PITT STREET RESEARCH

Archer Materials

Paradigm shifting technologies

Share Price: $0.31

ASX: AXE

Sector: Technology

1 February 2023

Archer Materials (ASX:AXE) is a company developing two emerging semiconductor technologies. Firstly, ^{12}CQ is a carbon-based quantum computing technology that is aimed at operating at room temperatures and integrate with today's semiconductor manufacturing processes. Secondly, the company's graphene-based Biochip is a lab-on-a-chip technology being developed to enable more efficient and practical detection of diseases.

AXE's technologies are potentially transformational

Once fully developed, ^{12}CQ can potentially enable the use of quantum computing in mobile devices at room temperatures. This is a big claim, but if the company could bring the technology to market, it could open up a broad spectrum of market opportunities, including better data security, Artificial Intelligence applications and more accurate and faster modelling of chemical reactions, e.g. in Life Sciences. The Biochip technology, meanwhile, could have a transformational impact on the speed of medical diagnostics workflows. Additionally, it could provide much better access to healthcare for those who might not otherwise have access to it, e.g. through integration of Biochips into mobile devices.

Key share price catalysts upcoming

We believe large-scale commercialisation of ^{12}CQ is most likely at least 5-7 years away, there may be smaller scale opportunities sooner than that. Biochip, however, could potentially be commercialised in much less time than that. We see several catalysts for shareholder value creation in the short to medium term. In particular, we believe continued achievement of development milestones for both ^{12}CQ and the Biochip will be key value drivers. Additionally, potential development partnerships with leading semiconductor, technology and life sciences companies will likely provide validation of Archer Materials' technologies, which in turn would be a major share price catalyst, in our view, as would further additions to the company's patent portfolio.

Early days to value, but peer group implies upside

Because it is an early-stage semiconductor development company, it's hard to put a valuation on Archer Materials. However, the company has $21.6m in cash and its relevant ASX peers trade at valuations that are at least 60% higher. We see upside for Archer Materials to a range of $0.60-$1.00 per share. Please see p.22 for the key risks associated with an investment in Archer Materials.

Market Cap. (A$ m)	79.0
# shares outstanding (m)	254.9
# shares fully diluted (m)	254.9
Market Cap Ful. Dil. (A$ m)	79.0
Free Float	100%
52-week high/low (A$)	0.79 / 0.30
Avg. 12M daily volume ('1000)	269.3
Website	https://archerx.com.au

Source: Company, Pitt Street Research

Share price (A$) and avg. daily volume (k, r.h.s.)

Source: Refinitiv Eikon, Pitt Street Research

Analysts: Marc Kennis, Nicholas Sundich

Tel: +61 (0)434 838 134

Marc.kennis@pittstreetresearch.com

nick.sundich@pittstreetresearch.com

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Introducing Archer Materials

Archer Materials is developing the 12CQ qubit processor device and its Biochip lab-on-a-chip device.

ASX-listed Archer Materials (ASX:AXE) is developing its ^{12}CQ qubit processor device, aimed at performing quantum computing in mobile devices at room temperature. Its second key technology under development is its Biochip, a lab-on-a-chip device that should enable the efficient and parallelised detection of diseases on a single chip (Figure 1).

Figure 1: Archer Materials' two key development projects

Source: Company

History

Archer was founded in 2007 and was a graphite explorer at the time. The company transitioned into quantum technology development in 2019, beginning to build prototypes of its ^{12}CQ device at the Research and Prototype Foundry within Sydney University's Sydney Nanoscience Hub.

- In May 2020, AXE was invited by IBM to join the invitation-only IBM Q Network, a global community of stakeholders, led by Big Blue, seeking to advance quantum computing.
- In mid-2021, it had an early indication of on-chip qubit control in microscopic-scale qubit material.
- Archer Materials gradually expanded its patent portfolio around ^{12}CQ and now has patents in South Korea, Hong Kong, Japan, China, Australia, the US and Europe.
- The company proved its technology could be incorporated in devices manufactured with existing semiconductor processes, including complementary metal-oxide-semiconductor (CMOS) silicon chip manufacturing.
- Meanwhile, Archer Materials initiated development around its graphene-based Biochip aimed at rapidly detecting viruses and bacteria in medical diagnostics workflows and mobile devices.
- The Biochip development has progressed to the point where we believe this is now Archer Materials' key project, i.e. closest to market introduction in due course.
- Archer has initiated several partnerships, including with foundries, such as Taiwan Semiconductor Manufacturing Company and GlobalFoundries.

We will discuss both technology development projects in depth in this report.

The Archer Materials investment case

1. Archer Materials provides investors with unique exposure to groundbreaking quantum computing technology. It is the only ASX-listed company, and one of only a few companies in the world, attempting to develop mobile integrated room temperature quantum computing.
2. Similarly, the graphene-based Biochip is unique in that it aims to provide a substantially more efficient way to detect viruses and bacteria in a way that makes the technology mobile and, hence, facilitates many different use cases.
3. If and when one of the technologies (or both) is successfully developed and commercialised, we believe there is a very substantial revenue opportunity for Archer Materials to capitalise on.
4. While the technology development road ahead is long and winding, we believe achievement of development milestones as well as new strategic and technical partnerships with leading industry players are likely to be clear share price catalysts in the meantime.
5. Archer Materials has a well-rounded patent portfolio for the ^{12}CQ technology in key jurisdictions globally as well as patents pending for its Biochip technology.
6. Archer Materials is a fabless chip company, i.e. it doesn't operate its own manufacturing facilities. Fabless chip companies typically have low Capex and are highly scalable with high operating margins once they generate meaningful revenues.
7. The company is already working with several foundries, including Tier 1 foundries GlobalFoundries (NASDAQ:GFS) and TSMC (TPE:2330), to progress both its technologies onto silicon for further development work and proof that they can be captured in integrated circuits.
8. The company's CEO, Dr Mohammad Choucair, has the ideal resume and network to drive Archer Materials' strategic technology development and commercialisation efforts (see Appendix I). He is an Alumni of The World Economic Forum and has an extensive technical background in nanotechnology having published on the subject in leading publications, such as Nature Communications[1].
9. Based on what the market is currently willing to pay for 4DS Memory and AudioPixels, Archer Materials' most relevant peers at the moment, we believe its shares have the potential to rerate to a range of $0.60 to $1.00 in the medium term if and when the right share price catalysts materialise (see below). This implies at least 50% upside from current levels. We would also highlight the example of Weebit Nano, a company that is approx. 5 years ahead of Archer Materials, as an example as to what Archer Materials' share price could achieve in the long-term, i.e. a substantial valuation multiple rerating.
10. We see two main catalysts for Archer Materials' share price, i.e. ongoing achievement of technological milestones for both the ^{12}CQ quantum chip and Biochip as well as potential partnerships with established, global semiconductor, technology, and Life Sciences companies.

