ARAP WITH IMRE RESEARCH AREA: QUANTUM SCIENCE AND TECHNOLOGY

#	A*STAR Researcher	Designation	Email Address	Research Area
1	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	A diamagnetically levitated particle is predicted to be able to perform ultrahigh sensitivity quantum sensing that can go far beyond the standard quantum limit. In this project, we will use a ferromagnetic particle to precess about the magnetic field like atoms precessing at a Larmor frequency under conditions where its intrinsic spin dominates over its rotational angular momentum. Observing atomic precession at a mesoscopic scale requires frictionless levitation to allow free precession, and good magnetic shielding to reduce the orbital angular momentum. Such levitated object is a correlated system of spins that can rapidly reduce quantum uncertainty. The dynamic of such an object can be described by the Landau-Lifshitz-Gilbert equation. The “artificial atom” can be used for developing the next-gen quantum sensors, such as gyroscopes, magnetometers, gravitometer, and accelerators. The “artificial atom” is also useful for quantum information and metrology. For example, coupling Nitrogen- Vacancy (NV) center spin qubits in diamond to the diamagnetically levitated ferromagnetic particle enables single phonon experiments and quantum state preparation of a mesoscopic object. Required background: The project may suit students interested in theoretical modelling and/or experimental work depending on interest and experience. Familiarity with cryostat, SQUID, optical levitation, Paul trap, modeling of hybrid system, and quantum sensing is highly desirable but not necessary.
2	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	Generating highly entangled photons is a long-standing goal in quantum optics due to its broad ranging applications. An attractive platform on which to achieve this goal is to use the extremely nonlinear properties of atomically thin 2D crystals. Since the discovery of graphene in 2004, many materials with a stable monolayer form have been found, including the important subclass of transition-metal dichalcogenides (MX2; M = Mo/W; X = S/Se/Te). These materials are centrosymmetric when in bulk form, but the inversion symmetry is broken when they are thinned down to mono- or few layer thickness. As a result, 2D materials feature an atomic-level dipole that gives rise to extraordinary physical properties including dichroism, ferro and piezo-electricity. Moreover, These monolayers also exhibit enormous second-order susceptibility $\chi(2)$ (per unit length) that can be exploited for efficient nonlinear optical processes. 2D materials can be used for high efficiency spontaneous parametric down-conversion (SPDC). SPDC is a well developed technique in quantum optics to produce entangled photons. This PhD project aims to investigate enhancement techniques to bring SPDC technique down to the atomic scale to enable the generation of highly entangled photons. Required background: Undergraduate physics and mathematics. Familiarity with experimental physics, optics, 2D material research is highly desirable.
3	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	How can we tell if there is one or more bright stars when they are very close to each other? Two point sources of light that are close together will produce a blurry image difficult to be resolved. Traditionally, the resolution limit on distinguishing point sources of light is called the Rayleigh's limit. This project aims to use coherent measurement techniques in the quantum regime to overcome the Rayleigh's limit. The goal of this PhD is to precisely estimate the separation between two close by point sources. The Fisher information quantifies the precision of an estimator. Using standard measurement techniques that looks at the intensity distribution from the two point sources, the Fisher information goes to zero as the separation goes to zero. However, coherent measurement techniques can be used to overcome this limit. By using an interferometric setup, we can arrive at an estimate that is independent of the separation. Ideally, this setup will accurately determine the separation of two arbitrarily close point sources of light. Required background: Undergraduate physics and mathematics. Familiarity with experimental physics, interferometry and laser optics is highly desirable.
