Research Highlight #302

David Martinez-Martin, Ph.D.
The University of Sydney

Bridging the gap between academia and industry with innovative nanotechnologies

Making advances in science and society is not a straightforward path and often requires innovative technology and collaboration with multidisciplinary stakeholders. Dr. David Martinez-Martin has a passion for innovation and creates opportunities for advancement in nanotechnology as a senior lecturer in biomedical engineering at the University of Sydney and as the deputy director of Sydney Microscopy and Microanalysis—a modern research microscopy facility with outstanding infrastructure and state-of-the-art instrumentation.

David grew up in Spain and from an early age found himself fascinated with physics and math. This passion followed him through international education spanning the United States, Germany, and Switzerland, and allowed him to work with leaders in microscopy, such as Franz Giessibl and Christoph Gerber.

David goes into more detail about the path that brought him to his current job and what working with these renowned scientists did for his career;

> "During my Ph.D. in physics, I was working on developing and advancing atomic force microscopy in all different environments: vacuum, air, and liquid with applications in material science and biophysics. I also felt the need to continuously learn and collaborate throughout my career while pursuing my Ph.D and later on during my postdoctoral time in Switzerland for approximately seven years. Throughout that path, I was very lucky to have the opportunity to learn and collaborate with pioneers in the field [...], which was a great opportunity for me to collaborate with people who are creating and leading the field. It was also a big push to open my mind and develop new innovative technologies."

ABOUT THE RESEARCH

Dr. David Martinez-Martin is Deputy Director of Sydney Microscopy & Microanalysis and Senior Lecturer in Biomedical Engineering at the University of Sydney. He obtained his BSc and MSc from the University of Valladolid and did his Ph.D. in physics at the Autonomous University of Madrid, obtaining the University Medal and Award of the Royal Spanish Academy of Doctors respectively.

Notable Awards

- Finalist Alliance Award from the American Chamber of Commerce (2024)
- Distinguished by the World Intellectual Property Organization (2022)
- Innovation Award of Alberto Elzaburu Foundation (2018)

Complementary Publications

Martinez-Martin, D., Rudolf, F., Müller, D.J., et al. High-Resolution Mass Measurements of Single Budding Yeast Reveal Linear Growth Segments. *Nature Communications* 13, 3483 (2022). https://doi.org/10.1038/s41467-022-30781-y.

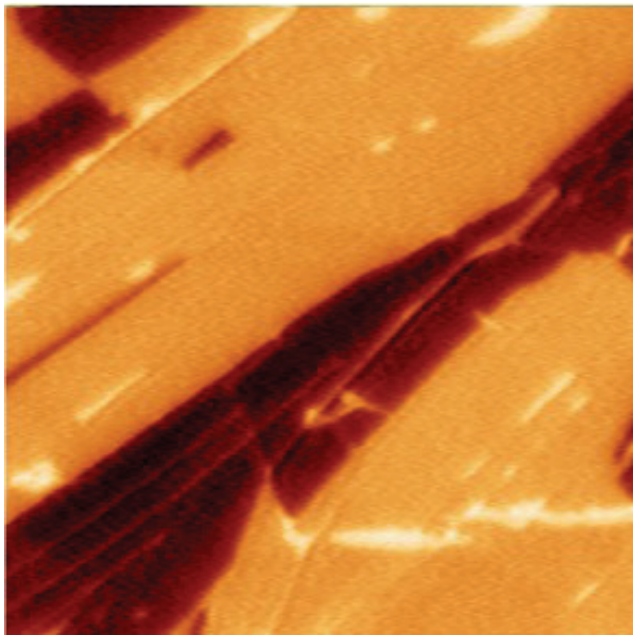
Martinez-Martin, D. Dynamics of Cell Mass and Size Control in Multicellular Systems and the Human Body. *Journal of Biological Research – Thessaloniki* 29 (2022). https://doi.org/10.26262/jbrt.v29i0.8600.