[1] https://www.nature.com/articles/ncomms12232

^{12}CQ: Quantum computing made widely accessible

^{12}CQ could potentially enable quantum devices that are mobile and that could operate at room temperature.

Archer Materials' ^{12}CQ (pronounced one-two-see-queue) is a carbon-based quantum bit (qubit) semiconductor technology. Once fully developed, the technology may potentially enable quantum devices that process quantum information in mobile technology and be accessible to a more broader population than today.

This is a big claim considering that today's quantum computing devices are very large, impractical, expensive and accessed by few. This is for several reasons including that they require operating temperatures near absolute zero degrees, i.e. close to -273C degrees, to enable sufficient time to read the values of the qubits.

Archer Materials aims to change this paradigm with its ^{12}CQ technology. Before we take a deep dive into the technology, let's have a look at what quantum computing is and what makes it so special.

Quantum computing is a big deal

Quantum computing is information processing that uses the laws of quantum mechanics. It can solve problems that existing computing can't, because today's computers operate on 'bits' (units of information that can store and process either a zero or a one). Quantum computers, however, are built on quantum bits, or qubits, which can store and process zeros and ones and any value in between at the same time. In practice, quantum computers will still need classical computers to function, though, because the input and output devices process in 0's and 1's i.e. classical information or bits.

When classical computers solve a problem with multiple variables, they must conduct a new, sequential, calculation every time a variable changes. Each calculation is a single path to a single result.

Quantum computers can process calculations much faster than regular computers.

However, because of their ability to represent multiple values at the same time, quantum computers in principle have a much larger processing capacity, which means they could potentially make calculations much faster than regular computers on their own for certain problems.

To illustrate the difference, in 2019 a Google quantum computer was found to have solved a niche problem in 200 seconds that would have theoretically taken a classical computer 10,000 years – the difference was argued to be *that* significant. Of course, it is not intended to be taken that literally because no one can live that long, although it does highlight the advantage of quantum computers.

So, there is no shortage of potential tasks quantum computing could either enable or perform better. And, like with regular computers, the more qubits available, the more powerful a quantum computer will be (Figure 2).

Figure 2: The possibilities of quantum computing

Source: Company

Two key hurdles Archer Materials is trying to overcome

As good as the potential of quantum computing sounds, we are a long way off from quantum computing becoming mainstream. With its ^{12}CQ technology, Archer Materials is specifically trying to solve two key issues with today's quantum computers:

- **Today's quantum computers do not operate at practical conditions,** they typically must operate at near-absolute zero temperatures (-273°C degrees) to extend so-called coherence times as much as possible, i.e. the period of time a qubit can maintain its quantum state (and hence its value) before that state decays and the value can no longer be read. In other words, the time window for processing quantum information.

- **They tend to be large and difficult to scale**, because of the accompanying systems and infrastructure that is required to keep quantum computers operating.

As a result of these issues, quantum computers are difficult to integrate into modern electronics and are currently Cloud-based or installed on site, i.e. customers wanting to use, say, IBM's quantum computers can buy time on that system and their job is queued. They send through the data related to their "problem", IBM will run it through their quantum computer and send back the results to the customer.

Even if and when, quantum computer processors are miniaturised and integrated into modern electronics, it will take a few years before quantum computing can be adopted on a wider scale – organisations will need time to acquire devices and integrate them into their operations, which requires adopting new workflows and new processes, including new quantum algorithms. The good sign is that many large companies across several sectors, primarily the financial sector, are already doing this with the quantum computers available and widescale adoption of the technology is now generally expected by 2030.

How ^{12}CQ would work

^{12}CQ is a world-first qubit processor technology being developed that would pave the way for mobile quantum computing-powered devices. It comprises of:

- A carbon nanosphere adapted to store a qubit represented by an electronic spin,
- Readout and control devices to set the qubit and read the value stored on the carbon nanosphere.

The coherence time of electron spin in carbon nanospheres at room temperatures is long enough for read out

There are two important parameters of a qubit. The first is coherence, the time window for processing quantum information, as measured by the electron spin lifetime. The second is fidelity, the quality of the calculation.

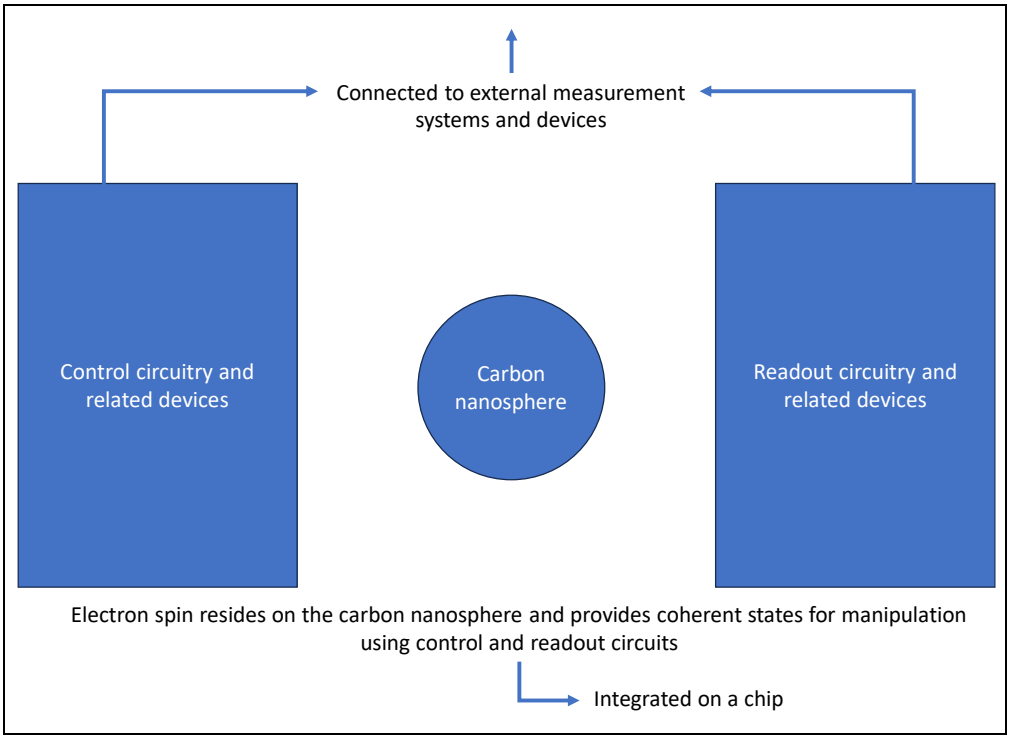
Qubits stored on carbon nanospheres have a greater coherence at room temperature and don't require near-absolute zero operating temperatures to prolong coherence. Additionally, the value of carbon-based qubits could potentially be controlled and be read without having to apply "tricks" to lengthen read times, although colder temperatures will lengthen spin lifetime.

