Free Hydro Cells
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NEWSLETTER

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Welcome to the third edition of the FreeHydroCells project newsletter!

Foreword from Dr Ailbe Ó Manacháin, FreeHydroCells Project Coordinator, Lead PI, Senior Staff Scientist, University College Cork

The Horizon Europe project FreeHydroCells designated by the EU as a "high-risk/high-reward" research and innovation action, aims to disrupt the green energy landscape.

At its core is the ongoing development of a novel, efficient method of solar-to-chemical energy conversion to produce low-cost renewable fuel in the form of green hydrogen.

In our third newsletter, we give a flavour of our activities, achievements, team member updates and event contributions during the second-to-third period of the project, and follow up on the first newsletter that set the scene and context of the project regarding our urgent need today for new and viable green energy sources to counteract climate change and reverse the rapid depletion of our finite resources; and the second newsletter that discussed our first-to-second period activities and intermediate, step-by-step, achievements at that time.

The focus in this foreword for the third newsletter is twofold: firstly, to highlight the immense and important progress made by the consortium, and secondly, to reflect on that progress and identify the key remaining areas that still need advancement to meet the objectives. I am delighted to share an overview of the progress we have made to date:

- Formation and integration of a substrate materials subsystem with thermal budget stability
- Growth and integration of transparent conductive oxide (TCO) thin layers with thermal budget stability for multijunction formation (properties already optimised)
- Thin electrolyte/semiconductor interface stability layers for photoanodes and photocathodes
- 2D/3D electrolyte/semiconductor surface enhancement achieved for surface integration
- Growth and integration of transition metal dichalcogenide (TMD) thin layers with thermal budget stability for multijunction formation (optimisation of properties still ongoing)
- Small-to-large area materials growth for Cell-to-System upscaling transitioning achieved
- First and second pass sets of large area buried multijunction (BMJ) cells created and tested
- Integration and test of the gas collection subsystem with the bath/chamber subsystem

- Integration and test of a novel water and gas management functionality
- Cell-to-System transition achieved with formation of single-cell and multicell PEC systems
- Integration and test of the 1st/2nd pass cell sets into the photoelectrochemical (PEC) system
- Achievement of a novel technological baseline PEC system platform for test & optimisation
- External driver connectivity capability for 24/7 hydrogen production (e.g. wind, hydro, etc.)
- All advances fully cognisant of overall objectives, incl. upscaling and commercialisation

The highlighted list of advances and achievements to date across the entire project – although still undergoing some optimisation in places – represents significant advances on the state-of-the-art in PEC systems for producing green hydrogen fuel. Additionally, the level of novelty developed in the project has been astonishingly high, despite the demanding challenges posed by the high-risk/high-reward designation in the Horizon Europe call documentation.

We have achieved nearly all the scientific and technical steps needed to form a PEC system ready for proof-of-concept verification and meet the KPIs set in the overall project objectives. I say 'nearly' because we are not there yet. The focus now is to amplify our efforts to complete the remaining optimisation of material, cell and system properties to reach the level of performance required to meet the overall project objectives.

This optimisation step has always been part of our project plan, originally envisioned as part of the implementation process. We define it as an interrelationship and iterative optimisation loop functionality, which has been active from the start of the project. This loop works between and within work packages, tasks and partners across the entire breakdown of the technical focus. The methodology permits us to carry out "create-test-improve" loops to optimise performance at every level: the materials alignment building block level, the materials integration level, the cell formation level, upscaling, subsystems and overall system level.

It is a critical part of the functionality of the project and will be important in determining our success level. There are always hurdles in projects, some outside our control, such as tool and equipment operation and availability, as well as other resource and infrastructure dependencies that can affect technical and timeline planning. In coordination with Horizon Europe, we do our best to navigate and mitigate those hurdles and maximise our opportunity to succeed.

At the General Assembly meeting of the project during September 2025, I stated, *"By coming together as a general assembly at this pivotal juncture, we can really take stock of the incredible achievements in the project to date, most of which remain confidential at this intermediate stage. We have a clear strategy going forward on how to solve the remaining bottleneck challenges, and although significant and difficult, we will work very closely as a consortium to do our very best to overcome the hurdles to take the technology forward to our end objective of a novel, low-cost, sustainable green hydrogen production technology platform with a high STH system efficiency, durability and rapid impact."*

This newsletter provides the main core highlights of that incredible success to date, while protecting the confidentiality of the detail.

Finally, whether the project is fully successful or not, the main vision of the project should not be lost, and in fact, is more important than any one project success given the immense challenge before us.

