PostGraduate Institute
for measurement science

GRADPOST

Quarterly newsletter of the PGI

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Material for change

The PGI is going digital

In times of sizeable world-changing challenges and profound problems, collective efforts are needed from all sciences and their applied fields. Metrology, the science of measurement is essential for these efforts since it involves the processes for producing accurate and trustworthy solutions. In material science, metrology sits at the heart of our understanding of material properties and our ability to tailor those for the purpose of further improving our technologies.

This final issue of GradPost will look at some of the inspiring work of our students, pushing the boundaries of the material science field by growing cells on a bioelectronic scaffolds to pave the way to combat cardiovascular diseases, designing a nanometrology platform for emerging electronic materials, and moving a step closer to support emerging technologies with 2D materials.

Although, this is the last issue of GradPost in its current format, we want to do things a little differently, ensuring we continue our commitment to communicating our PGR's contributions to their respective fields, celebrating their successes, and promoting unique opportunities to engage in world changing research through social media. In the meantime, we would like to thank everyone who worked on this and the previous version of GradPost and we hope you enjoy reading this edition of GradPost, acknowledging the work done by our wonderful PGI research community and delivering the recognition it truly deserves.

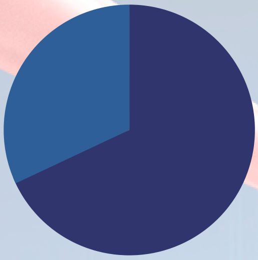
Jennifer Blair, Tarek Haloubi
& Himanshi Singh

Communication Ambassadors

Bioelectronics are paving the way to combat cardiovascular diseases

Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide, with an estimated 17.9 million people dying from CVDs in 2019, representing 32% of all global deaths according to the World Health Organisation (WHO). The development of bioelectronics devices that can interface with the biological systems to monitor and manipulate cell behaviour, while delivering therapeutic support can provide a much-needed solution to better combat such diseases.

32 % CVDs
(17.9 m)



Global Deaths (2019)

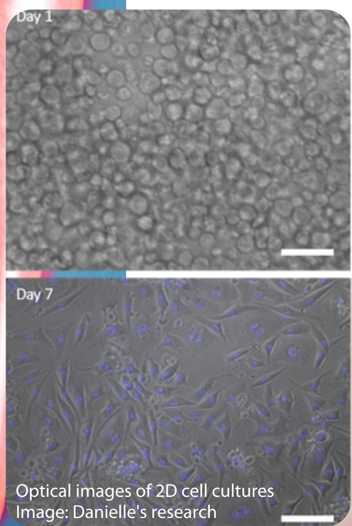
Available cardiovascular tissue engineering methods are limited and are unable to create reliable tissue that can be used in both research and clinical settings. A potential solution is the creation of heart tissue in vitro. The engineered tissue can be used to understand how diseases develop and progress, to ensure drug testing efficacy, or for implantation to replace damaged tissue.

My project involves the fabrication and application of a biocompatible biomimetic device that can be introduced into tissue engineering to encourage the creation of physiologically relevant cardiac tissue. Electrodes and electrical stimulation can promote cell alignment, maturation, and contraction. While integrated biosensors can provide real-time, non-invasive monitoring of cell status, in turn, allowing for tailoring of stimulation.

The creation of engineered cardiac tissue in vitro, which is truly representative of cardiac tissue present within the in vivo cardiovascular system, in time could help elucidate tissue growth, disease processes, drug development, and treating abnormal electrical activities of the heart.

"The incredible advantage of growing cells on a bioelectronic scaffold is that active electronic components are seamlessly integrated into the engineered tissue. Integrated electrodes can promote the correct development of cardiac tissue by electrically stimulating heart cells, which can influence; cell migration, orientation, maturation, and increase contractile behaviour. While highly sensitive biosensors present within the bioelectronics can measure contractility and electrophysiology of the cardiac tissue during clinical testing, giving us a more accurate representation of the human bodies' response to that treatment."

Danielle Cox-Pridmore
University of Surrey



Optical images of 2D cell cultures
Image: Danielle's research

Image: Danielle Cox-Pridmore

Find out more about this research:
Cox-Pridmore, D. M., Castro, F. A., Silva, S. R. P., Camelliti, P., Zhao, Y., Emerging Bioelectronic Strategies for Cardiovascular Tissue Engineering and Implantation. Small 2022, 2105281. https://doi.org/10.1002/smll.202105281

Nanometrology platform for emerging electronic materials

In emerging electronic technologies, the nanoscale structure is increasingly understood to play a critical role in the performance of devices. By identifying the fundamental interaction mechanisms, it is possible to develop bespoke strategies to improve material characteristics.