In simple terms, ^{12}CQ works as follows:

1) A carbon nanosphere is positioned in a magnetic field (Figure 3), which "sets" the basic value of the qubit. Specifically, depending on how the magnetic energy in the electron in the carbon nanosphere affects the spin of this electron, the state of the electron can be an "up" spin or a "down" spin.
2) To change the state of the qubit, electromagnetic radiation, like microwaves, are directed at the nanosphere, which changes the spin of the electron, e.g. from Down to Up.
3) In quantum computing, however, the state of the qubit (the spin) can be Up and Down at the same time, and even a complex combination of both. This is known as Superposition, which makes quantum computing so powerful.
4) To read out a value of the qubit, a second microwave pulse is sent out. The energy of this second pulse is only absorbed if the spin of the electron is Down. If the spin is Up, the new pulse won't be absorbed. Hence, whether or not the energy from the second microwave pulse is absorbed tells you what state the qubit was in, Up or Down, or 1 or 0.

5) Along with Superposition, Entanglement would then be required, presumably by engineering two of the carbon nanospheres close together to 'connect' them and performing the scientific experiments and measurements to test for proof of entanglement.

Figure 3: Basic ^{12}CQ configuration



Source: WIPO, Company, Pitt Street Research

^{12}CQ may facilitate smaller and cheaper quantum computers.

Key take aways

The description above is an overly simplified one and explaining the exact way quantum computing works is well beyond the scope of this report. However, there are a few key take-aways:

1. Practical operation of qubits

Electron spin, both direction and duration, is easily affected by things such as temperature and unwanted influence by air/oxygen in the system. For instance, in "traditional" quantum computing set ups, the duration (coherence) of a certain spin is prolonged by operating close to -273°C.

The carbon nanosphere in Archer Materials' ^{12}CQ system could potentially operate at any temperature between close to -273°C and room temperatures, because of the properties of the materials. Coherence in the carbon-based system at room temperature is in principle long enough to effectively read out the values generated by the system.

2. ^{12}CQ should lead to smaller and cheaper quantum computers

As long as the electron spin is protected well enough from outside influences, such as radiation and "foreign materials", the ability for ^{12}CQ to operate at room temperatures can potentially facilitate substantially smaller and cheaper quantum computers as the carbon nanomaterial is integrated with modern electronic devices to control and readout the associated qubits.

Opportunities for ^{12}CQ chip may be very substantial

Rising investments by governments globally are driving expansion in the quantum computing industry.

The quantum computing market opportunity is growing rapidly due to the rising demand for SaaS business models, increasing workloads in data centres for any number of applications, including financial, medical etc, as well as the increasingly complex processor designs for traditional computing systems. The latter makes it increasingly harder, and expensive, to keep up with Moore's law, which stipulates that the number of transistors on a given surface area will double every two years or so.

The quantum computing industry is also likely to benefit from increasing investments in quantum computing technologies by governments worldwide. China has been the top investor as governments commit to and finance the development of the technology. The Chinese government is committing significant funds to quantum computing under its current five-year plan and has been investing heavily in the R&D of various computing technologies.

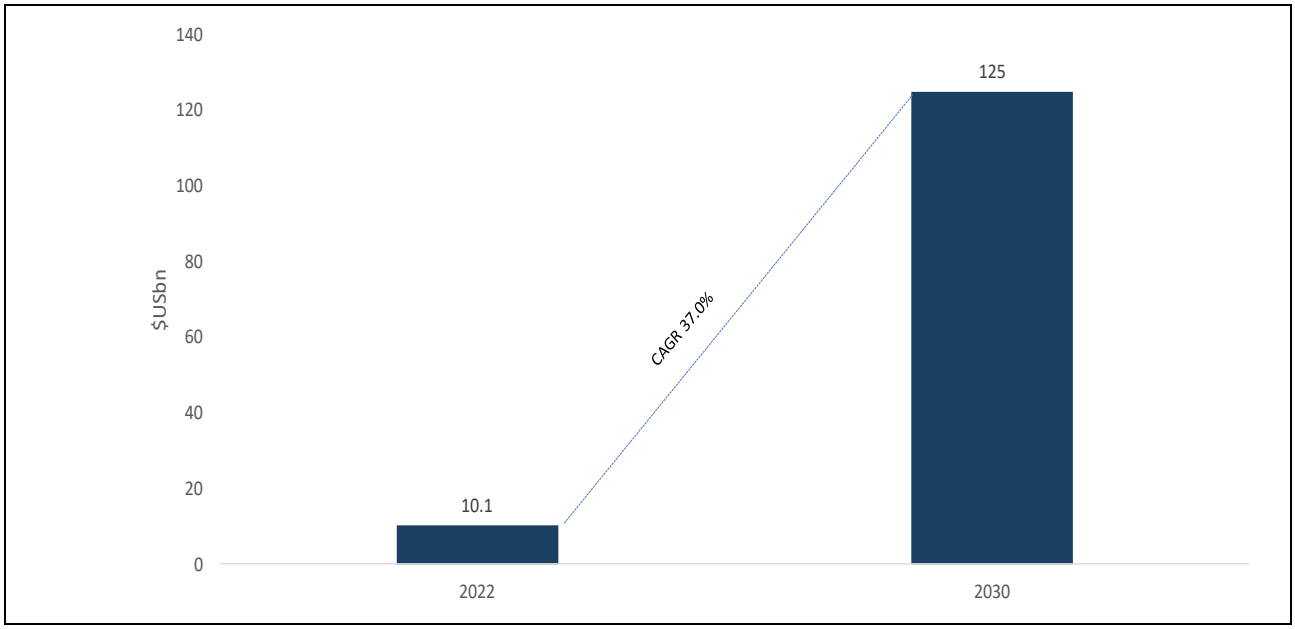
China is one of the largest funders of quantum computing research.