Our vision is to have a viable strategy, plan and driving force to reverse climate change and global warming, to reverse the damage being caused to our atmosphere, to reverse the damage to our natural environments, and to stop the rapid depletion of our natural resources. By advancing low-cost, sustainable and efficient locally-distributed green energy production and storage systems, we aim to empower local communities to manage their own green energy operations and thus increase local resilience and enable communities to drive local redevelopment in harmony with nature, while step-by-step reducing the demand on the overburdened energy grids. To be effective in tackling climate change, there must be an economic driving force behind any alternative green energy efficient solution that makes sense to local communities to adopt and advance, and this is something we are trying to ensure in our efficiency versus cost considerations.

This third newsletter invites you to look back on the past three years of activity in FreeHydroCells – in this and the previous newsletters – and aims to provide a glimpse of both technical and non-technical aspects of the project, including its context within the green hydrogen development area.

I hope you enjoy reading it. We welcome your feedback, thoughts, ideas, visions, and questions as we seek not only to advance this important technology, but also to inspire others to join in the search (including to think outside the box) for viable, disruptive and even radical renewable energy sources that protect the planet while serving the energy needs of humanity.

For more information, visit our website *freehydrocells.eu*, connect with us on *Twitter/X* and *LinkedIn*.

You can also get in touch with our team directly via email at *freehydrocells@ucc.ie*.

About the FreeHydroCells project

The FreeHydroCells concept draws inspiration from nature. Much like how a leaf absorbs sunlight to fuel photosynthesis, the FreeHydroCells system aims to absorb solar energy to power a water-splitting reaction that generates hydrogen. This hydrogen, a clean and versatile fuel, can be stored and used to power a wide range of applications, potentially transforming the way society meets its energy needs.

Our concept envisions a system submerged in water, built from thin-film semiconductors layered in many-junction arrays on a transparent, flexible substrate. These materials would absorb solar energy and convert it directly into chemical energy, storing it as molecular hydrogen. The ultimate goal? A solar-to-hydrogen (STH) energy conversion system that is efficient, affordable, and built from sustainable materials, offering a truly green alternative to fossil fuels.

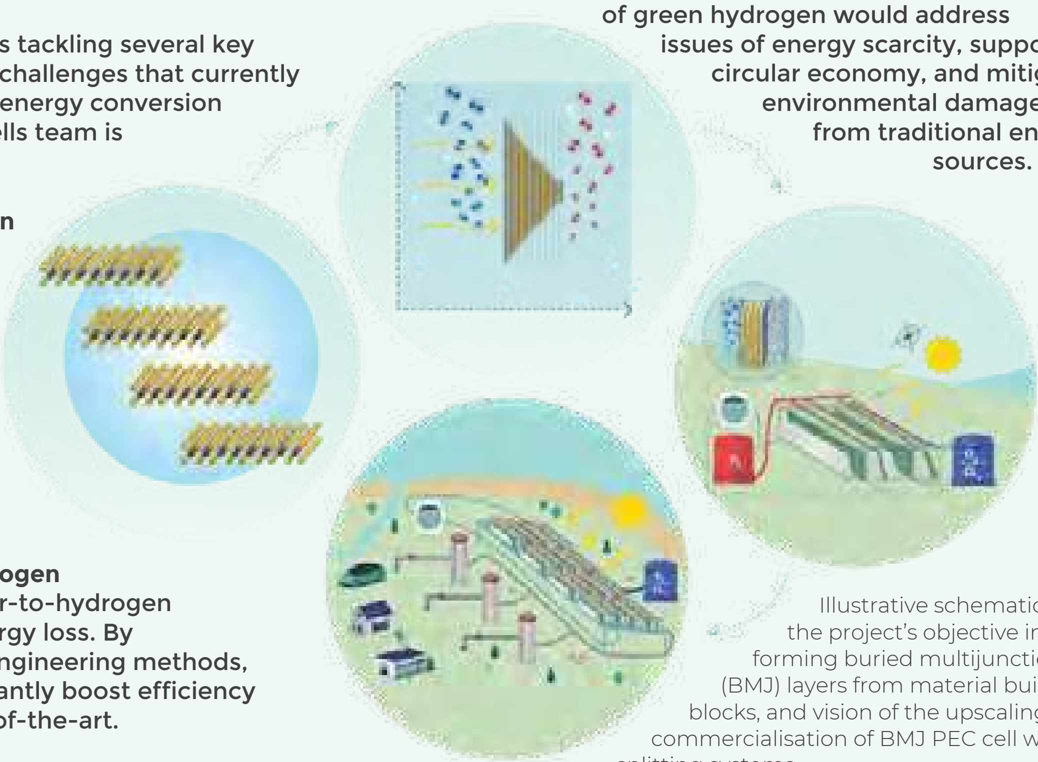
Achieving our vision means tackling several key scientific and engineering challenges that currently limit the efficiency of PEC energy conversion systems. The FreeHydroCells team is working to:

1. **Develop Next-Generation Materials:** Existing PEC systems often rely on costly or limited materials. We aim to identify abundant and sustainable semiconductor materials that maximise energy absorption and minimise losses during conversion.