4	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	How well can one determine the parameters of a quantum state? A simple example of a quantum state is the two-level system, which describes a number of physical quantum systems including the polarisation of a photon and the spin of an electron. Even though this state is simple, to fully specify it requires the determination of its Bloch vector which has three non-commuting parameters. If we wish to attain the maximum possible information about a quantum state, we may need to use a more sophisticated measurement technique that can extract multi-parameter information at the same time. Recently, we have developed a semi-definite program that can find the ultimate precision for multi-parameter estimation. This new theory puts a fundamental limit to how well we can perform state estimation on a variety of quantum systems. When an ensemble of identical quantum states is available, a combined measurement on two independent copies of the quantum state will give a higher precision compared to two separate individual measurements on each copy. This type of “quantum collective measurements” are very important for quantum computation and communication applications because they represent a class of optimal measurements. This PhD project will investigate the precision limits for estimating the state of quantum systems. The student will design quantum circuits that saturate multi-parameter estimation limits and will be given opportunities to run the algorithms on a real quantum computer, such as on the IBM or Google quantum computer. Required background: Undergraduate physics and mathematics. Familiarity with quantum physics is highly desirable.
5	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	In recent years, neural network based deep learning has been used to optimise the performance of quantum information experiments. The problem we have tackled was in improving the number of ultra-cold atoms captured in a magneto-optic trap (MOT). Even with decades of research and engineering, there is no proven recipe to maximise atom number and minimise temperature in a MOT. Improving the MOT has mostly been limited to intuition based on approximations and trial-and-error. The solution found by our machine learner outperforms all previous human optimisations. The AI manipulated the experiment parameters in a way that no sensible human would have tried. In this PhD project, we aim to extend this AI to ask the following questions: (1) What is the physics behind the AI solutions? (2) Besides MOT optimisation, what other complex quantum experiments can be improved? The answers to these questions are expected to deliver better optimisation and control for a range of quantum systems that are too complex to be analytically modelled. The AI may also serve as a tool for probing these quantum systems deeper and for developing new heuristic understanding to complement our theoretical models. Required background: Some programming (C++, Python, Tensorflow) will be very helpful. Background in quantum physics and optics is desirable.

6	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	Levitation of macroscopic objects has been demonstrated using superconducting magnetism, electrostatic fields, acoustic pressure, and other physical effects. Perhaps the most well-known application of levitation is the Maglev high-speed train, where levitation is used to eliminate track friction and enable speeds of more than 500 km/h for passenger carrying transport. While levitation is not new, it was only recently thought of as a technology that could be used for probing quantum theory and for precision sensing. Optical tweezers (2018 Nobel prize), for example, use the levitation of nanoparticles for the purpose of studying the quantum opto-mechanical interactions. This PhD project aims to be the first in the world to demonstrate the coherent levitation of a macroscopic object using lasers. By setting up a tripod of high finesse optical resonators, our experiment will operate in the optical spring regime where light inside the optical resonators will provide an amplified radiation pressure sufficient to levitate a macroscopic mirror. We will demonstrate that such a levitated system is scatter-free and is able to retain all quantum information in a closed system. This makes the setup suitable to be used as a quantum sensor for magnetometry, accelerometry and other precision measurements. Required background: Undergraduate physics and mathematics. Familiarity with experimental physics, opto-mechanics and optics is highly desirable.
7	Prof. Lam Ping Koy	Chief Quantum Scientist	lampk@imre.a-star.edu.sg	Squeezed light is a quantum state of light that squeezes the Heisenberg uncertainty circle of $\Delta x \Delta p > \hbar$ into an ellipse. A squeezed state of light therefore has uncertainty in amplitude (or phase) that are much smaller than the quantum noise limit by “dumping” the noise onto the unused orthogonal observable. In some sense, it is a beam of light that is quieter than vacuum. In a handful of labs around the world, squeezed light has been demonstrated to successfully cancel more than 90% of vacuum fluctuations. This quantum state of light has been used for enhancing the precision of measurements, such as in long-baseline gravitational wave detectors (LIGO). Squeezed light can also be used to generate Einstein-Podolsky-Rosen entanglement. This PhD project aims to build Singapore’s own squeezed light source. A goal of this PhD is to create a strong squeezed light source useful for quantum error correction. The PhD student will also use squeezed light to generate EPR entanglement and explore its use in continuous variable quantum information and communication applications, including quantum teleportation, probabilistic quantum cloning and quantum amplification. Required background: Undergraduate physics and mathematics. Familiarity with experimental nonlinear or quantum optics is highly desirable.