Chinese state funding for quantum computing research is estimated to be close to US$15bn, with China holding more than 30% of the world's quantum patents. European governments and universities are also spending considerable funds on developing quantum technologies.

The mix of public and private investments has sparked a constellation of companies developing quantum computers or their building blocks. A growing number of startups have entered the quantum computing industry and attracted funding from investors worldwide.

There are various estimates of how the global quantum computing industry is likely to grow over the rest of this decade. One estimate, from Precedence Research (a Canada based providers of strategic market insights) suggests the global quantum computing industry is likely to grow from US$10.1bn in 2022 at a CAGR of 36.9% to US$125bn in 2030. (Figure 4). Other studies put the current global market for quantum computing at US$2bn, but foresee a similar market size by 2023, i.e. approx. US$130bn.

Figure 4: Global quantum computing market is likely to register robust growth by 2030



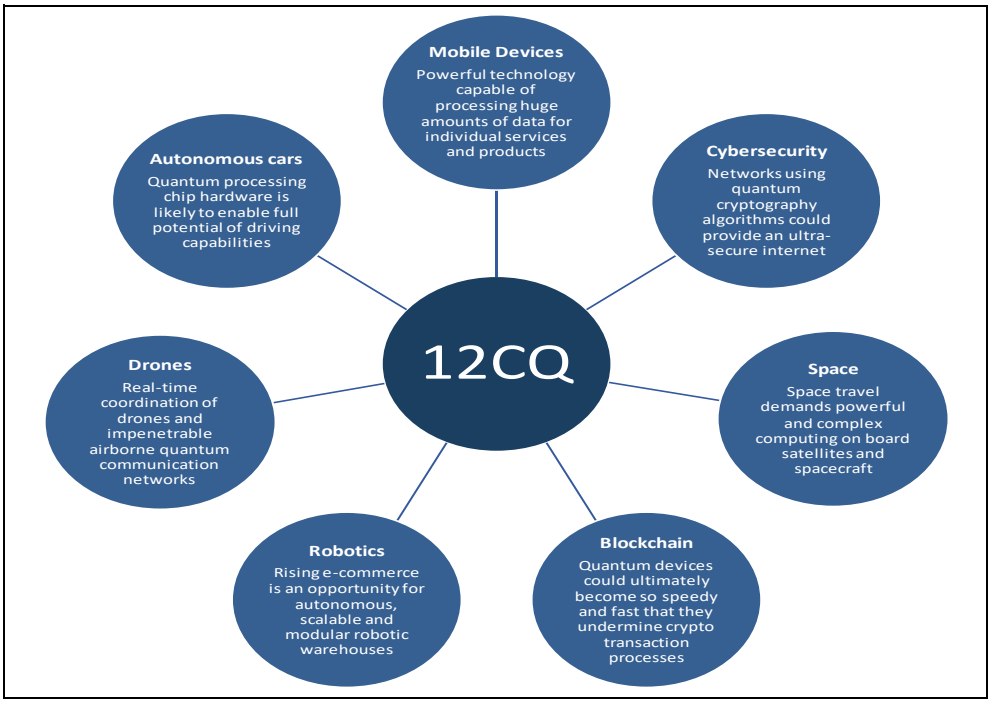
Source: Precedence Research, Pitt Street Research

There are several specific reasons for the expected high growth in the quantum computing market.

There are several reasons for the expected high growth in the market:

- **Rapid technological breakthroughs** – The growth in quantum computing is likely to be fuelled by the increasing reliance on sophisticated computing technologies to address complex issues that are beyond the capabilities of today's computers.
- **Increasing adoption of cloud technology** - In terms of deployment, the quantum computing market is divided into cloud and on-premise segments. With the development of more robust systems, the demand for cloud-based computing services is expected to rise. Additionally, the cloud offers alternative avenues to leverage quantum computers, along with comprehensive solutions from major market players.
- **Increasing traction gained by the machine learning segment** – The machine learning / Artificial Intelligence (AI) segment is likely to dominate market demand. Machine learning would potentially enable the development of quantum error-correcting codes and the creation of novel quantum algorithms.
- **Increasing traction gained by Banking, Financial Services & Insurance (BFSI) and health care sectors** – BFSI is the major demand side sector up to 2030. And in the healthcare space, quantum computing is anticipated to facilitate the creation of virtual environments where specialists can analyse variables such as skin temperature, electrolytes, circulation, body fluids and metabolism using digital human replicas. Quantum computing devices are being deployed in the healthcare and research industries to manage applications such as large healthcare data processing and rapid DNA sequencing.
- Lastly, quantum computers can **address some other lucrative key end markets**, such as autonomous cars, drones, robotics, blockchain, space, cybersecurity and mobile devices (Figure 5).