2. **Maximise Solar-to-Hydrogen Efficiency:** Traditional solar-to-hydrogen systems struggle with energy loss. By employing cutting-edge engineering methods, the team hopes to significantly boost efficiency beyond the current state-of-the-art.

3. **Achieve Self-Sustaining Power:** One of the boldest objectives is to develop a system that drives energy harvesting and hydrogen generation autonomously, without the need for an external power source. Achieving this would mark a major leap forward for green energy technologies.

If successful, FreeHydroCells could pave the way for a modular, eco-friendly hydrogen production system that is easy to scale and implement. The project's impact extends beyond climate action: a clean, reliable source of green hydrogen would address issues of energy scarcity, support a circular economy, and mitigate environmental damage from traditional energy sources.



Illustrative schematic of the project's objective in forming buried multijunction (BMJ) layers from material building blocks, and vision of the upscaling and commercialisation of BMJ PEC cell water splitting systems

Meet the FreeHydroCells Team

The FreeHydroCells consortium is a partnership of seven leading European research organisations. Coordinated by University College Cork (UCC), the FreeHydroCells team leverages expertise in materials science, nanotechnology, and system integration to push the European Union closer to achieving cleaner, renewable energy solutions.

University College Cork (UCC), Ireland

University College Cork (UCC) is a university located in the city of Cork, County Cork, in the southern province of Munster in Ireland. An award-winning institution with a history stretching back over 170 years, today UCC is ranked in the top 1.1% of universities globally.

As the coordinating institution, UCC brings together expertise from the *Tyndall National Institute*, Environmental Research Institute and the School of Chemistry, enhancing FreeHydroCells with advanced facilities for material growth, analysis, and PEC cell characterisation.

Leading Work Package 4, and contributing to WPs 1, 2, and 3, UCC's goal is to validate and optimise materials, including novel transition-metal dichalcogenides (TMDs) and transparent conductive oxides (TCOs), for efficient water-splitting systems.

AMO GmbH, Germany

Founded in 1993 in Aachen, Germany, *AMO GmbH* is a research institute for nanotechnology. Its mission is to bridge the gap between fundamental science, innovation and applications.

A leader in nanotechnology, AMO GmbH spearheads the early stages of PEC cell design and materials growth. With extensive experience in semiconductor and nanofabrication technologies, AMO leads WP 2, focusing on the integration of TMDs and TCOs into the PEC cells.

AMO also supports partners with technical expertise in thin-film and device engineering.

BARDS Acoustic Science Labs

BARDS Acoustic Science Labs (BASL) was established following the development of a pioneering new acoustic spectroscopic instrument.

Broadly speaking, BARDS, or Broadband Acoustic Resonance Dissolution Spectroscopy, is a technology which tracks changes in acoustic sound in solution to characterise drug dissolution, powder blend uniformity, and coating thickness on formulations. Furthermore, BARDS can help to determine Inter Batch Variability, Stability Testing and Counterfeit ID.

BARDS brings its patented acoustic spectroscopy technology to optimise gas bubble detachment on PEC cell surfaces, increasing efficiency. As a key contributor to Work Package 2, BARDS' technology assists in characterising bubble behaviour, which enhances the effectiveness of gas generation and separation within the PEC cells.

