of hybrid devices." His talk was mainly about two sources of natural-based macromolecular materials for tissue engineering scaffolds. One kind of selected material is platelet lysates, containing mostly globular proteins and including relevant growth factors with high regenerative potential [9]; the other kind of material is amniotic membrane proteins, composed of fibrous proteins such as collagens and other components of the extracellular matrix [10]. With chemical modification, these proteins can be generated into hydrogels with tunable mechanical properties that are capable of three-dimensionally accommodating cells with good viability and proliferative ability. Such biomaterials can be finally fabricated into implantable devices for regenerative medicine and as platforms to bioengineer tissues to be used as disease models.

The next plenary talk was brought by Prof. Zhanfeng Cui, one of the editors-in-chief of *BDM*. His talk was titled "Bio-design and manufacturing in practice—development of Oxsed RaViD Direct for COVID-19 test." In this interesting talk, he shared the experience as a case study to illustrate how to embed biodesign in the product design and how to overcome practical issues in biomanufacturing [11]. In a very vivid tone, he described how to lead the team to develop a rapid diagnostic test kit for coronavirus disease 2019 (COVID-19) that is widely used in almost all international airports in the UK and Hong Kong and played a key role in helping with the resumption of international flight. The amazing point is that the time taken for the above rapid diagnostic test technology from research and development to commercialization with the approved name "Oxsed RaViD Direct" is only 10 months during the most difficult time in 2020.

Subsequently, Xiaodong Chen, a member of the Singapore National Academy of Science and the Academy of Engineering, Singapore, editor-in-chief of *ACS Nano*, from Nanyang Technological University, presented a talk titled "Conformal sense digitalization." He first illustrated that the definition of conformal sense digitalization is an emerging interdisciplinary field that aims to revolutionize sensing and interaction by seamlessly integrating digital technology with physical objects, environments, and human experiences. This talk was mainly about the principles of conformal sense digitalization, its potential applications, and the challenges it faces in realizing its full potential. Professor Chen discussed the latest advancements in materials science and soft electronics, which have paved the way for the development of conformal sensors and interfaces that can adapt to complex geometries, surfaces, and biological systems [12, 13]. These conformal systems have the potential to transform various industries, from healthcare and robotics to wearable technology and smart environments. By bridging the gap between the digital and physical realms, conformal sense digitalization has the potential to redefine how we interact with our surroundings, unlocking a new era of seamless and intuitive human–machine interaction.

The eighth plenary talk was given by Professor Yong Huang, a senior international biomanufacturing expert from the University of Florida. The talk titled "Novel implementation of three dimensional bioprinting" first reviewed the definition and classification of additive manufacturing and the perspective of ongoing bioprinting research. Then, it introduced process innovations in 3D bioprinting using continuous extrusion, drop-on-demand inkjet [14], and drop-on-demand laser-induced forward transfer technologies, with an emphasis on embedded bioprinting [15], which the speaker had investigated for a long time. Finally, Professor Huang shared some perspectives regarding basic scientific challenges related to bioink development and construct design, support material development, process development and damage mitigation, developmental biology, and evaluation and certification during bioprinting [16].

The final plenary speaker was Professor Bin Liu, who is the senior vice provost of the National University of Singapore. She is also a fellow of the Singapore National Academy of Sciences and the Academy of Engineering, Singapore, and an international member of the US National Academy of Engineering. She brought a talk titled "Aggregation-induced emission: materials and biomedical applications." Recent years have witnessed the rapid growth of fluorogens with aggregation-induced emission (AIE) characteristics in biomedical research [17]. In this talk, Professor Liu summarized their recent AIE work in the development of new fluorescent bioprobes for biosensing and imaging. AIE dot probes with different formulations and surface functionalities show advanced features over quantum dots and small molecule dyes in noninvasive cancer cell detection, long-term cell tracing, and vascular imaging. By combining the accurate prediction of material performance via first-principle calculations and Bayesian optimization-based active learning, a self-improving discovery system was realized for high-performance photosensitizers, which significantly accelerated the material innovation for biomedical research.

During the afternoon plenary talks, Dr. Liqian Wang, the deputy editor-in-chief of *Nature Biomedical Engineering* (*NBE*), presented a keynote talk titled "Nature biomedical engineering—discovery and technology for improving human health," detailing the development process, scope of submission, and submission policies of *NBE* journal.

Academic journals and international conferences grow together and promote each other

The *BDM* conference (BDMC) series is based on the journal of *BDM*, so it is routine to hold the *BDM* editorial board meeting during each conference. Due to COVID-19, the BDMC series was suspended for 4 years, and *BDM* launched a *BDM* Young Scientist Forum [18, 19] hybrid online and offline.

During the lunch time of August 7, the third *BDM* editorial board meeting was in full swing (Fig. 3). The conference minutes are as follows.