Figure 5: Quantum computing is likely to enable industry-wide innovation

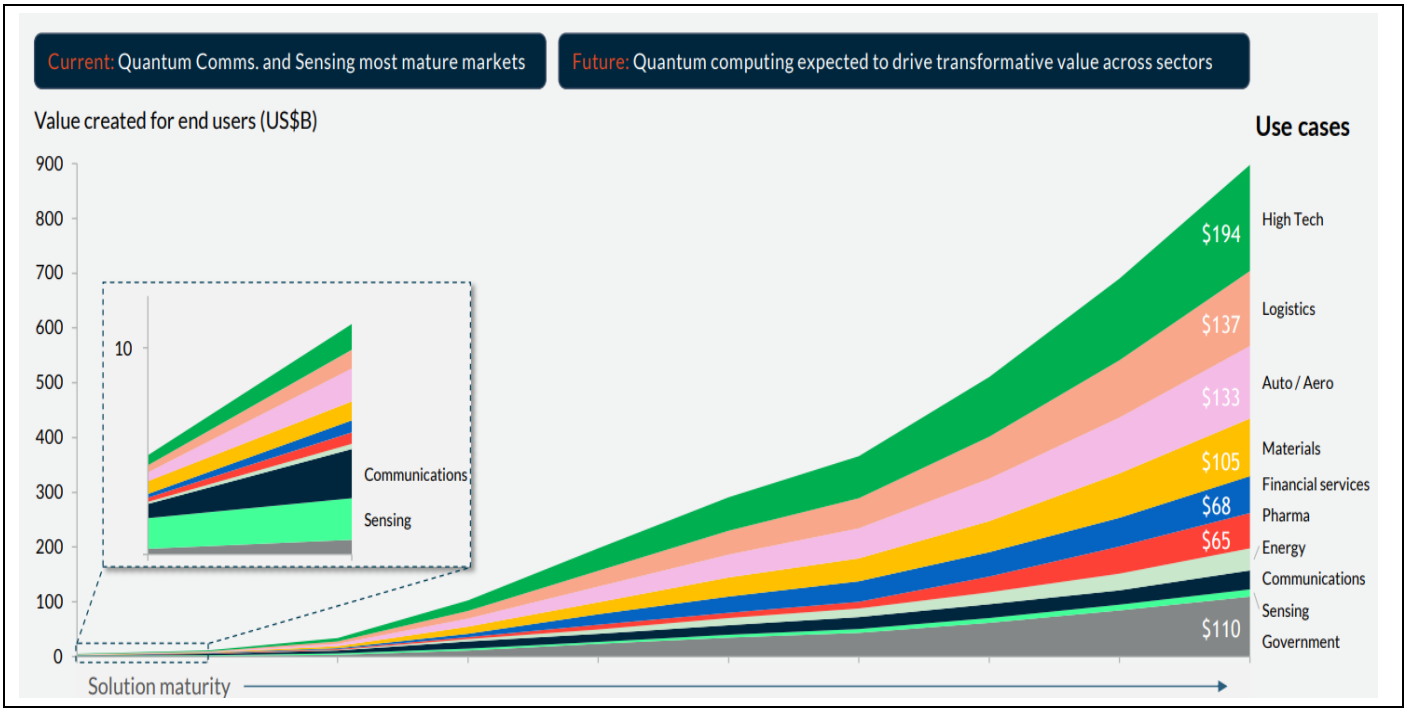


Source: Company, Pitt Street Research

Archer Materials aims to capture a sizeable market share

Quantum computing presents a compelling opportunity for Archer Materials, which aims to grab a sizeable portion of this market. The company considers quantum technology to be the next great technological advancement and the adoption of quantum computing is likely to increase as quantum hardware matures. Quantum cloud providers have announced their goal of achieving moderate to high quantum maturity by 2030.

Figure 6: US$900bn in value creation for end users as quantum computing reaches maturity



Source: Company

Currently, quantum computing addresses computational problems in four key areas: simulation, optimization, machine learning and cryptography (Figure 6). Archer Materials' patent portfolio, having obtained permission for commercialisation in multiple countries, including South Korea, Japan, China, Australia, the US, in Europe and Hong Kong, provides an added advantage to expand into various geographical markets (Figure 7).

Figure 7: Patents granted could provide Archer Materials access to quantum computing markets in key regions

Country	Benefits of patents granted in key geographies
Australia	The Australian government has identified advanced materials, AI and quantum technologies as critical technologies of national interest. Grant of the patent in Australia represents an early-stage milestone in the development of the ^{12}CQ chip. Grant of the patent is further likely to contribute to strengthening quantum computing and technology innovation in Australia.
US	The US patent enables Archer Materials to access the world's largest economy to make use of IP rights pertaining to the ^{12}CQ chip. The ^{12}CQ trademark is also owned by Archer and registered in the US. The patent marks a significant milestone for the company's participation in the US technology economy.
Europe	Archer's development of the ^{12}CQ chip is also being underpinned by ten patents in Europe including UK, Spain, Italy, France, Germany and Switzerland. In particular, Switzerland serves as the first logical step for international expansion given Archer's existing long-term R&D collaborations with EPFL and significant size of the European deep technology communities.
China	China has the world's largest population and has been making a shift from a low-cost manufacturer to a technology consumer incorporating the AI, autonomous systems and blockchain technologies. More than half a billion people use mobile devices in the country and would be set to benefit from mobile integrated quantum processor devices and applications.
South Korea	South Korea is a major global manufacturer and exporter of semiconductor chip devices with two of the world's largest technology and semiconductor companies in Samsung and SK Hynix.
Japan	Grant of the patent in Japan is relevant geographically with economic ties to China, Singapore, Taiwan and the broader APAC region. Japan is a major global economy and ranks as one of the top 5 economies in the world for global competitiveness and GDP.

Source: Pitt Street Research

Ushering in an era of quantum devices

Mobile applications play a crucial role in digitisation and are gaining momentum through the utilisation of advanced technologies, such as blockchain, IoT, AI and more. For instance, quantum-enhanced security could strengthen an ecosystem's security in mobile phones, differentiating products and services while enabling users to benefit from additional revenue streams through security-first services.

Quantum computing is likely to lead to the development of smartphones with improved batteries that are both lighter and offer higher energy capacity. Modern quantum technologies can also enable smartphones to perform a wider range of functions, including more precise navigation with quantum sensors and physically secure communication through quantum key distribution.

The era of quantum computing is already here.

Some companies have already introduced smartphones with quantum technology features. In May 2020, the first 5G smartphone equipped with a Quantum Random Number Generator (QRNG) chipset was announced. Following this, Samsung introduced its first quantum technology-based smartphone, Quantum 2, in 2021, which includes the world's smallest QRNG for enhanced security.

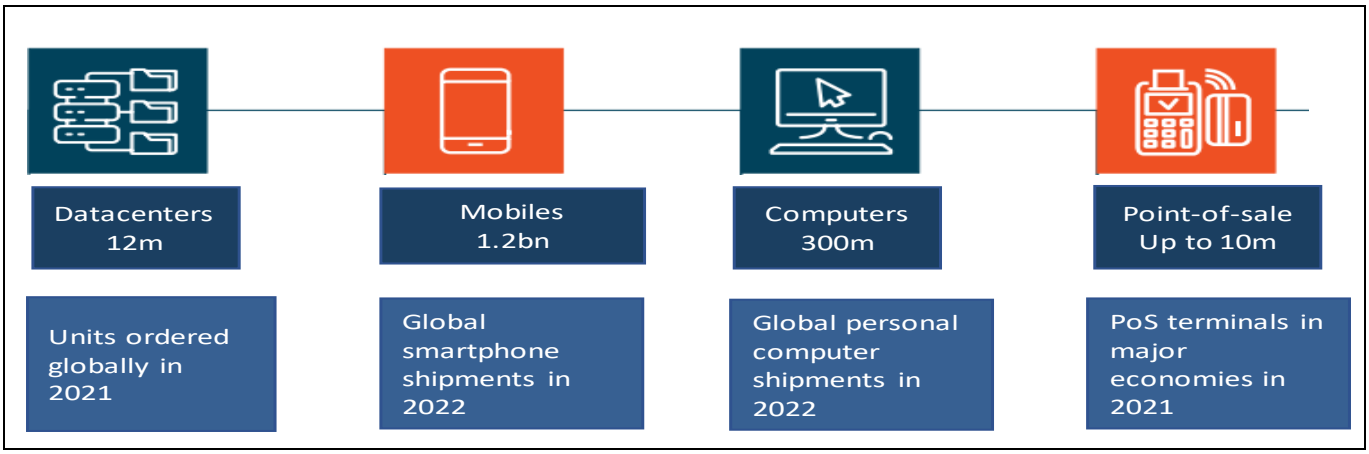
Subsequently, the company launched Galaxy Quantum 3 in 2022 and Galaxy Quantum 4 in 2023, expanding the use of QRNG for critical services in each successive version. As the security provided by quantum technology is theoretically unbreakable, a phone equipped with quantum technology is expected to be completely secure.