8	Prof. Johnson Goh	Principal Scientist	gohj@imre.a-star.edu.sg	Research in my lab: Development of scalable solid-state qubits. Interest to collaborate: Groups that can complement towards reproducible quantum materials deveopment, characterization, fabrication of quantum devices, and related modelling techniques.
9	Prof. Johnson Goh	Principal Scientist	gohj@imre.a-star.edu.sg	The objective of this project is to establish the engineering recipes to fabricate donor-based silicon spin qubit in Singapore. While there are a few promising material candidates for building a scalable quantum computer, semiconducting qubits based in Silicon (Si) holds a prominent advantage over the other material platforms due to the near total dominance of Si in the conventional classical computing technology, promising eventual on-chip integration of classical and quantum electronics. The student will be trained in scanning probe microscopy and lithography techniques and have hands on experience with developing a Si based qubit. The student will also be involved in electrical characterization and the actual measurement of the fabricated qubit devices at mK temperatures.
10	Prof. Johnson Goh	Principal Scientist	gohj@imre.a-star.edu.sg	A realistic quantum computer that can solve real world problems will likely need on the order of a million qubits. Currently, a method to grow high quality material stacks capable of hosting multiple qubits in a scalable 2D material platform is still lacking. In this project, we develop the advanced growth and characterization techniques to realize high quality device-ready 2D semiconductor material stack with dielectric encapsulation for valley pseudospin qubits. The students will be trained on material growth methods, device fabrication methods, optical and electrical characterization techniques, and soft skills such as problem solving, report writing, and effective communication. This PhD training will allow students to pursue a career in both scientific research and the industry after graduation.
11	Aaron Lau	Scientist	aaron_lau@imre.a-star.edu.sg	The research in our laboratory focuses on fabrication and measurements of devices based on 2D materials such as transition metal dichalcogenides, e.g. WS2. We have strong capabilities in cryogenic measurements (2 dilution refrigerators with associated electronics capable of mK temperature measurements), optical measurements (circular dichroic photoluminescence with electrical measurements) and material characterization with angular resolved photoemission spectroscopy. We can process and fabricate 2D TMDC based devices, and also have growth capabilities for WS2. Our main interest revolves around material processing and engineering of 2D TMDCs for quantum transport studies and applications in quantum information processing. I will like to collaborate with groups with similar interests in studying 2D materials, and who might have complementary expertise in areas such as material synthesis and preparation, material characterization, functionalization, device fabrication and theoretical modelling.

12	Aaron Lau	Scientist	aaron_lau@imre.a-star.edu.sg	Two-dimensional materials have unique properties for next-generation device applications in areas such as quantum, bio and nano technology. However, realizing quantum nanoelectronics based on these advanced materials requires overcoming two crucial challenges: dielectric integration and contact engineering. Conventional approaches inevitably introduce surface damage that are severe in these atomically thin materials. State-of-the-art solutions remain unsatisfactory in either quality, compatibility or scalability. To overcome these shortcomings, we propose to use liquid metal reaction synthesized ultrathin oxides as gate dielectrics or as protection/seed layers for subsequent dielectric deposition. These ultrathin oxides form as a native oxide skin on liquid metals. They can be printed over large areas onto suitable substrates/materials to form unique heterostructures exciting for various device applications. We have demonstrated the successful printing of ultrathin Ga_2O_3 onto various substrates and 2D materials to form functional electronic devices. By mixing different elemental metals, eutectic alloys can be created where the ultrathin oxide skin formed on the surface is a mono-elemental oxide for which the reduction of Gibbs free energy is the greatest. Through careful control of the environment such as temperature, pressure and oxygen/moisture