Quantum Design
OXFORD

Case Study:

University Of Glasgow

University of Glasgow

About Professor Martin Weides

Professor of Quantum Technologies
(Electronic & Nanoscale Engineering)

Director
(James Watt Nanofabrication Centre)

Martin, you are an expert in experimental solid-state physics at the interface of materials science and electrical engineering. Could you please explain this in an accessible way for a wider audience?

We build tiny quantum electronic circuits using advanced nanofabrication techniques. In our cleanroom, we pattern structures that are thousands of times smaller than the diameter of a human hair.

Interestingly, while the critical features are nanoscale, the overall circuit itself is much larger and can be seen with the naked eye – it is the fine details within it that enable its quantum functionality.

They behave as macroscopic quantum objects, so they act like atoms but on a larger scale. And with these quantum electronic circuits, we can then explore quantum mechanics, the fundamental properties of nature.

We know that you worked in a number of research centres, universities and institutes around the world. What led you to the position at the University of Glasgow?

I did my PhD at the University of Cologne in Germany. During that time, I also worked at a nearby national laboratory, and after completing my doctorate, I stayed on for a postdoctoral position.

I then moved to the United States for further postdoctoral work. I joined the University of California, Santa Barbara, where I worked with John Martinis (2025 Nobel Laureate in Physics – though I should say I had no contribution to that!). After Santa Barbara, I continued to the National Institute of Standards and Technology (NIST) in Boulder, Colorado.

At that point, I felt it was time to start building my own research group. An opportunity arose at the Karlsruhe Institute of Technology (KIT) in Germany, where I established my own team and stayed for several years. In parallel to running my KIT research group, I also spent three years at the University of Mainz, where I was involved in teaching and worked in the area of quantum spintronics. That dual role allowed me to broaden my scientific scope – combining superconducting quantum circuits with spin-based quantum systems – while further developing my independent academic profile.
In 2018, I moved to the University of Glasgow, where I continue my work today.

In many ways, it's the typical academic journey – moving between institutions and countries, gaining experience, building collaborations, and gradually developing an independent research profile.

How big is your research group? What roles do you have in your team?

We are a team of about 20, with 15 on the core team today comprising seven PhD students and eight postdocs. We also have a few undergraduate students who are doing their internship at the University of Glasgow. Over time, our team members develop specialised expertise across the full quantum hardware stack – nanofabrication, cryogenics, measurements, and software – typically focusing in depth on one of these areas while maintaining a strong understanding of the overall system.

University of Glasgow's research focus

Your team is working on the fundamentals of superconducting quantum computing hardware, how to make better qubits and improved interfacing for scalability. Why is this important for the world today? What problem are you trying to solve?

Quantum computing has huge, massive potential – not to replace classical computing, but really as an add-on, as a speed-up to classical computers to enable the calculation, the computation of some problems we can't really solve today, like nitrogen fixation or many sorts of optimisation problems in chemistry, material science, finance, or logistics.

But to build these large quantum computers, we need better qubits – much better than we have today. There are many challenges, but a particular one is scalability. To go from today's 100 or 1,000 qubits to a million or even more in a cryogenic environment, working at 10 millikelvin, is a massive, massive challenge.

My team is exploring ways to operate qubits at higher temperatures so we can integrate more qubits within the same cryogenic environment. We're also looking into qubit interfacing and interconnects, and into integrating the control and readout electronics into the cryo-system to ease scale-up and reduce latencies between the control and readout systems and the quantum computer hardware.

You shared earlier that you work with niobium a lot. Why do you use this material? What important properties does it have in comparison to other materials?

Conventionally, superconducting qubits are based on aluminium for resonators and tunnel junctions, and aluminium has a rather low superconducting critical temperature of about 1 Kelvin. To avoid thermal excitations (which we refer to as quasiparticles), one has to cool (and stay cold) much below the critical temperature.

Working with niobium which has a critical temperature of 9.2 Kelvin, close to 10 times higher than aluminium's 1.2 Kelvin, allows one to operate at 10 times higher temperatures, and that means the qubits we're building out of these superconducting niobium circuits can then operate at higher frequencies and temperatures.

We can also do pre-testing at 4 Kelvin, and we don't have to reach 1 Kelvin or lower to characterise its superconducting properties. That's a major advantage, actually.

It's also fairly established material: many SQUIDs (Superconducting Quantum Interference Devices, used for example in medicine to detect brain activity) are based on niobium, which is the conventional superconductor for metallic circuits. Until recently, it didn't have good coherence when used for qubits, but that has changed with improvements in materials science and nanofabrication.

One of your research goals is to achieve better resonant circuits. Why is this important for quantum applications?