There is a big opportunity to be reaped for Archer Materials.

We believe Archer Materials, once its ^{12}CQ technology is fully developed, is potentially well-positioned to participate in the global quantum computing

industry as the only ASX-listed company and one of the few players in the semiconductor industry with patent protection in qubit processing technology (Figure 8).

Figure 8: Archer to benefit from the opportunity to integrate the ^{12}CQ chip technology into millions of devices



Source: Company, Pitt Street Research

Biochip is the nearer-term opportunity

gFETs allow for an ultrasensitive approach to disease detection.

Archer Materials' Biochip is a Lab-on-a-Chip technology being developed to enable rapid, parallelised detection of diseases. It would allow droplets of biological specimens to be analysed and processed using graphene sensors. It does so by using graphene field effect transistors (gFETs), allowing an ultrasensitive approach to detection compared to conventional sensors used in current Lab-on-a-Chip devices and other electronic devices[2].

Field-effect transistors generally are transistors that use an electric field to control the flow of current in a semiconductor. A gFET uses graphene, i.e. a single layer of carbon atoms, which is an ideal material to use given it is ultrasensitive, highly tuneable, very durable and provides for very fast device response times.

Graphene can conduct both positive and negative charges allowing it to carry electrons (negative charge) and holes (positive charge) simultaneously. As a result, the so-called The Dirac point (the point where the valence and conduction bands of graphene meet) can be manipulated and read out relatively easily, which gives graphene its high sensitivity and responsiveness.

Why the Biochip is needed and is superior to today's methods

Faster and more reliable results.

Simply put, Archer Materials' Biochip could generate faster and more reliable results than competing technology and (crucially) on device. It's true that there's no shortage of ways to use nucleic acids and biosensors for medical diagnostics purposes, such as gene sequencing, isothermal amplification and Polymerase Chain Reaction (PCR). As useful as they are, these methods can be cumbersome due to lengthy sample purification or assay procedures and the requirement for additional equipment, cold supply chains, and/or highly trained personnel.

Anyone who undertook a PCR-test for COVID-19 during the pandemic would appreciate this. Test results would typically take several hours to generate a result and potentially cost hundreds of dollars to the patient (unless the public healthcare system funded it). Archer Materials' Biochip, however, would speed up the process of diagnosing diseases.

The detection could be performed at room temperature, unless it is used downstream of another assay that uses a different temperature. Most other methods rely on an optical signal readout, such as a fluorescent signal of a nucleotide (making device integration difficult), unlike the all-electronic read-out for Archer's Biochip.

Biochip reads the electronic signature of a disease

Multiplexing allows for detection of multiple diseases through 1 Biochip.

In principle, droplets of biological specimens (such as saliva, blood, breath or tears) would be collected and then dropped onto the Biochip. From there, the sample is divided in regions of the chip and the liquid shuttled to smaller built-in sensing areas that analyse for evidence of electrically active biochemical targets, for instance, chemicals created from reactions with the viruses or bacteria. A Biochip can be tuned to detect multiple diseases (multiplexing) at once.

The read out is electronic, not optical

Reading the electronic signature of a disease

Today's detection methods, such as PCR tests, typically rely on an optical or spectroscopic read out of the result, e.g. the fluorescent signal of a nucleotide, the basic building blocks of nucleic acids RNA and DNA. However, Archer Materials' Biochip would read out the test results electronically.

The Biochip would act to detect the nucleic sequence of the specimens by either altering their electrochemical signals on a gFET chip surface or undergoing a

[2] The Apple Watch is one such example of a technology with sensors for human health, although these are not Lab-on-a-Chip devices.

reaction on another part of the chip that then sends the product of that reaction to the sensing area[3]. This surface can be tuned to electronically register the presence of a specific disease. E.g. one of the multiple, individual detection surfaces on a single Biochip can be tuned to detect the electronic signal given off by a virus, while another can be tuned to another virus and so on. So, only one specimen is required to test for multiple diseases, or one specimen to test for the same disease multiple times at once.

Archer Materials filed a number of patent applications for this invention which are pending examination and grant processes in Australia and the US.

Where Archer Materials is at with the Biochip

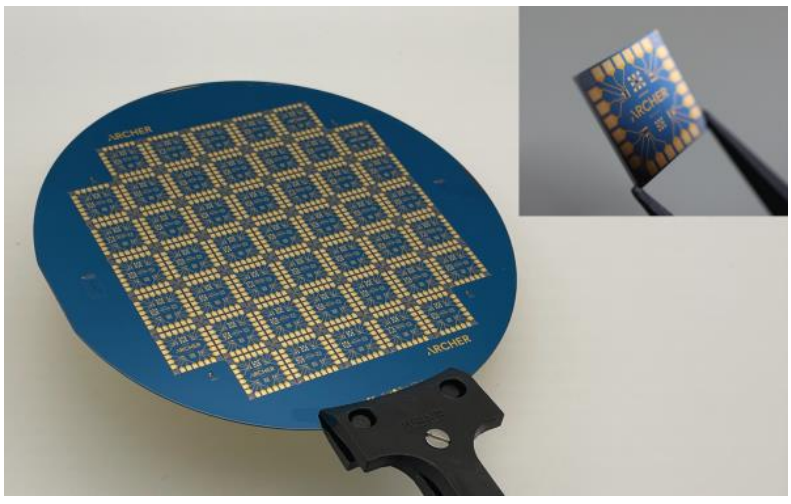
Archer Materials is at an early stage with the Biochip, but has made substantial progress in CY23, having taken the gFET technology from concept to design and through successful early-stage commercial testing at semiconductor foundries.

It has unveiled the first-generation hardware and software in the system platform, which was designed to run using a chip with single isolated gFETs as sensors, allowing for an ultrasensitive approach to analyte detection over conventional electronic sensors used in current lab-on-a-chip devices. In July 2023, the company completed a proof-of-concept biosensing graphene transistor for use in its biochip and submitted it to a commercial foundry to verify manufacture and scalability.