1. The editors-in-chief, Professor Huayong Yang and Professor Zhanfeng Cui, welcomed the editorial board members and associated editors, including Professor James J. Yoo, a new editorial board member.
2. Ms. Helen (YH) Zhang, managing editor on behalf of the *BDM* editorial office, reported *BDM*'s 5.5-year profile and plans for the next three years.
3. Dr. Liang Ma, deputy director of the *BDM* editorial office, briefly introduced *BDM*'s editorial board composition policies and current status.
4. The attendees, including Professor Y. Shrike Zhang, Professor Yong Huang, Professor Paulo Bartolo, Professor Zhanfeng Cui, Professor Boris Chichkov, Professor Jerry Ying Hsi Fuh, Professor Yan Yan Shery Huang, Professor Zhiguang Guo, and Professor Changchun Zhou, presented their views and suggestions on *BDM* development. The discussions covered the following topics:
   (1) the content range of *BDM*, or scope, especially how to emphasize biodesign;
   (2) future positioning for *BDM*;
   (3) ways to enhance *BDM*'s global academic impact;
   (4) sustainable development strategy;
   (5) possibility of publishing the conference special issue in the future;
   (6) the organizational structure of *BDM*'s editorial board and associate editors; and
   (7) retirement of those inactive editorial board members.
5. Professor Huayong Yang, editor-in-chief of *BDM*, thanked the enthusiastic support and constructive suggestions from the attendees and concluded that the editorial office would seek "evolution" to strengthen *BDM*. The attendees looked forward to meeting again next year.
6. The meeting was closed at 1:57 p.m., 3 min before the afternoon session was scheduled to start.

Academic and humanistic interactions echo each other

After the first day of plenary talks, there was a conference banquet held in National University of Singapore Society (NUSS). During the banquet, Dr. Liang Ma announced that there were two newly established awards of *BDM* that would be given to the winners who contributed greatly to the journal of *BDM*. The *BDM* Outstanding Contribution Award and *BDM* Young Scientist Award were presented for the first time, recognizing senior scientists and young scientific scholars, respectively, who have made outstanding contributions to the development of *BDM* journal. The winners of this year's *BDM* Outstanding Contribution Award were Professor Yong Huang from the University of Florida, Professor Jerry Ying Hsi Fuh from the National University of Singapore, and Professor Paulo Bartolo from Nanyang Technological University. Professor Huayong Yang presented three awards and calligraphy works personally written by Ms. Helen (YH) Zhang. The winners of the *BDM* Young Scientist Award were Professor Y. Shrike Zhang from Harvard University and Professor Changchun Zhou from Sichuan University. Professor Zhanfeng Cui presented awards to the two winners (Fig. 4).

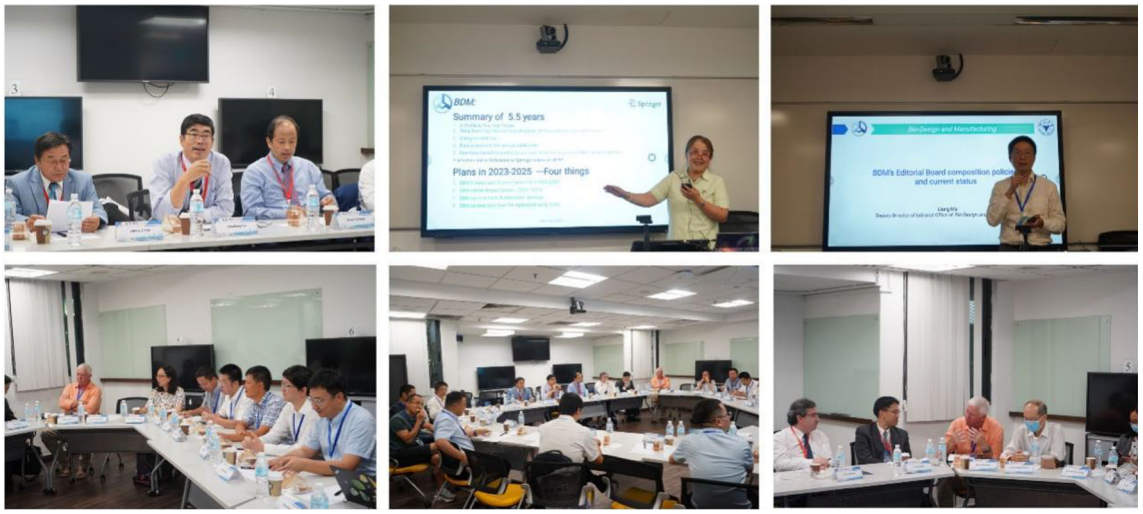

Fig. 3 Third *BDM* editorial board meeting

Fig. 4 **a** The *BDM* 2023 Outstanding Contribution Awards ceremony and **b** the *BDM* 2023 Young Scientist Awards ceremony

At the same time, *BDM* journal also created professional values and humanistic elements that highlight scientific research for every participant in BDMC2023, especially young scholars, such as "All hard work brings profit" and "Curiosity" in both Chinese and English calligraphy and cultural creations, as well as QR code information on the *BDM* website, making it easy to read *BDM*'s published content and thus helping to enhance the academic impact of the journal. This was also a beautiful cultural landscape at this international conference (Fig. 5).