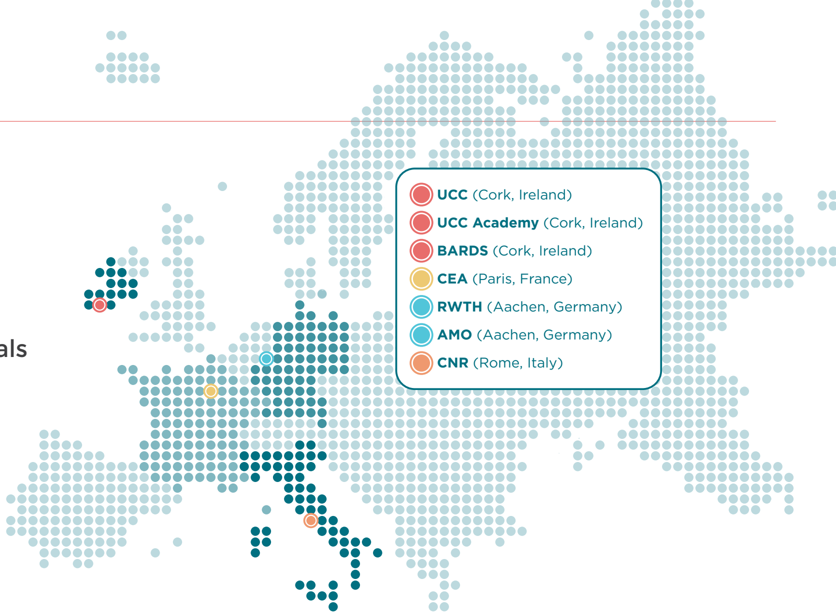
CEA-Liten, France

CEA is a key player in research, development and innovation in four main areas: defense and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences.

The CEA-Liten labs contribute towards the advanced modelling and prototyping of PEC systems, optimising the structure and efficiency of the PEC cells.
Leading WP 3, CEA's expertise lies in designing the photoelectrochemical subsystems and gas collection units, and it supports scaling efforts through its state-of-the-art solar and hydrogen testing platforms.

Institute for Microelectronics and Microsystems, Consiglio Nazionale delle Ricerche (IMM-CNR), Italy

Consiglio Nazionale delle Ricerche (National Research Council) is the largest research council in Italy (CNR).



Based within CNR, the Institute for Microelectronics and Microsystems (IMM-CNR) leverages its expertise in nano-manufacturing and materials characterisation to conduct critical analyses of the consortium's materials and devices.

Leading WP1, IMM-CNR contributes valuable expertise to the project through optical, electrical, and nanostructural characterisation, aiding in the refinement of material properties and device performance.

RWTH Aachen University (ELD), Germany

RWTH Aachen University (in German: Rheinisch-Westfälische Technische Hochschule Aachen), is a German public research university located in Aachen, North Rhine-Westphalia, Germany.

Specialising in two-dimensional materials, RWTH Aachen's Chair of Electronic Devices (ELD) collaborates on the development and characterisation of TMD-based thin films for the PEC cells.

Their contributions are central to WPs 1 and 2, focusing on material quality and optimising device interfaces for enhanced photoelectrochemical activity.

UCC Academy DAC, Ireland

UCC Academy DAC is the in-house consultancy of University College Cork, based in Cork, Ireland. Established a decade ago, the organisation's purpose is to define, develop, drive and deliver key projects that further the University's strategic goals.

UCC Academy provides research project management, communications, and impact strategy, ensuring efficient coordination and dissemination of project outcomes. Through WP 5, UCC Academy supports project logistics, regulatory compliance, and stakeholder engagement.

FreeHydroCells General Assembly 2025

The sun was shining and the energy was high as members of the FreeHydroCells consortium gathered in Cork – in-person and online – for the latest General Assembly on 22nd – 23rd September 2025, hosted by University College Cork (UCC) and UCC Academy.

Partners from across Europe came together to exchange knowledge, share progress, and strengthen the partnerships driving our shared mission: transforming solar energy into clean hydrogen to power a sustainable global energy future.

Day 1 – A Warm Welcome and Knowledge Sharing

The assembly opened with a vibrant day of collaboration, featuring focused sessions led by consortium members on interrelationship activities and key challenges within the project. A special thank you goes to Professor Brian Ó Gallachóir, Associate Vice-President of Sustainability at UCC, Director of UCC Futures Sustainability, and Director of UCC's Environmental Research Institute (now known as the Sustainability Institute), for joining us to welcome the consortium to the UCC campus and highlighting University College Cork's commitment to sustainability and innovation.

Dr. Dara Fitzpatrick providing a research update

The discussions concluded with an overview of the project management updates - including upcoming milestones, deliverables, and timelines. The atmosphere was filled with ideas, discussion, and a collective drive to push the project forward.

Dr. Matthew Ferguson speaking to the consortium on his research

Day 2 – Technical Achievements and Future Goals

The second day took a deeper look at FreeHydroCells' progress toward a fully functional photoelectrochemical (PEC) solar-to-hydrogen (STH) system, with discussions on critical topics such as improving STH efficiency in PEC cells, scaling up from cell to system, and strategies to maximise overall system performance. The day wrapped up with an 'Impact Committee' meeting, which sparked discussions on next steps and opportunities to drive continued innovation.

In addition to formal sessions, the assembly provided valuable opportunities to strengthen relationships across the consortium. From networking lunches to an evening project dinner, and even a guided walking tour of historic Cork city, members enjoyed time to connect, share insights, and celebrate the collaborative spirit of FreeHydroCells.