Successful validation of gFETs and platform compatible.

From there, the company began working with a commercial foundry partner in the Netherlands for a whole four-inch wafer run validation. This validation was successfully completed in September 2023 (Figure 9). The electronic and spectroscopic characteristics of the gFET chips and the foundry fabrication process yield were consistent with what Archer expected. The gFET chips were designed for liquid gating, i.e., to test liquid samples, and compatibility with Archer's biochip system platform.

Figure 9: Archer's gFET chips for advanced biosensing diced from the whole four-inch wafer fabricated in a commercial foundry in the Netherlands



Source: Company

Automation and real-time sensing.

In early November 2023, Archer demonstrated multiplexing readout for its liquid gated gFET devices. In other words, it proved it could test multiple liquids from

[3] Patent pending WO 2023/097367 A1 (https://patents.google.com/patent/WO2023097367A1/en?oq=WO+2023%2f097367+A1)

a single chip at once, instead of activating just one sensor at a time, as was the case with the earliest generation of the Biochip system.

The system also provides an automated hands-free operation as it integrated liquid handling automation and data acquisition. The software developed by Archer Materials can display all single and time series measurements in real-time for the four gFET sensors simultaneously.

Within days, the company validated its first-generation Biochip gFETs designs that had been sent for manufacturing as part of a multi-project wafer run in a German foundry – a separate trial to the one that occurred in the Netherlands. This marked Archer's first joint fabrication of graphene devices with an external foundry partner.

Strong financial position.

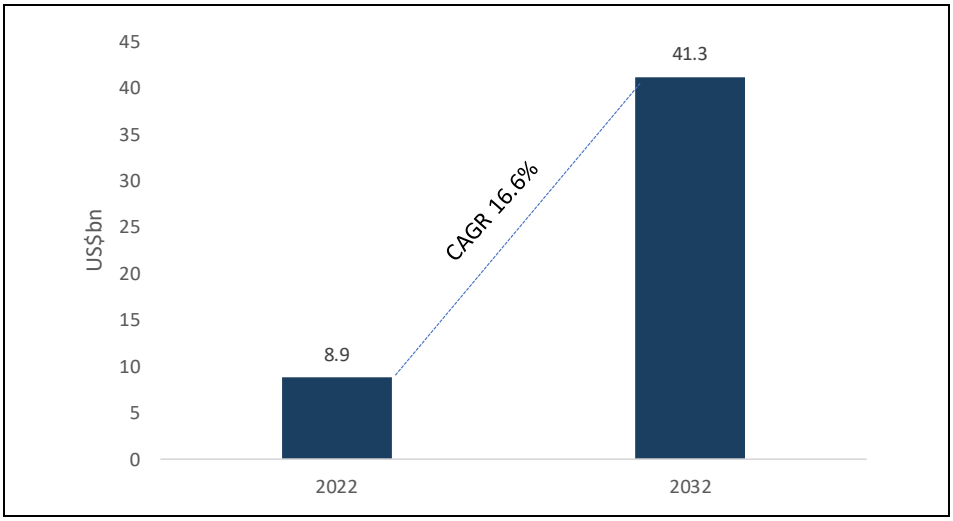
Archer will continue developing the Biochip and gFET devices to enhance its capabilities, including integrating bio-functionality, and optimising the device size and geometry to build advanced sensing regions. The company is in a strong position to advance this with a $21.6m cash balance (having received a $2.45m R&D Tax Incentive during 2023) and no debt.

The market for biochips is growing strongly

The Biochip market has several key drivers, including:

Increasing adoption of personalised medicines and improvements in next-generation sequencing (NGS) – The rise of personalised medicines, which customise medical treatments based on an individual's genetic makeup, has driven the demand for biochips. Biochips offer several significant advantages, such as analysis of genetic variations, identification of biomarkers and providing data for personalised diagnostics, drug selection, and monitoring treatment responses. Additionally, biochips assist in the analysis of NGS data, providing valuable insights into genetic variations and disease-associated mutations.

Figure 10: The biochip market is likely to register robust growth over the next decade



Source: Market Research Future, Pitt Street Research

Competitors in the biochip market include Affymterix (acquired by Thermo Fisher Scientific), Bio-Rad Laboratories, Encapsulate, Nutcracker Therapeutics and Grapheal

Advancements in Lab-on-a-Chip along with biomedical advancements for microfluidics-based devices – The market for biochips has seen advancements in Lab-on-a-Chip diagnostic platforms. These advanced platforms encompass microfluidic chips, paper-based systems, lateral flow assays, electrochemistry and innovative biosensor concepts.

Increasing use of biochips – The use of biochips has increased in applications like disease marker identification, accelerated drug development, genotyping, proteomics and genomics. Significant advantages include low sample consumption and miniaturisation.

Increasing prevalence of chronic disorders, such as cancer and diabetes – Chronic diseases have been found to be the leading cause of death, disability and morbidity worldwide. Accurate and timely decision-making is essential due to the chronic nature of these diseases. As per estimates by Market Research Future, a US-based research company, the market for biochips is expected to grow from US$8.9bn in 2022 at a CAGR of 16.6% to US$41.3bn in 2032 (Figure 10).

Biochips to compete with and complement MEMS devices

A Lab-on-a-Chip is a miniaturised device that can conduct multiple-sample biological and biochemical analyses in a single platform. Healthcare delivery is likely to be revolutionised through the miniaturisation and integration of medical diagnostic tests into a chip for the diagnosis, monitoring and uploading of healthcare data.

Biochips can benefit from MEMS fabrication, reduced component size and low power operations.

Lab-on-a-Chip devices are a type of microfluidic device and they often utilise MEMS (Micro-Electro-Mechanical Systems) technology for their fabrication. MEMS encompasses various devices that integrate mechanical elements, sensors, actuators and electronics on a small scale. Lab-on-a-Chip devices fit broadly within this category due to their miniaturised components for conducting laboratory functions on a chip-sized platform.

Liquid-gated gFETs are superior when it comes to signal transducing.

Liquid-gated gFETs, like the ones Archer Materials is developing, carve a niche for themselves in highly sensitive, miniaturised and adaptable sensing applications where the interaction with liquid environments or biological substances is crucial. MEMS struggle against gFETs when it comes to signal transduction — this is where graphene is superior.

As a result, Lab-on-a-Chip sensing devices represent a high-growth opportunity in the semiconductor industry. These sensors integrate biology and electronics for diagnostic and therapeutic healthcare treatments.