Academic exchange leaves the participants wanting more

On August 8, speeches from five subsessions focusing on different themes continued from 9:00 a.m. to 5:30 p.m. During the noon period, laboratory visits to NUS and NTU were also arranged. Attendees visited the MechanoBio-Engineering Lab led by Professor Chwee Teck Lim in NUS, arranged by the conference secretary-general, Professor Kaichen Xu, and the Singapore Center for 3D printing in NTU with the arrangement of Professor Paulo Bartolo (Fig. 6).

The conference on August 8 was divided into 5 subsessions.

Session 1: Bionic design and 3D bioprinting;

Session 2: Issue engineering and organization on a ship;

Session 3: Bioelectronics;

Session 4: Biomaterials;

Session 5: Special section of *International Journal of Bioprinting*.

It can be said that students and scholars were inseparable from each other, everyone participated in speaking, everyone was busy discussing, academic exchange was unobstructed, and there was still much enthusiasm, leaving people wanting more.

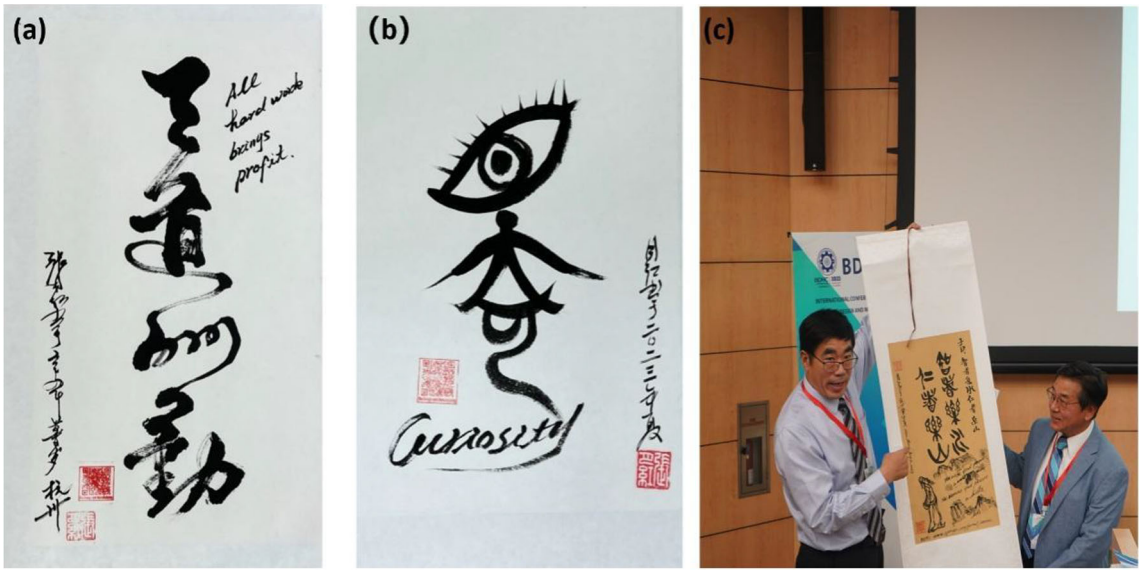

Fig. 5 The Chinese and English calligraphy art works created by Ms. Helen (YH) Zhang were a gift to all conference presenters. **a** All hard work brings profit. **b** Curiosity. **c** Professor Zhanfeng Cui (left) showed one of the calligraphy art works to Professor James J. Yoo (right)

Fig. 6 Conference attendees visited the Singapore Center for 3D Printing at Nanyang Technological University

Fig. 7 The closing ceremony of BDMC2023. **a** Attendees were waiting for the closing ceremony. **b** The winners of BDMC2023 best student oral presentation awards

Almost half of the attendees (more than 70 people) were waiting to the last minute and attended the closing ceremony. Professor Huayong Yang introduced the general data of the conference and announced that there were six winners for the best student oral presentation awards (Fig. 7):

Dengke Zhao from Zhejiang University, China;

Abdellah Aazmi from Zhejiang University, China;

Yueying Yang from Huazhong University of Science and Technology, China;

Tomasz Szymański from Adam Mickiewicz University, Poland;

Yaxin Wang from The University of Manchester, UK;

Phoebe Leam Xin Ni from Singapore University of Technology and Design, Singapore.

Since then, BDMC2023 had come to a successful conclusion.

In summary, BDMC2023 received 130 abstracts, with 9 plenary talks, 25 keynote talks, 55 invited talks, and 33 student oral presentations, for a total of 122 talks. The successful convening of this conference has greatly promoted international academic exchange and cooperation in the field of biomanufacturing, deepened the friendship between scholars from various countries, encouraged a group of young scholars and students to devote themselves to this field, significantly enhanced the international academic impact of China in this field, and effectively promoted the development of the biomanufacturing industry.

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Declarations

Conflict of interest HYY is an editor-in-chief and LM is a managing editor for *Bio-Design and Manufacturing*, and both were not involved in the editorial review or the decision to publish this article. The authors declare that they have no conflict of interest.

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