Creating, Applying, and Translating Research Across Topics

David has spent a lot of time collaborating with other researchers, industrial leaders, and students across many different topics. When asked what some of his broad research questions were, David responded that his background in physics and an appetite for working in multidisciplinary research let him cover many topics with a common goal:

> "My research is focused on creating, applying, and translating new technologies with the goal of deciphering and harnessing how physical properties give rise to biological functions or interesting behaviors in materials. For instance, how is the mass of a cell related to its biological function, or how are the mechanical properties of a biological molecule related to its biological function? In material science, how are the physical properties of graphite related to some of its behaviors? I work across scales, all the way from single molecules to cellular and even multicellular systems."

In the course of these explorations, David has been granted 19 patents, 17 of which have been licensed or assigned to industry. David is gratified at how these patents are being utilized, and he continues to explore new ways to positively impact science, industry, and society.



Surface properties of graphite (HOPG) acquired with Kelvin probe force microscopy. The approximately 5 µm x 5 µm image has contrast showing that the contact potential on the graphite surface is not homogeneous due to airborne contaminants, with differences of up to ~200 mV. Image and research courtesy of David Martinez-Martin, et al. Carbon, 61 (2013).

Addressing Societal Challenges with Bruker's BioAFM Team

David started working with Bruker's BioAFM team more than 10 years ago and has found it to be a beneficial relationship that provides new perspectives in industry and his academic research. This partnership has led to cutting-edge research, such as the coupling of an atomic force microscope to a confocal and a widefield microscope. David, along with other researchers at the University of Sydney and the Bruker BioAFM team, hope to drive innovation and make important advances in nanomedicine/nanobiotechnologies:

> "Society is facing significant challenges, and I believe that in order to address those challenges, we need more innovative development. This can be achieved by having genuine collaborations between different stakeholders, particularly between industry and academia. I think these types of partnerships and the type of collaboration we have with Bruker enable us to bring together different points of view and perspectives and to optimize resources when we need to address a challenge. It gives us the opportunity to bring together expertise to be able not only to make stronger teams, but also to manage much better the risk associated with innovation because there is always a risk associated with this activity."

This partnership with the Bruker BioAFM team continues to help drive the creation of novel technologies needed to make discoveries in cell/tissue dynamics, properties, and potential applications.

Unraveling Cell Mass Dynamics, Tissue, and Material Properties

Identifying and understanding the mass dynamics of cells has many important implications, as cell mass dynamics can be used as a universal biomarker to identify fundamental processes at the cellular level. This is one important topic that David and his team are looking into with the *picobalance* technique:

> "I'm the principal inventor of the picobalance technology, which allows us to measure in real-time and with high accuracy, the mass of an individual or multiple cells while they're alive. This is actually quite interesting because understanding how cells regulate their mass is one of the most fundamental processes for life, and dysregulation of these processes is related to multiple disorders like cancer, hypertrophy, aging, obesity, and diabetes."

Using picobalance, David was able to uncover that mammalian cells actually fluctuate their mass at different timescales, sometimes very quickly. Understanding these processes can have a profound effect on the formation of complex structures in the human body. David has also done research on the behavior of yeast cells and found that these cells grow in sequential intervals or segments of largely linear growth at different speeds. These findings are expected to have a big impact on the medical field, as understanding and harnessing these behaviors may

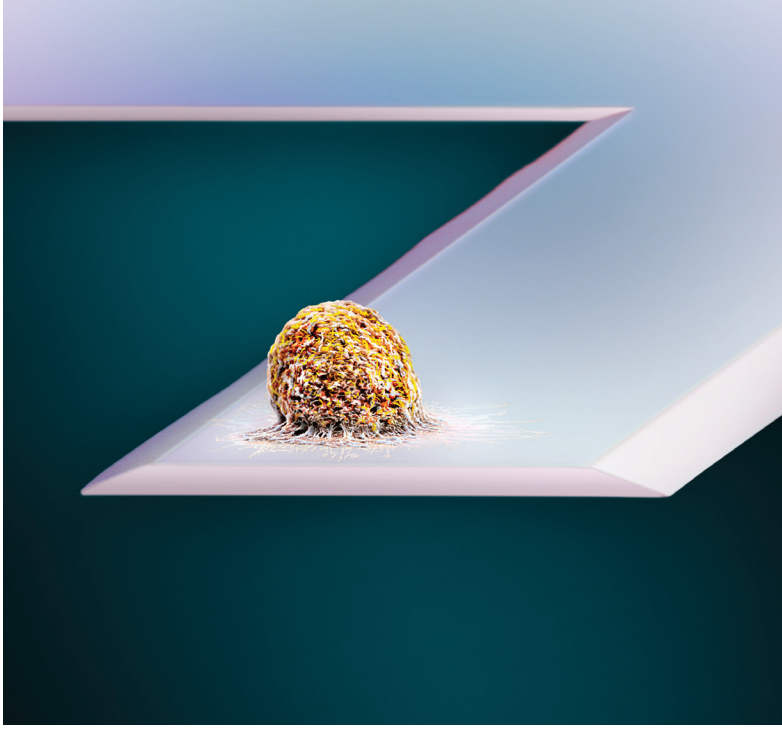
enable the development of more accurate diagnostics and better treatments.