It's all about the loss or conversely the quality factor of the superconducting resonant devices. Higher-Q resonators store microwave photons for longer, reduce energy decay, and provide cleaner environments for qubit control and readout.

Compared to aluminium, niobium offers several important advantages. Its higher superconducting critical temperature and larger superconducting energy gap reduce the impact of thermal quasiparticles and make devices more robust against stray radiation and nonequilibrium excitations. This can directly translate into lower loss and improved stability.

> My team is exploring ways to operate qubits at higher temperatures so we can integrate more qubits within the same cryogenic environment.

In addition, niobium allows the use of trilayer junction technologies with well-controlled barrier formation and cleaner interfaces. These structures can offer better reproducibility and scalability than traditional shadow-evaporated aluminium junctions. From a materials and processing perspective, niobium is also more compatible with multilayer fabrication, enabling more complex circuit architectures and integration strategies – which are essential for scaling up quantum processors.

Previous experience with Quantum Design Oxford

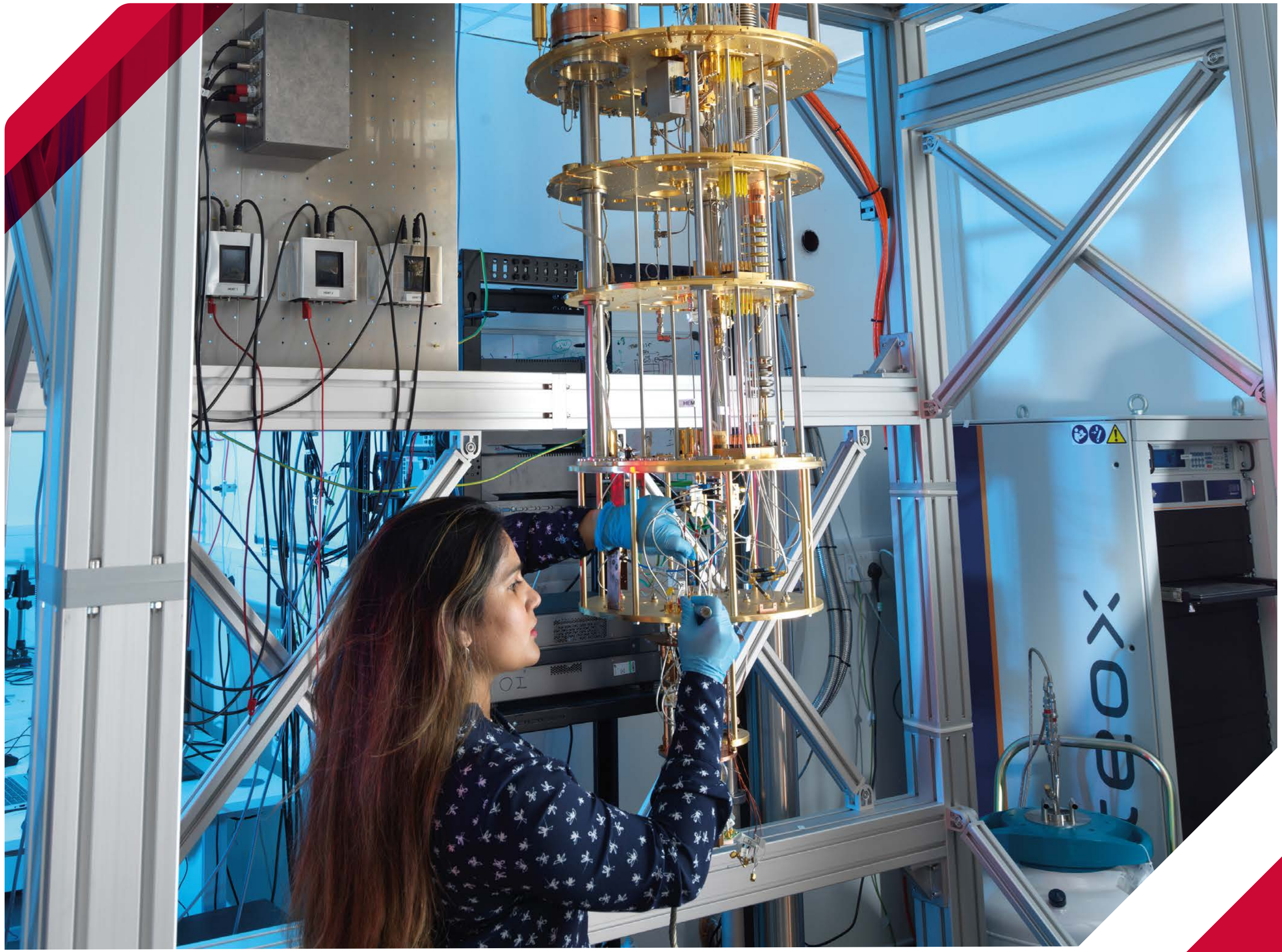
Have you used Quantum Design Oxford (formerly Oxford Instruments NanoScience) dilution refrigerators or cryostats before? What is your experience with our company?