content, many different oxides, including HfO_2, can be created on the surface of Galinstan, a eutectic alloy made from gallium, indium and tin. There are two work scopes. Students will investigate the oxidation process and characterize the resulting ultrathin films. They will also explore the feasibility of tuning the material properties of the oxide films through post treatments or during the oxide printing process. For example, we have showed that the stoichiometry of Ga_2O_3 ultrathin oxide films can be changed through oxygen annealing. Mastering control over the properties of these films will widen the potential application areas, e.g., power electronics, solar blind UV detectors, catalysis and water splitting etc. Students will also investigate suitable integration processes for ultrathin oxides with 2D semiconductors and fabricate unique heterostructures. Conventional dielectric growth processes that are scalable and compatible with industrial techniques are unfortunately not compatible with 2D materials. The atomically thin nature and pristine surfaces of 2D materials render them susceptible to damage or poor-quality dielectric growth from these conventional processes. However, growing high-k dielectrics are of extreme interest to industry, for e.g. Intel and Imec are both working on HfO_2 dielectrics and their use for next-generation 2D material-based electronics. The use of ultrathin liquid metal synthesized oxides including HfO_2 can protect the underlying 2D material from damage and promote high-quality and uniform dielectric growth. Students will investigate and establish these growth approaches for the creation of high-quality 2D material heterostructure stacks that are compatible with industrial techniques. They will fabricate and characterize devices using state-of-the-art facilities at A*STAR, including a unique cleanbox that provides complete material processing, lithography, and thin film deposition in a class-1 cleanroom and inert environment, standard cleanroom lithography and fabrication facilities, and cryostats including dilution refrigerators that can reach millikelvin temperatures equipped with superconducting vector magnets and low-noise DC and RF capabilities.
13	Aaron Lau	Scientist	aaron_lau@imre.a-star.edu.sg	The enormous potential of quantum computing is now well accepted among the scientific community. What is not well accepted, however, is the type, or even types, of qubit platforms that will form the basis for a fully programmable, fault-tolerant universal quantum computer. A critical challenge today is therefore the development of qubit platforms that are scalable and hopefully also compatible with established industrial CMOS manufacturing capabilities Two-dimensional materials hosting coupled spin valley degrees of freedom provide an attractive option for quantum information processing. Their unique spin-valley coupling, atomic thinness, and large spin-orbit coupling provide a unique opportunity for electrically defined and driven spin-valley qubits with fast driving times and long spin-coherence lifetimes. However, realizing such quantum devices will demand the highest levels of quality in material processing and device fabrication. Our group has demonstrated the first WS_2 bilayer quantum dot device using scalable approaches such as chemical vapour deposition growth, atomic layer deposition and thermal evaporation for the channel, dielectric and contacts. In the next phase of this ambitious undertaking, the student will work with a team of scientists at IMRE to develop a ‘passive-first-active-last’ device architecture. This device geometry aims to be a general, scalable platform for the fast characterization of quantum transport of different types of low-dimensional materials. The student will fabricate and characterize devices using state-of-the-art facilities at A*STAR, including a unique cleanbox that provides complete material processing, lithography, and thin film deposition in a class-1 cleanroom and inert environment, standard cleanroom lithography and fabrication facilities, and cryostats including dilution refrigerators that can reach millikelvin temperatures equipped with superconducting vector magnets and low-noise DC and RF capabilities. The student will investigate quantum transport phenomena such as Coulomb blockade, Shubnikov–de Haas effect, Kondo effect etc. and work towards building the first-ever solid-state qubit capable of single-shot readout and manipulation in 2D semiconductors.