On the material science side of things, David is proud of his team's discovery on the properties of graphite. Using a combination of technologies, including Kelvin probe force and magnetic force microscopy, they were able to find that graphite is hydrophilic, and its hydrophobic behavior is mediated by airborne contaminants (hydrocarbons). These hydrocarbons also disrupt the electric properties on graphite's surface, creating domains with potential differences of up to 200 mV. This is having a significant impact on the understanding of graphitic materials and their applications.

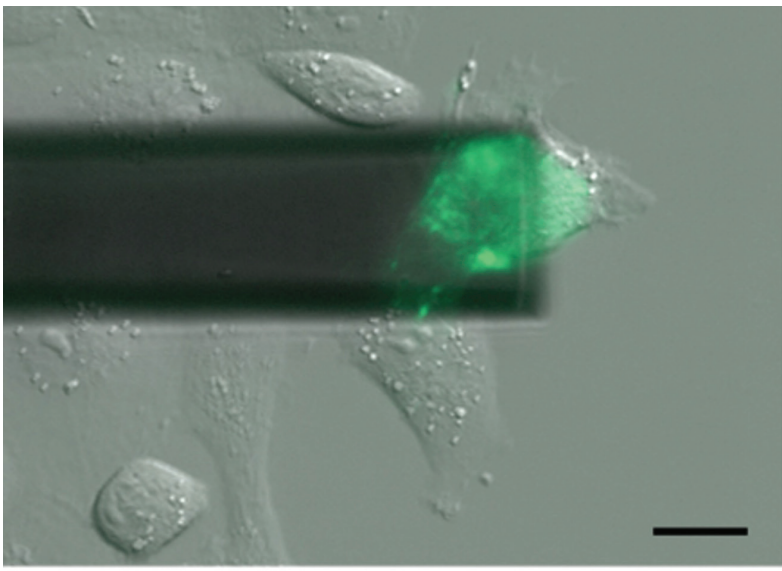
The Benefits of New Knowledge

David's body of research and large variety of teams he's worked with have led to the generation of important scientific knowledge and innovative new technologies. Whether it was in his lab at the University of Syndey or with other teams in academia and industry, he summarizes the favorite aspect of his work as;

> "In a role where you can actively learn pretty much every day from different disciplines and experts, and then combine those learnings to try and push the boundaries of knowledge and drive innovation, I think that's very rewarding. Being able to contribute to that, it's a fantastic feeling."



David is the principal inventor of the picobalance technology. This image, acquired with electron microscopy, shows a human cell attached on a tipless cantilever, which is used as a mass sensor in picobalance. Image courtesy of David Martinez-Martin, Daniel Mathys, Martin Oeggerli, et al./ ETH Zurich/ University of Basel/ micronaut.ch.



David also developed a single-cell infection method. The image shows how this method infects a single human cell with vaccinia virus (glowing in green) by establishing individual contact with the picobalance between a non-infected cell that sits on the cantilever and an infected cell. The scale bar is 20 µm. Image courtesy of David Martinez-Martin et al., Nature, 550 (2017).

David's lab at the University of Sydney.

Learn More

To discover more about BioAFM and Bruker's NanoWizard AFMs, visit here

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