I've used Oxford Instruments NanoScience, as Quantum Design Oxford was then known, systems for many, many years. We had flow cryostats based on liquid helium. We had helium-3 systems, helium-4 systems, and dilution refrigerators of various generations, going back to the 1970s (the time I was born) and using liquid helium for pre-cooling.

When I started my own group about 10 years ago, the first dilution refrigerator we received was the Triton Cryofree® (dry) system from Oxford Instruments NanoScience [now Quantum Design Oxford]. That was in our first year, and it was also one of the first dry cryostats at the institute as well. It has been moved twice: first from Karlsruhe, Germany, to a different lab here on campus at the University of Glasgow, and then to this lab, which is our base. It has quite a journey behind it. We have not experienced any issues with it. Building on that success, we have since acquired two ProteoxMX dilution refrigerators and have just installed a ProteoxS this year. Our lab has one Triton and three Proteox systems, internally named Proteox, Demeter, and Athena, in keeping with Greek mythology.

Why did you choose the ProteoxMX dilution refrigerator for your research needs at the University of Glasgow?

We needed a reliable cryogenic system with a large volume and reliable software for data logging, and the ProteoxMX was a good choice based on our previous experience with the Triton dilution refrigerator.



What are the steps your team is going through to achieve your research results? How does ProteoxMX help you to do so?

Cryogenics has changed a lot over the last 10 years. Having dry systems means we don't need to operate liquid helium liquefiers on site; the cool-down, warm-up, and operation of cryostats are much, much easier.

Students and postdocs can now focus much more on the science and the experimental setup itself, rather than spending significant time managing liquid helium and nitrogen orders or performing frequent leak checks – tasks that are far more common with wet systems.

What criteria or metrics define success for you?

Success for us is defined by the full experimental cycle working reliably and reproducibly. We fabricate a device in the cleanroom, package and wire-bond it, install it in the cryostat, cool it down, and acquire high-quality data that demonstrates novel and publishable results.

Key metrics include device performance (e.g. coherence times, reproducibility, and parameter spread), measurement stability, achievable base temperature, and the ability to iterate efficiently. In practice, reaching this point typically requires several fabrication and measurement cycles – systematic optimisation is part of the process.

How did Quantum Design Oxford (formerly Oxford Instruments NanoScience) support the setup, training, or integration?

Very good. The latest cryostat was installed in a few days, I think less than a week.

It was cooled down over the weekend, and it was cold about a week after the installation started. Then we had two days of training for our students, who are now able to operate the cryostat themselves. It was very fast.

Can you quantify the benefits of using ProteoxMX?

There are many commonalities between dry dilution fridges, but I would like to highlight service, because it is really a factor. It is an easy system to use, but there will always be problems or maintenance required at some point. With an Oxford system, we can call for remote assistance when needed. They can also come on site to support us – which they have done in the past – and they are able to provide spare parts promptly when required. It is really important to increase the uptime of our system.

Other than reliability, not having to worry about cryogenics. So, not having to think about supply, and also, there is now no need to train students on what to do with liquid nitrogen and liquid helium. Topping up a wet fridge needs a lot of training, lots of responsibilities. The operational costs are much larger as well, because then, you would have to collect the helium for reusage, condense and liquefy, store and pump it back into the system, also top-up the lost helium. That's an additional expense for an institution. Now we just have to fill up the liquid nitrogen trap!

> “
> Success for us is defined by the full experimental cycle working reliably and reproducibly.

Would you say the skill set needed to run these systems has completely evolved from the olden days, focusing more on the devices as opposed to the actual cryostat?

Yes, absolutely. Today, you purchase a system and it is essentially turnkey. As with any sophisticated instrument, some routine maintenance is required, but there is no longer the need to develop an in-depth technical understanding of dilution refrigeration to operate it effectively.

The system was installed, commissioned, and it simply worked from the outset.

Future for the team at the University of Glasgow

What is next for you and your team? What is the 3-5-year plan?

We would like to focus on the science. For a long time, sample fabrication was a bottleneck, and we spent a lot of time setting up the fabrication of our circuits in our cleanroom, the James Watt Nanofabrication Centre. That's where we put most of our effort.

Previously, we did not have the bandwidth to focus extensively on the cryogenic measurement side, but that has now changed. We are producing high-quality devices, and this has allowed us to significantly increase both our measurement capacity and the depth of our characterisation, enabling us to study the samples as thoroughly as we would like.