Emerging electronic materials such as 2D materials, perovskites and compound semiconductors are all being looked at for the upcoming electronic technologies. The functional performance of these materials is often critically dependent on their nanostructure. As a result, we need quantitative measurement techniques that are able to resolve parameters critical to device structure and performance at the required length scales.

The outcome of this project is a nanometrology platform that enables us to study structure-function relationships in these emerging electronic materials with particular focus on a next-generation photovoltaic technology in the form of organic-inorganic perovskites. This platform was realised by combining electrical and tip-enhanced optical modes of scanning probe microscopy all enclosed in an environment-controlled glove box.

By resolving local charge redistribution effects as well as early stage degradation mechanisms under simulated operational conditions it was possible to identify key nanoscale mechanisms, such as links to the film microstructure, which influence both operational performance and stability.

The ability to develop passivation methods that inhibit the accumulation of charges at grain boundaries and subsequently extend the organic-inorganic perovskites is one of the main factors delaying their widespread incorporation into solar modules. Improving operational lifetime would greatly accelerate commercial uptake, having both economic impact as well as helping to reach net zero targets.

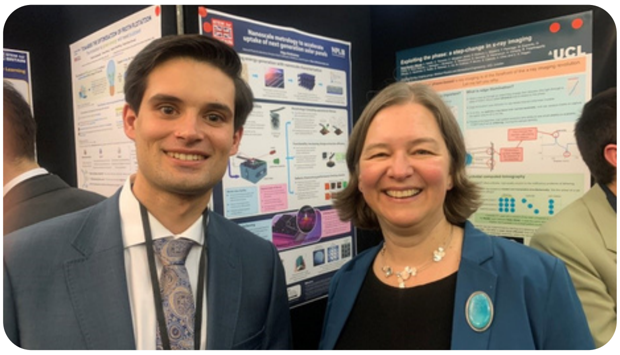


Image: Felipe Richheimer with Fleur Anderson (MP) at a research dissemination event

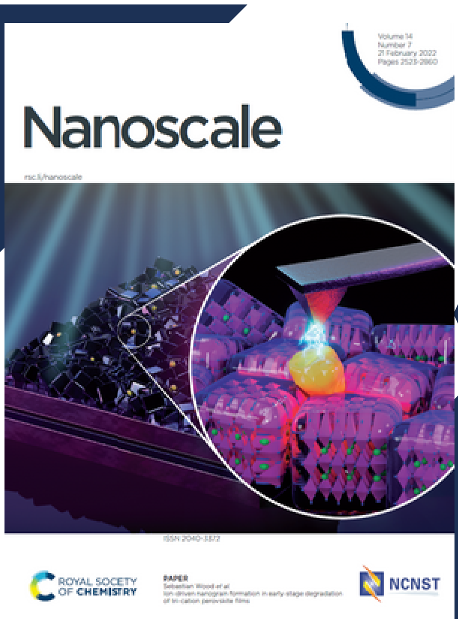


Image: Felipe's research featured on Nanoscale cover

"My nanometrology platform is not limited to those particular material systems. More recently my team have been offering our characterisation technique to the UK emerging electronics industry on a commercial basis. As a result, we are bringing further impact towards the development of products based on materials such as compound semiconductors and composites."

Felipe Richheimer,
University of Surrey

2D materials moving a step closer to support emerging technologies

Image: Dimitrios Sagkovits

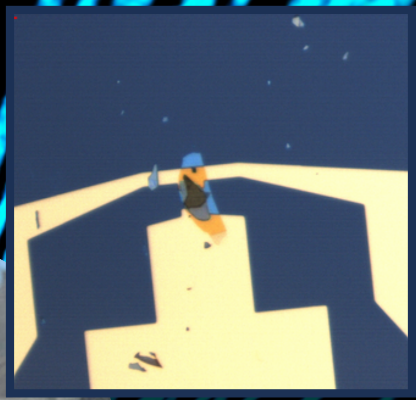


Image: Dimitrios Sagkovits 2D device

Recent advancements in material science have allowed us to push technological applications to their extreme fundamental limits. 2D materials with thickness of just one atom, like a sheet of atoms arranged on a plane, were discovered about 15 years ago and have since been a major research field. Since then, a very large number of 2D materials has been discovered. Importantly, a few years ago, layered materials that preserve their magnetic properties down to the single layer limit have been added to the list of 2D materials. One such limiting factor is research in class of two dimensional (2D) materials.

This project aims to investigate the properties of magnetic 2D materials, by fabricating electrical devices that consist of different layers of 2D materials stacked on top of each other, much like LEGO® blocks. The resulting devices, called van der Waals heterostructures, are essentially artificial materials, and their properties can be tuned by combining different materials or even by twisting the angle of each respective layer.

