

DATE 7 February 2025

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Talk2D

An **AM2D** event

Electrochemical Engineering and Direct Ink Writing 3D Printing: Cost-Effective Production of 2D Nanomaterials and their Bespoke Assemblies

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Electrochemical engineering is a powerful technique that has been applied on industrial scale to cost-effectively produce valuable chemicals and materials that are otherwise difficult to produce via traditional chemical synthesis. As such, it is a highly viable method to overcome the bottleneck in the commercialisation of novel 2D nanomaterials (production cost) and enabling them, through in situ modifications, for their niche application in flexible and energy-related devices.[1]

We have employed a combination of highly robust boron-doped diamond (BDD) with a wide electrochemical potential window and commercially available fused deposition modelling (FDM) 3D printing to fabricate a scalable packed-bed electrochemical reactor (PBER) for GO production.[2] In our recent work, the niche feature of two-dimensional carbides and nitrides of transition metals (MXenes) was capitalised in our packed-bed electrochemical reactor to produce MXenes at an unprecedented reaction rate and yield with minimal chemical waste.[3] Regarding bespoke assembly, we have demonstrated a new effective formulation for Direct Ink Writing (DIW) 3D printing of conductive PDMS/graphene ink by using an emulsion method to form a uniform dispersion of PDMS nanobeads, EGO and PDMS precursor binder.[4] To power the wearable devices, we have introduced a highly printable MXene ink that was prepared by incorporating a surfactant (C12E9) into the MXene hydrogel.[5] This nanocomposite ink facilitated the alignment of the MXene flakes during extrusion and the formation of the aligned porous structures, leading to the improved electrochemical performance of the printed microsupercapacitor.

These examples collectively demonstrate the benefits of functional 2D materials production via electrochemical engineering and their targeted device fabrications using innovative 3D printing technology.

Reference:

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4. Shi, G., Lowe, S. E., Teo, A. J. T., Dinh, T. K., Tan, S. H., Qin, J., Zhang, Y., **Zhong Y. L.** & Zhao, H. A Versatile PDMS Submicrobead/Graphene Oxide Nanocomposite Ink for the Direct Ink Writing of Wearable Micron-Scale Tactile Sensors. *Appl. Mater. Today* **16**, 482 (2019).
5. Shi, G., Zhu, Y., Batmunkh M., Ingram, M., Huang, Y., Chen, Z., Wei., Y., Zhong, L., Peng, X. & **Zhong Y. L.** Cytomembrane-Inspired MXene Ink with Amphiphilic Surfactant for 3D Printed Microsupercapacitors. *ACS Nano* **16**, 14723 (2022).

Biography:

Prof Yulin Zhong completed his B.Appl.Sc.(Hons) and PhD in Chemistry at the National University of Singapore (NUS). He did his post-doctoral training at Princeton University (2009) and Massachusetts Institute of Technology (2011). After spending three years in the USA, he worked as a Research Scientist at the Institute of Bioengineering and Nanotechnology, A*STAR Singapore, (2012) and thereafter, as an ARC DECRA Fellow at Monash University (2013). In 2016, he started as a Senior Lecturer at Griffith University and awarded the ARC Future Fellowship in 2020. His research group interests include electrochemical production of 2D nanomaterials and 3D printing of energy storage and wearable devices.