Over the last year, we have invested in cryogenics, and our newest ProteoxMX dilution refrigerator has just arrived. This will help us set up a dedicated cryogenic measurement setup and accelerate the R&D cycle from Nanofab to measurement back to design and back into Nanofab.

We have also spun out Quantcore (https://quantcore.co.uk/) to commercialise our niobium-based superconducting circuits and translate this technology into scalable products.

How does your work integrate into the broader context of the University of Glasgow's research projects?

The University of Glasgow has a strong and growing activity in quantum technologies, and over the past decade we have seen a clear shift of many quantum platforms toward cryogenic operation.

For example, the highest-performance single-photon detectors operate at deep cryogenic temperatures. Likewise, quantum computing across multiple platforms increasingly relies on cryogenic environments. This includes superconducting circuits, semiconducting quantum devices, and even ion-trap chip technologies. Depending on the platform, these systems operate at temperatures ranging from a few Kelvin down to the millikelvin regime.

Quantum communication is predominantly based on photonic systems. Information is carried by single photons, which must be detected with extremely high efficiency and low noise – requiring advanced single-photon detectors, typically operating at cryogenic temperatures.

Looking ahead, the networking of quantum computers will also rely on photonics to transmit quantum information over

> “
>
> Communication channels will become quantum-secure, and imaging technologies will improve significantly.

long distances. However, most leading quantum computing platforms – particularly superconducting systems – operate in the microwave domain at deep cryogenic temperatures. To connect these microwave-based processors to photonic communication channels, cryogenic quantum transducers are required to coherently convert signals between microwave and optical frequencies.

At the University of Glasgow, we are fortunate to have expertise spanning the full landscape of quantum technologies – from single-photon detection and photonics to qubits across multiple platforms, including superconducting and semiconducting systems.

Increasingly, all of these technologies depend on advanced cryoelectronics: control hardware, readout systems, low-noise amplification, and signal processing operating at cryogenic temperatures. A well-equipped cryogenic laboratory, therefore, enables us not only to fabricate and test quantum devices but also to develop and integrate the electronic infrastructure required to control and scale them.

How is your research contributing to the quantum computing field? What does it mean for the average person?

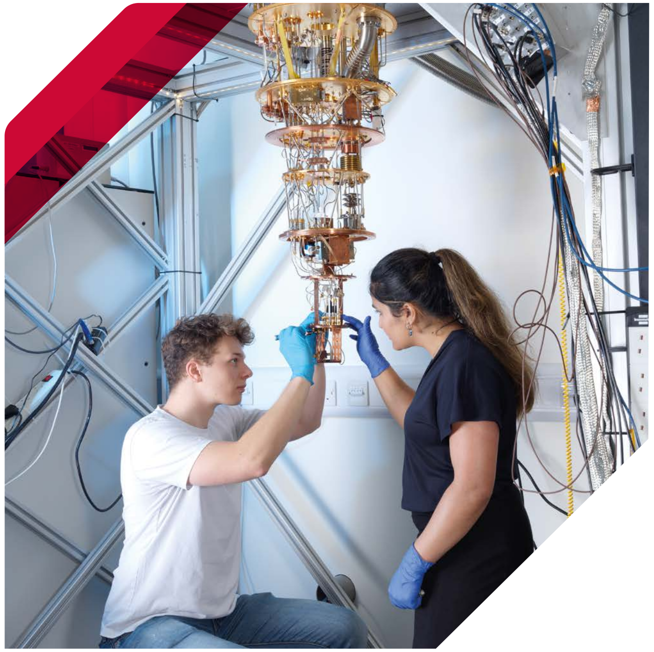
We are developing higher-performance qubits as the fundamental building blocks of quantum computers. These quantum processors will not sit on people’s desks; their impact will be delivered primarily through data centres.

In practice, most users will access quantum computing via the cloud, where quantum hardware is integrated into large-scale computing infrastructure. That is where the technology will have its greatest impact on everyday life – through enhanced computational capabilities delivered remotely.

How do you think our world and lives will change within the next 10-20 years because of what your research group is doing? Will it affect banking services, the healthcare system, education, etc.?

I expect the transition to be gradual rather than sudden. We may not notice a single defining moment, but over time we will see more quantum technologies quietly entering everyday life. Quantum computers will increasingly complement and accelerate classical computing. Quantum sensors will deliver higher precision and sensitivity. Communication channels will become quantum-secure, and imaging technologies will improve significantly.

These advances are likely to emerge as steady, incremental improvements over the next decade – subtle in appearance, but transformative in their long-term impact.



Quantum Design
OXFORD

FOR MORE INFORMATION CONTACT:

Tel: +44 1865 393200

info@qd-oxford.com

Quantum Design Oxford
Tubney Woods, Abingdon
Oxfordshire, OX13 5QX
United Kingdom