Understanding the properties of 2D materials is the first step in order to eventually integrate them in industrial production lines, which is the ultimate big picture scope. This could potentially have a major impact for the semiconductor chip industry, where 2D materials are a natural extension of the traditional Silicon based electronics, which is already reaching its limit in terms of scaling down and which is looking for alternatives in the never-ending pursuit of Moore's law verification.

Right now, the exotic and tunable properties of 2D materials are a suitable playground for understanding the fundamental properties and phenomena underlying these novel technologies, but in the future, they could become the foundation on which real-life applications are built on.

"My project, funded as part of the Centre for Doctoral Training in Advanced Characterization of Materials and embedded in NPL's excellence in metrology. It has enabled me to develop new methods of making such devices, in order to measure their properties both in the direct current and high frequency regimes, making it easier to bring novel ideas one step closer to becoming a viable solution for emerging technologies."

Dimitrios Sagkovits
UCL and NPL student

We're going digital!

Catch our PGI student showcases, PhD opportunities, events and more on:

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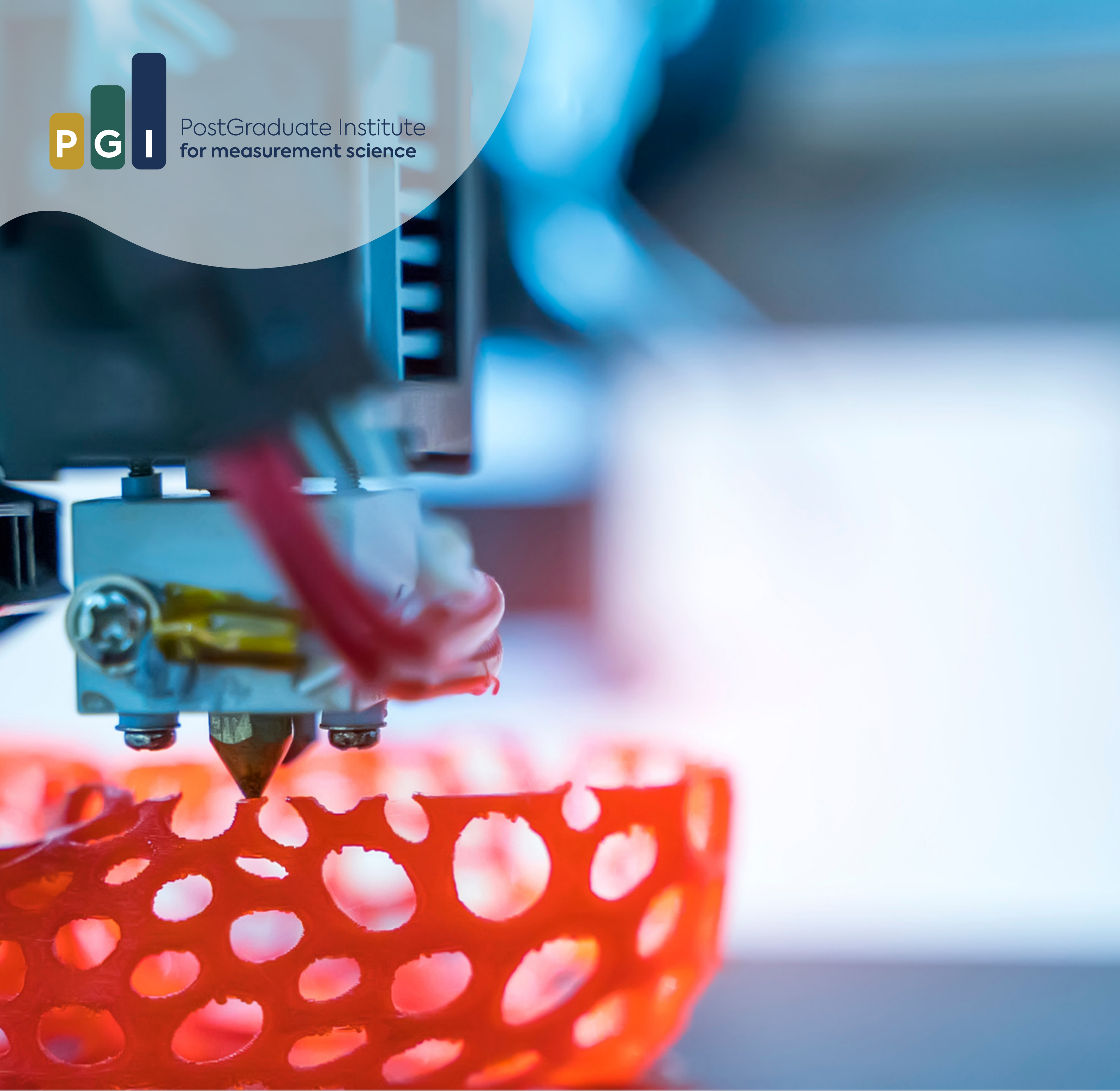

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