14	Anna Paterova	Scientist	paterova_anna@imre.a-star.edu.sg	Collaboration in controlling the spectrum of entangled photon pairs
15	Anna Paterova	Scientist	paterova_anna@imre.a-star.edu.sg	Quantum infrared micro-spectroscopy (QIM) via the detection of visible light is of interest for wide research applications, such as sensing, biomedical and chemical studies. Probing the infrared fingerprints of a specimen allows identifying its chemical composition with high accuracy. For biomedical and explosive studies, so called “fingerprint” infrared range (from 7 µm to 16 µm) is most useful and informative. Currently, QIM is well developed for the mid-IR range up to 5 µm wavelength. Going beyond 5 microns requires studying of novel nonlinear crystals for the generation of quantum light. We have primary results with the AGS nonlinear crystal for the generation of quantum light at 7-8 µm wavelength range. However, the efficiency of the quantum light generation is quite poor. Therefore, we require to find suitable crystal working at “fingerprint” infrared range, which would have higher nonlinearity. Possible candidates for that are GaP, GaSe, Se, etc. Another problem of extending the QIM into “fingerling” infrared range is angular distribution of the generated quantum light: longer wavelengths have higher scattering angles. Therefore, high NA optics is required to do QIM measurements in the “fingerprint” infrared range. To address this problem we need to investigate on designing special parabolic mirrors, which will allow collecting as much scattered angles as possible. The student will be trained to perform experimental work on quantum optics, including the generation of quantum light, alignment of optical setups, analysing of the data, designing the optical and mechanical parts etc. He/she is expected to keep all the experimental notes and to make presentations, reports and write-ups. This will allow developing both his/her scientific qualification and writing/presentation skills. By the end of the first year of the scholarship, student is expected to gain knowledge of conducting and planning experimental work independently.

16	Aravind Anthur	Scientist	aravind_padath_anthur@imre.a-star.edu.sg	The project aims at design, fabrication and characterization of high-quality optical resonators for nonlinear optical applications focusing on the development of on-chip optical parametric oscillators and frequency combs. The optical parametric oscillators and frequency combs are two types of lasers giving single frequency and multiple frequency emissions respectively. The first step involves the design of nano-photonic structures engineering the modes of the waveguide and its dispersion for the efficient generation of these types of laser light. A typical dispersion profile of a nano-photonic waveguide is given below. The dispersion profile decides the emission wavelength of the laser. The PhD student will be trained the device design, fabrication and characterization with state-of-the-art infrastructure. In particular, the student will gain expertise of nano-photonic device design and simulation using FDTD and FEM tools like MEEP, Lumerical and COMSOL. The student will also learn photolithography, etching and deposition for fabricating devices with a very high tolerance. The student then will perform characterization of the devices using optical systems where she/he will learn about lasers, optical alignment, and imaging. Going through the whole cycle of design, fabrication and characterization will provide a complete understanding of the process flow for nanophotonic device development. This will provide critical skill to the student necessary for optimizing different steps and developing high quality resonators.
17	Calvin Wong	Scientist / Deputy Head of Dept	calvin_wong@imre.a-star.edu.sg	The research in my laboratory focuses on investigating spin and charge transport using scanning probe microscopy and low temperature electrical measurements of 2D materials, with the ultimate goal of making qubits (quantum bits) out of them. I would like to collaborate with groups who have expertise in this field and work with 2D materials to study novel physics phenomena at low temperature.
18	Calvin Wong	Scientist / Deputy Head of Dept	calvin_wong@imre.a-star.edu.sg	Transition metal dichalcogenides are new materials with potential application in ‘valleytronics’ due to the presence of spin-valley coupling in the band structure, allowing us to address the valley states using the carrier spin states for advanced modes of data storage. However, spin injection is a challenging problem as there is a fundamental impedance mismatch between the ferromagnet and the semiconductor. In this project, the student will instead explore spin injection using ballistic spins, where the spin polarized current is driven by kinetic energy and is not limited by the impedance mismatch. The student will be involved in device fabrication using advanced lithography techniques and measurements using scanning tunnelling microscopy.