UCC Academy team members (left ro right) Jen Doran, Tamela Maciel and Abhisweta Bhattacharjee

Watch the recap video from our General Assembly meeting *on our YouTube channel.*

The FreeHydroCells team at University College Cork

Conferences & Events

FreeHydroCells Civic Engagement Workshop
16th January, 2025 | Cork, Ireland

On January 16, 2025, FreeHydroCells brought together 25 experts and thought leaders from academia, industry, investment, policymaking, and general public to explore the future of green hydrogen.

This Civic Engagement Workshop provided a platform to discuss not only the potential of green hydrogen but also the transformative role the FreeHydroCells project could play in creating a sustainable energy landscape.

Read the summary report from the workshop *here* and view the workshop slideshow *here*.

A moment from the online workshop

247th ECS Conference
18th - 22nd May 2025 | Montreal, Canada

Matthew Ferguson attended this conferenced and his presenation was titled "Vat polymerization 3D printing of metal and metal oxide-coated microlattice electrodes for water splitting". This presentation has not yet been made pubic due to publication constraints.

Matthew said, "It was a privilege to present our ongoing research into 3D-printed micro-lattice water splitting electrodes at the 247th ECS Meeting in Montreal. It's always so rewarding and insightful to discuss your work with fellow researchers from across the globe."

10th Conference for Analytical Science in Ireland (CASI)
3rd - 4th July 2025 | Cork, Ireland

Christopher Kent from UCC represented FreeHydroCells at CASi, which was attended by 170 participants. Christopher delivered a presentation titled *"Optimizing Parameters for Solar Electrolysis of Water to Yield Green H_2 Using Broadband Acoustic Resonance Dissolution Spectroscopy."*

His talk highlighted innovative approaches to improving hydrogen production efficiency through advanced spectroscopic techniques.

Christopher's presentation at CASi

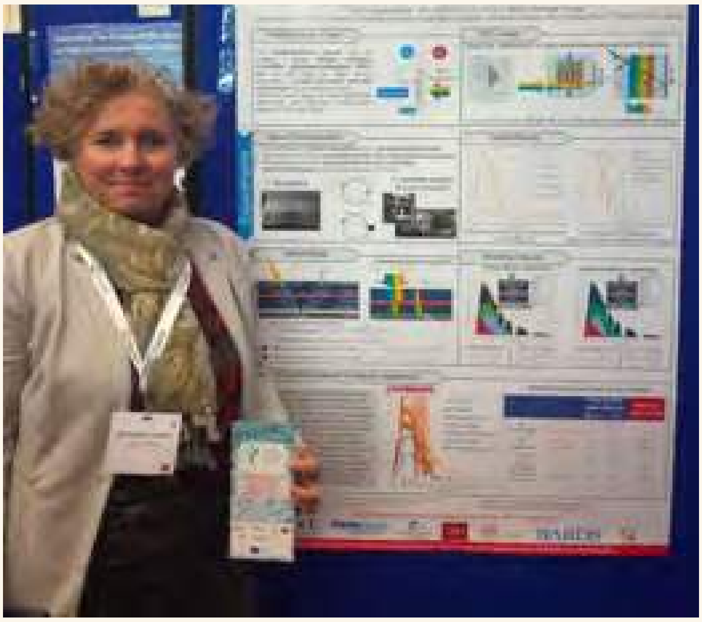
5th International Solar Fuels Conference (ISF5)
1st - 5th September 2025 | Newcastle, United Kingdom

The FreeHydroCells project was represented at the 5th International Conference on Solar Fuels (ISF5), a global gathering that brought together over 300 researchers from 35+ countries. The event covered a wide spectrum of topics, ranging from fundamental catalyst research to device deployment and real-world applications.

Elise Berut in fornt of her poster at ISF5

Elise Bérut and Estelle Le Baron from Commissariat a l'Energie Atomique et aux Energie Alternatives (CEA), France, both represented FreeHydroCells at this event.

Elise Bérut presented a posted titled *"Optical Optimization Considerations of a Potential Cell System for Upscaled Photoelectrochemical Reactors"*.



Estelle Le Baron (pictured above) *presented both a poster* and gave a presentation titled *"Multiphysics model for design optimization of a monolithic photoelectrochemical cell device"*.

Both Elise and Estelle's *reflections, detailed on our website,* highlight the importance of bridging fundamental research with scalable deployment to accelerate progress in solar fuels. Their participation underscores the value of FreeHydroCells' contributions within this vibrant international community.

