Mac Robertson Funding Report

About Me

Figure 1: Celebrating St. Patrick's Day in Cork (I'm on the far left with the hat!).

My name is Megan Powell and I come from a town in Southwest Wales called Llanelli, but now I live in Glasgow while I study for a PhD in Physics at the University of Strathclyde. My PhD is focussed on fabricating the heart of a quantum computer in the form of an all-electronic device and readout technique using a semiconductor, silicon carbide. I was awarded the Mac Robertson scholarship in the second year of my PhD, and I executed the project placement in my third year. The scholarship provided me £3235 to use for twelve weeks at the Tyndall National Institute in Cork, Ireland. This institute is a leading European research centre in integrated information and communications technology hardware and systems, and it is a research flagship of University College Cork.

Why did you apply for the Travel Scholarship?

I applied for this scholarship because it presented a unique opportunity to enhance my PhD research in a way that my home institution could not support. My doctoral work focuses on leveraging silicon carbide (SiC) to develop electronic devices for quantum computing, particularly exploiting spin-active defects within the material to create qubits. Our goal is to eliminate the need for external light sources, like lasers, to access these qubits, ensuring the scalability of our system while integrating seamlessly with classical circuit hardware.

Figure 2:2 a portion of one of our devices. Two 2D semiconductor flakes can be seen at the centre of the image.

I am passionate about bettering electronic devices, it was the main reason I chose to continue studying with a PhD, and within those electronic devices – the semiconductor chosen is critical. The properties inherent to that semiconductor can dictate the device performance; either hindering it or they can be exploited to make the device even better. In my PhD, I work with bulk semiconductors, but in some cases, we can break apart these bulk semiconductors into single atomic layers – that is, one sheet of atoms thick and more than 10,000 times thinner than a strand of hair! These materials are called two-dimensional semiconductors and at this size, we can unleash a whole world of properties such as improved electrical and mechanical performance, but also some very promising quantum phenomena too.

The scholarship provided an invaluable opportunity to delve into the fabrication techniques of 2D-material electronic devices alongside experts in the field. Collaborating with Dr. Farzan Gity's Group allowed me to gain first-hand experience in a state-of-the-art cleanroom environment and allowing me to help create a device directly integratable into my PhD research. Subsequently, I returned to Glasgow to conduct cryogenic tests on the fabricated quantum devices with Dr. Alessandro Rossi's SEQUEL group at the University of Strathclyde, leveraging their specialized cryo-electronics equipment.

Furthermore, collaboration with the University of Glasgow's Prof. Martin Weides' group will enable us to incorporate high-quality superconductive resonators into our research. This integration will empower us to develop an efficient all-electronic control and readout system for gate-controlled quantum devices using radiofrequency reflectometry characterization with high fidelity.
By integrating these techniques and collaborations into my research, I not only expand the scope of my thesis but also enrich my knowledge and skills, benefitting both my academic journey and future endeavours in academia or industry.

Figure 33: Some images from the cleanroom at Tyndall.

Details of your visit

During my visit facilitated by this scholarship, I had the privilege of collaborating closely with esteemed experts in the field of 2D-material electronic device fabrication at Tyndall National Institute. Our primary objective was to design and fabricate various types of quantum devices, with the initial goal of producing a single device for testing back in Glasgow. However, our collaboration exceeded expectations, resulting in the fabrication of multiple devices with many more in the pipeline. Throughout my stay, I was able to follow along the step-by-step process of building one of these structures, shadowing various fabrication and characterisations procedures. Notably, I conducted comprehensive electrical characterisations of 12 devices using an electrical probe station, contributing valuable insights into their performance.

Weekly meetings provided a platform for discussing relevant literature and refining our device plans, laying the groundwork for future collaborative endeavours. Moreover, the acquisition of this scholarship has catalysed funding applications between our respective research groups with the preliminary data harnessed in the 12 weeks.

At Tyndall, I had the pleasure of working alongside the friendly and knowledgeable team led by Dr. Farzan Gity, including Dr. Lida Ansari, Dr. Vilas Patil, and Hazel O'Neill. Weekly discussions with Dr. Gity and Dr. Ansari sparked innovative ideas for device designs, while Dr. Ansari generously shared her expertise in simulations, enhancing my understanding beyond the scope of the project. Whereas Hazel and Vilas were my main points of call to discuss/shadow the fabrication and characterisation steps. In particular, I spent a lot of time with Hazel watching her measure the number of layers in our 2D semiconductor with an atomic force microscope. Moreover, Dr. Gity gave me an in-depth tour of their state-of-the-art cleanroom patiently addressing my inquiries along the way.

Figure 4: Some members of the group I worked with a Tyndall, including Dr. Farzan Gity and Dr. Lida Ansari directly to my right.

Beyond the confines of the research group, I made meaningful connections with fellow researchers at Tyndall, forging friendships through outings to pubs, bowling and local parks. A special thanks to my friend Tarun, who generously acted as my tour guide, offering insights into the rich history of University College Cork (UCC).

Impact of the Travel Scholarship

The impact of the travel scholarship on my research journey has been profound. Through this opportunity, I transitioned from working predominantly with bulk semiconductors to fully immersing myself in the realm of 2D materials.

This shift not only broadened my understanding but also equipped me with comprehensive knowledge of the fabrication processes essential for creating devices from these remarkable materials. From inception to completion, I now possess a thorough understanding of the intricate steps involved in fabricating quantum devices from 2D materials, a skill set that significantly enriches my research endeavours.

Furthermore, the scholarship facilitated my exploration of characterization techniques, such as utilizing electronic probes for precise electrical measurements, which is unavailable at my home institution. This exposure has expanded my technical repertoire, enhancing the depth and rigor of my research methodology.

Moreover, the scholarship empowered me to pursue a personally driven project, allowing me to explore avenues of research aligned with my interests and aspirations. This freedom to pursue independent projects enriches not only my academic and industrial journey but also contributing to the advancement of knowledge within the field.

On a personal note, this project gave me a huge boost in confidence for my future career as a visiting researcher or a member of staff in another institution.

Figure 54: One of the stops on my tour around UCC, the UCC Quad.

Acknowledgements

Firstly, I would like to thank the Mac Robertson funders for the opportunity.

I would like to thank my host Dr. Farzan Gity and all the members of the lab for welcoming me into the group, their insights on 2D materials, their support during my visit and their thoughtful messages on my leaving card. Particularly I would like to thank Dr. Gity and Dr. Ansari for their supervision, enthusiasm, and encouragement in our literature meetings.

I also want to extend my gratitude to my supervisor, Dr. Alessandro Rossi, for his consistent support and guidance throughout the funding application process. Dr. Rossi's feedback on each application was invaluable, and his encouragement has been a constant source of motivation.

Lastly, I would like to thank all the colleagues I shared an office with for all the fun and laughter I was able to have in my stay.