19	Huang Ding	Scientist	ding_huang@imre.a-star.edu.sg	Superconducting qubit is one of the leading platforms to build quantum computers capable of solving problems beyond the reach of existing technologies. Current efforts to make large-scale quantum processors are hindered by the short quantum information storage times (T1) and the large footprint of superconducting qubits. Recently, there have been significant developments in enhancing the performance of superconducting qubits using two-dimensional van der Waals (vdW) materials. Replacing the planar capacitor of a superconducting qubit using vdW heterostructures drastically reduces the size of superconducting qubit by at least 250 times. This provides a viable pathway for high-density qubit integrations and suppressed crosstalk for large-scale qubit operations. However, despite the success in reducing sizes, even the best vdW-based superconducting devices show T1 at least an order of magnitude shorter than state-of-the-art superconducting qubits. It was hypothesised that the T1 of vdW-based superconducting qubits is mainly limited by material-related losses. In this project, we aim to identify the optimal material platform for vdW-based superconducting qubits. The student will perform interdisciplinary, collaborative research to investigate the limiting mechanisms of T1 for vdW-based superconducting qubits. This will include design, fabrication, and characterization of superconducting microwave circuits with embedded vdW materials. The project will involve all steps in the vdW-based superconducting device fabrication and measurement processes, including electromagnetic simulations, qubit chip design, nanofabrication, and qubit measurements. Nanofabrication will include cleanroom processes such as lithography, etching and metal deposition. The device characterization will include cryogenic measurements of microwave resonators and superconducting qubits at milli-Kelvin temperatures.
20	Ivan Verzhbitskiy	Scientist	ivan_verzhbitskiy@imre.a-star.edu.sg	Quantum information processing has been widely discussed as a new computational paradigm and has now become a viable commercial prospect. Quantum computing gains its power from exploiting coherent superpositions of quantum two-level systems. The generality of this idea led to an abundance of theoretical proposals and experimental demonstrations involving cold atoms and ions, quantum optics, superconducting circuits, quantum-confined electrons and spins in solids. Despite this diversity, major industries focus their attention on superconducting qubits. While this technology offers long coherence times and the potential for moderate scalability, the challenges for quantum error correction remain unresolved. Potentially, fault-tolerant computation can be realized through the non-local encoding in quasiparticle states whose entanglement is protected by symmetry. The latter requirement is theoretically fulfilled in topological superconductors. One path toward topological superconductivity is to realize an intrinsic spinless p-wave superconductor. However, such materials are extremely rare in nature. An exciting alternative approach to intrinsic systems is the proximity-engineered topological superconductivity in heterostructures of conventional (s-wave) superconductors and topological insulators. The family of van der Waals 2D crystals encompasses many material systems, including topological insulators (e.g. 1T’-WTe2) as well as s-wave superconductors (e.g. NbSe2). Here, we propose to realize topological superconductivity in vertical van der Waals heterostructures comprised of van der Waals layers, benefiting from the ideal interfaces and circumventing many challenges of conventional heterostructures. The ultimate goal is to demonstrate a compact van der Waals device platform that hosts topologically protected gapless excitations with prospects for electric-field-tunable, fault-tolerant on-chip qubits. The student will join a team of highly skilled researchers with diverse backgrounds in materials science, engineering, crystal growth, and quantum transport. He/She will actively participate in the fabrication of the van der Waals heterostructures in the inert environment of a glovebox assembly, equipped with a lithography setup, metal evaporation and ALD tools. The student then will carry out multiterminal transport spectroscopy studies using the state-of-the-art millikelvin refrigerators with vector magnets, capable of handling low-noise DC and RF measurements.