248th ECS Meeting

12th - 16th October 2025 | Chicago, USA

Dr Ian Povey from Tyndall National Institute, University College Cork, represented FreeHydroCells at the 248th ECS Meeting and delivered a presentation titled "Atomic Layer Processing of Doped Transition Metal Oxides and Dichalcogenides."

2025 MRS Fall Meeting & Exhibit

30th November - 5th December 2025 | Boston, USA

Stefania Privitera and Nino Marino from Consiglio Nazionale delle Ricerche represented FreeHydroCells at the 2025 MRS Fall Meeting in Boston. Nino gave a presentation titled "Scalable Room-Temperature Electrodeposition of Few-Layer MoS for High-Efficiency Optoelectronic Heterojunctions–Structure–Property Insights Across Synthesis Methods."

More Highlights

Presentation to delegation from Minzu University of China

19th March 2025 | Cork, Ireland

Project Coordinator Dr. Ailbe Ó Manacháin gave a presentation on FreeHydroCells to a visiting delegation from Minzu University of China.

In a talk on *"Pathways of Water, Heat and Light to Novel Renewable Energy Sources",* Dr. Ó Manacháin highlighted the potential of cheap and abundant renewable energy sources like sunlight, water and waste heat, and illustrated how these sources are being explored in novel ways at UCC.

FreeHydroCells project concept is presented to visiting group from Minzu University of China

Summer Research Seminar - Wind Value

27th May 2025 | Cork, Ireland

The Wind Value project ran a seminar for four research projects in the Sustainabilitiy Institute (Environmental Research Institute) of University College Cork.

Vittoria Anastasi provided the *latest results* from the FreeHydroCells project which makes green Hydrogen from water, light and new materials.

Attendees from Wind Value Summer Research Seminar

PhD Spotlight: **Vittoria Anastasi, Material Science & Nanotechnology**

Vittoria Anastasi is a PhD student from the University of Catania, Italy, in collaboration with CNR-IMM, Catania, Italy (a partner in the FreeHydroCells project). During 2025, Vittoria is seconded to the University College Cork (UCC) to complete a specific research collaboration activity as part of the FreeHydroCells Project that will contribute towards the completion of her PhD. Her journey through disciplines – from medicine to chemistry to materials science – reflects both her curiosity and commitment to sustainable innovation.

Vittoria Anastasi at the UCC Sustainability Institute

Tell us a little about your academic journey. How did you go from medicine to chemistry to materials science?

It started with a test-preparation course for medical school. I met a chemistry professor there who was just incredible. I honestly fell in love with chemistry because of how well he taught. From then on, I switched paths and pursued a bachelor's in chemistry, then a master's in organic chemistry. Now, I'm doing my PhD in material science and nanotechnology – so, yes, a few turns along the way!

What drew you to organic chemistry?

A professor! He described organic chemistry like poetry. I remember every lesson. I knew then that I wanted to spend my time in the lab, experimenting and learning. Organic chemistry was my first love.

And what led you to this specific PhD in material science and nanotechnology?

I didn't get selected in the first round of PhD admissions, but I was placed on a waiting list. Later, I got a call from my university, there was a new position, and I was next in line. At the time, I was already working with Prof. Salvatore Lombardo and Dr. Stefania Privitera at CNR-IMM, and they agreed to supervise my research.

What's your role in the FreeHydroCells project?

I work with molybdenum disulfide (MoS_2), which I exfoliate, purify, and deposit onto fluorine-doped tin oxide (FTO) substrates by applying an external potential, a process known as electrodeposition. The method involves ultrasonication, centrifugation, and precise control of the MoS_2 layer thickness. MoS_2 exhibits strong absorption in the visible range, making it a promising material for light-harvesting applications. This activity is not part of the confidential work in FreeHydroCells, so I can talk about it freely.

Vittoria presenting to the FreeHydroCells consortium at the General Assembly meeting in September 2025

What challenges have you faced working with these materials?

Achieving uniformity in deposition is the biggest one. If the MoS_2 layer is too thin, it doesn't absorb enough light. Too thick, and your solar cell increases in energy loss. You have to find the perfect balance, which takes time and patience.

What's been a proud moment in your research journey?

So many! I remember the first time I did exfoliation and deposition completely on my own. Also, my first optical and electrical measurements – these were big moments for me. At first, you doubt yourself –"Can I really do this?" – but then you do it, and that feeling is incredible.

You've moved countries after being seconded to a new team at UCC. What was that like?

At first, it was terrifying. I worried about being completely alone, about the language, the systems. But that fear disappeared quickly – especially after meeting Dr. Jun Lin

and Dr. Ailbe Ó Manacháin. They welcomed me and made me feel supported right away. Everyone at UCC has helped me with my experiments, answered my questions, and made me feel at home.