21	Lee Jun Yi	Scientist	lee_jun_yi@imre.a-star.edu.sg	Ultra-sensitive magnetometry with sensitivity at the fT/sqrt(Hz) level have diverse applications ranging from enabling non-invasive brain imaging with high spatial and temporal resolution, to sensitive applications in homeland security. This project seeks to build a scalar alkali atomic magnetometer in Singapore that is capable of operating in Earth’s field with a sensitivity of 10 fT/sqrt(Hz). In the longer term, this project also seeks to investigate the use of light-narrowing, together with conditional spin squeezing, to enable a significant increase of sensitivity in Earth’s field, which is currently impossible to achieve in a compact vapour cell due to relaxation of the alkali atoms. Overcoming this sensitivity limit in Earth’s field will have significant impact for magnetic sensing for brain imaging, explosives detection, Earth monitoring, and defence applications. Our PhD students will acquire both theoretical modelling and experimental skills in physics, which will prepare them for a variety of careers. For example, there is a growing interest within the research community for using atomic magnetometers and co-magnetometers for various applications. These include using atomic magnetometers for magnetoencephalography (measuring of the brain’s magnetic fields), stand-off chemical specific detection of explosives and narcotics, sensitive compact gyroscopes for defence applications, and space-based applications. A PhD student trained in atomic magnetometer could potentially work in any of these areas.
22	Liu Yuanda	Scientist	liuyd@imre.a-star.edu.sg	The research in my laboratory focuses on interlayer excitons devices, semiconductor devices, optoelectronics, optics, 2D materials, and nanofabrication. - I would like to collaborate with groups which are interested in novel physics and device physics on the basis of 2D layered materials, optoelectronics, microelectronics, quantum optics.

23	Lu Ding	Scientist	dingl@imre.a-star.edu.sg	The research in my lab focuses on nanophotonics, nanoplasmonics, resonantors, optoelectronics, etc. I would like to collaborate with groups which have expertise in on-chip integrated quantum information and condensed matter physics.
24	Victor Leong	Scientist	victor_leong@imre.a-star.edu.sg	This project involves the development of non-cryogenic on-chip integrated photonics single-photon detectors. Single-photon detection represent the ultimate sensitivity limit for light detection and integrating such detectors onto photonics circuits would open up a large variety of cutting-edge applications to the field of integrated photonics, including quantum cryptography, photonic computing, AR/VR/metaverse, etc. At the current stage, the projects are focused on refining existing prototype devices, and pushing the development of the devices towards demonstrable single-photon detection capability. Students can work on multiple areas, including device design, device fabrication, setup building/engineering, device characterization, opto-electronic packaging, control electronics, and so on. The students will have a well-rounded exposure and training to various aspects of integrated photonics development, including experimental optics, nanofabrication processes, opto-electronic characterization, electronics, setup automation, and so on.
25	Zhu Di	Scientist	zhu_di@imre.a-star.edu.sg	Our research group focuses on developing devices and materials for photonic quantum information processing. We work on two main areas: (1) integrated quantum and nonlinear photonics on thin-film lithium niobate, including photon-pair generation, quantum frequency conversion, and frequency comb generation; (2) superconducting nanowire single-photon detectors, including developing new materials and readout architectures, as well as integrating them with photonic integrated circuits. We would like to collaborate with groups that are interested in integrated photonics (classical or quantum), nanophotonics, applied superconductivity, or quantum materials/devices.
26	Zhu Di	Scientist	zhu_di@imre.a-star.edu.sg	Implementing practical photonic quantum computation and simulation requires thousands to millions of optical components. Integrated photonics is likely the only route to achieve such scale. However, existing leading integrated photonic platforms, such as silicon and silicon nitride, lack many crucial functionalities required for quantum information processing. To address this problem, we aim to develop an integrated photonic platform based on thin-film lithium niobate, an emerging and versatile material ideally suited for quantum photonics. We will develop on-chip quantum light sources and controllers and leverage them to realize advanced quantum computation protocols.
27	Zhu Di	Scientist	zhu_di@imre.a-star.edu.sg	Superconducting nanowire single-photon detectors (SNSPDs) are currently the best performing single-photon detection technology at infrared wavelengths. They are widely used in quantum information, deep-space communication, and biochemical sensing. However, some applications are posing increasingly demanding requirements on photon detections, such as requiring large arrays, and photon number as well as energy resolution. These are beyond what standard SNSPDs can achieve. In this project, we aim to expand the functionalities of existing SNSPDs by developing new device architectures, exploring new materials, and combining them with novel photonic and microwave structures.