FreeHydroCells is a big, multinational collaboration. What's it like to be part of that?

I've never been part of something like this before. It's amazing to see so many brilliant people working together, everyone contributes something unique. It's inspiring. Sometimes I look around and think, "Wow, look at all these incredible minds working for one shared goal."

Do you see yourself staying in academia or exploring industry?

I'm considering both. Academia is beautiful – you learn something new every day. But I'm also curious about industry, especially research and development. I'd love to explore both before deciding.

Would you want to continue in the area of photovoltaics and green hydrogen?

Yes, absolutely. I really like this field and hope to stay connected to sustainable energy and materials science.

What do you do to recharge outside the lab?

I have a lot of passions! I go to the gym early in the morning, I walk in nature or around the city, I read a lot, call my family, watch movies, spend time with friends. And I also love spending time alone – just me, music, a good book. That balance is important to me.

Finally, what advice would you give to young researchers or students?

Research can be scary, but don't let fear stop you. Sometimes you'll feel like it's not working or you're not good enough. But go ahead anyway. Maybe it will work, maybe it won't – but you'll never know if you don't try.

And a message to the public about green hydrogen and sustainability?

This world is our home – and the home of future generations. Sustainable energy is the key to making that future possible. We need to respect our planet so it can support us in return. Green hydrogen and sustainability aren't just science – they're survival.

Watch our full interview with Vittoria on YouTube

PhD Spotlight: **Matthew Ferguson, 3D Printing, Electrochemistry & Sustainable Energy Technologies**

Dr. Matthew Ferguson is a postdoctoral researcher at University College Cork (UCC) and part of the EU-funded FreeHydroCells project. His work lies at the intersection of 3D printing, electrochemistry, and sustainable energy technologies. We spoke with him about his journey from undergraduate student to postdoc, the science behind his work, and what lies ahead.

Dr Matthew Ferguson in his lab showing a 3D printed electrode

Can you tell us a bit about your academic journey?

It's all been at UCC, actually. I started a degree in Biological and Chemical Sciences, convinced I'd pursue biology. After the first year, though, I realised it wasn't for me - I wasn't enjoying the biology aspect so much. However, I loved the chemistry modules, so that's what I decided to pursue for the rest of my degree! My final undergraduate year was during the COVID lockdown, which wasn't ideal for the full "college life" experience, but perhaps also helped with studying for final exams.

I didn't do a master's - I went straight into a PhD after finishing my undergrad. I reached out to several supervisors about postgraduate positions and Professor Colm O'Dwyer responded with an opportunity to pursue a PhD in his Applied Nanoscience Group. I've been working with the same group since, now continuing as a postdoc.

What changed for you between undergrad, PhD, and postdoc?

It's definitely become more personable. The people who were once lecturers, demonstrators, etc are now colleagues and even friends. The environment feels more familiar. Overall, it's a very positive working environment here in UCC. I've very much enjoyed my time working in Ireland, but for the next step I'll be hoping to continue my career elsewhere in Europe (France, Germany, Belgium, the Netherlands, etc.).

What's your role in the FreeHydroCells project?

I use SLA 3D printing to create complex, high-surface-area, lattice electrodes. We design several different lattice geometries and coat them in electroactive materials – for now, simple, well-understood materials, like nickel and gold. We then carry out various electrochemical tests on these coated lattices to determine which ones perform the best; overall stability, current responses, volume of hydrogen gas evolved, etc.

Eventually, we'll collaborate with other FreeHydroCells partners who are developing advanced photocatalytic coating materials. The goal is to combine our best-performing lattices with their advanced materials to contribute to a full water-splitting device that produces hydrogen more efficiently.

Dr Matthew Ferguson presenting to the FreeHydroCells consortium at the General Assembly meeting in September 2025

Is this work similar to your PhD research?

Very similar! During my PhD, I used the same 3D printer and similar electrochemical analyses, but for energy storage - specifically supercapacitors. Supercapacitors are like batteries, but simpler in their chemistry and energy storage mechanism. They discharge their stored energy in a quick, powerful burst, rather than slowly over time. The core techniques for that work were the same, so transitioning to water splitting felt quite seamless.

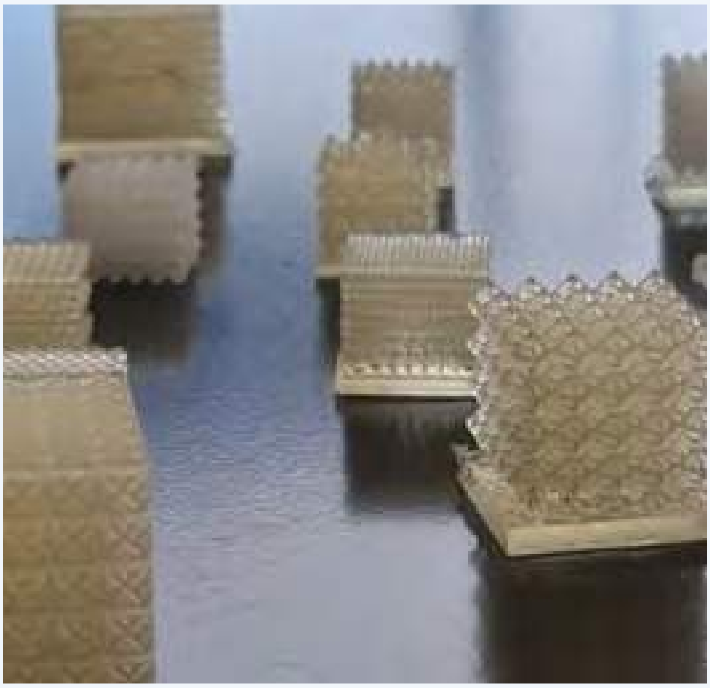
How do you design and produce these 3D-printed electrodes?

We start with CAD software like FreeCAD to design the lattices. We vary the geometry to create different surface areas and bubble pathways. Once designed, we upload the files to the printer, which does the rest. We're using an SLA 3D-printer for our work. The raw material consists of a photopolymerisable liquid resin, which is selectively solidified by a laser light layer-by-layer until your printed models are complete.

After printing, we clean the lattices of any residual liquid resin and place them into a UV-light curing machine, which hardens the material. Then we coat them with the electroactive materials that we wish to test. It's a user-friendly process - thankfully, the printer does all the technical heavy lifting.

How do you decide which geometries to test?

We reused six or seven lattice designs from previous projects in Colm's group - mostly ones that worked well for batteries or supercapacitors and theoretically would work as water splitting electrodes. We didn't want to go overly complex; simpler designs are easier to print and fully-coat in electroactive materials, especially when we move onto the more complex multi-layer materials I mentioned before.



3D printed electrodes from Dr Matthew Ferguson's lab

Have any particular lattice types stood out?

Yes - one lattice has consistently outperformed the others in nearly every test. It's also the easiest to print, so we'll likely move forward with that one for the next phase of collaboration.

Dr Matthew Ferguson demonstrating a 3D printer

How new is the concept of 3D printing electrodes? What was done before?

It's probably only a decade or so old. Earlier 3D printers weren't as advanced as the models that we are using for our work, so initial designs for printed lattices were quite basic. Over time, as 3D printing technology improved, so did the complexity that could be achieved for printed electrodes.

The best catalyst materials for HER and OER reactions are often incredibly rare, therefore very expensive (like platinum metal). 3D printing allows us to print high-surface-area templates which are coated with thin layers of electroactive material - giving us much larger electroactive surface areas while only using a fraction of the catalytic material.

Watch our full interview with Matthew on YouTube

Research & Publications

FreeHydroCells is committed to open science, sharing our results and findings with as broad an audience as possible. All our publications are freely accessible and published as open access articles at either gold or green standard.

Check out our *Zenodo page*, where all our research publications and data are stored in an open-access data repository to enable others to access, exploit, reproduce and disseminate them in the future.

This repository is validated as Open Access by OpenAIRE, with an associated *OpenAIRE project page*.

Publications

Combined Structural and Plasmonic Enhancement of Nanometer-Thin Film Photocatalysis for Solar-Driven Wastewater Treatment.
Read here

Photoelectric response of ultra-thin MoS2 sandwiched between transparent conductive oxides.
Read here

Operando Acoustic Spectroscopy for Optimizing Gas Evolution In Hydrogen Evolution Reaction and the Oxygen Evolution Reaction Processes (Poster).
View here

Public Deliverables

D1.1 Report findings on the growth and structural, chemical, and physical characterization of TCO, TMD materials, and substrates.
Read here

D1.3 Report on the electrical and opticalcharacterisation and the photoelectrochemicalanalysis of TMD/TCO pn-junctions in the darkand under different illumination and different electrolyte pH conditions.
Read here

D5.6 Data Management Plan (DMP), Version III.
Read here

Get in touch

Email:
freehydrocells@ucc.ie

Twitter/X:
@freehydrocells

Website:
freehydrocells.eu

LinkedIn:
FreeHydroCells