Over the past few years, interest in biomedical sensing devices has increased significantly, and widespread applications have been found in various areas of life sciences including diagnostics, therapeutics, and drug delivery.

Biosensing devices have become indispensable.

Biosensing and analysis systems are now considered indispensable in biomedical research and life sciences. Research and diagnostics for genetic diseases are also undergoing unprecedented growth. DNA sequencing, for instance, has become cheaper, faster and more powerful since the first complete human genome sequencing reported in 2021.

Biochips offer several advantages over MEMS devices

Archer Materials' Biochip could potentially incorporate MEMS technology and Archer has demonstrated this early on with prototyping fabrication of microfluidic channels and compartments. But if and when the Biochip becomes commercially available it will still likely need to compete with a subset of MEMS devices that have biological or biomedical applications (BioMEMS). In our view, in the context of electronic sensing of biologically relevant samples, the Biochip technology would be superior to BioMEMS technologies two ways:

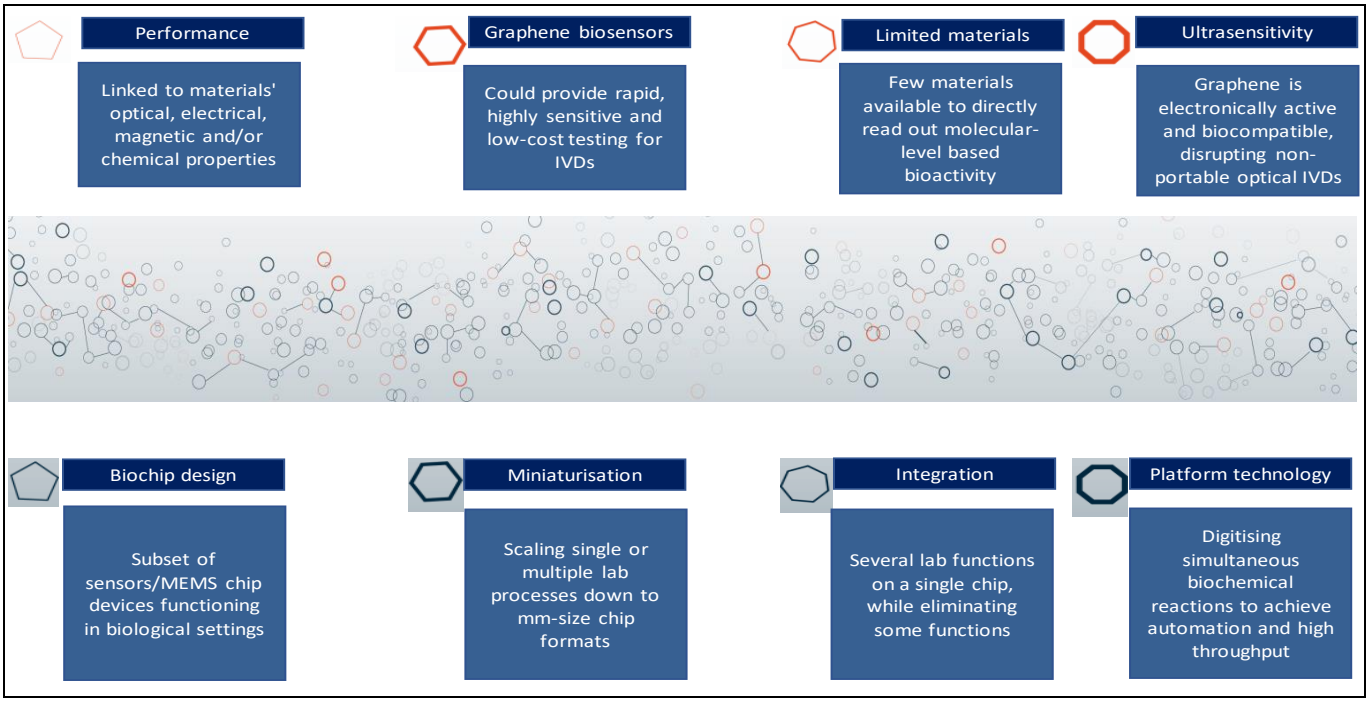
- **Multiplexing in biological interactions.** Biochips are specifically designed to handle biochemical reactions with high precision. This is to say, multiplexed biochips that can transmit many signals simultaneously on the same circuit when handling biological specimens. Archer's patent pending biochemistry may offer superior control and specificity in capturing and detecting the reactions due to their tailored design.
- **Graphene integration for biocompatibility**. Graphene is the ideal material to use because of its extremely high sensitivity and chemical robustness on the micro and nanoscales. It doesn't dissolve or melt when exposed to biological samples or liquids. Graphene can be optimised with dedicated functionalities that may allow for precision detection of biological interactions. Granted, some MEMS devices can use graphene, however the utility of graphene in MEMS is limited.

Remaining work to be done ahead of market entry

Archer Materials' Biochip has many advantages compared to today's solutions.

Archer Materials' current focus is on producing gFETs in a semiconductor foundry with a quality, quantity and consistency that will ensure maximum performance in the ultimate devices. The company is currently engaging several commercial semiconductor foundries and is developing various gFET design techniques. Commercial scale gFET manufacturing will require precise and near-perfect engineering, needing specialised processes that will align seamlessly with conventional semiconductor manufacturing techniques, ensuring there is no trade-off between large-scale production and quality uniformity.

Figure 11: Potential for graphene biochip technology extends beyond simple detection of diseases



Source: Company, Pitt Street Research

Early gFET chips at Archer Materials designed for liquid gating and multiplexing have been validated through multi-project wafer and whole wafer runs with foundry partners in Europe. The semiconductor chip manufacturing processes

and technology in each graphene foundry differ, including the characteristics of graphene within the devices. Performing wafer runs at several foundries will be required as part of the gFET chip development process to optimise the gFET design and manufacturing for foundry readiness and compatibility.

The partnerships between Archer and the semiconductor foundries will address these challenges and are pave the way for large-scale production of graphene-based devices for biosensing applications.

Archer Materials is actively seeking international patent protection for its early-stage end-to-end prototype of the Biochip platform. We believe the company can potentially derive significant benefits from the biochip project once fully developed, given the heightened focus on disease detection and prevention (Figure 11).

Archer Materials has a diverse range of peers

The Quantum Computing market is highly fragmented across various dimensions, including approaches, hardware architectures and algorithms.

Peers in quantum computing

With the global quantum computing market being nascent and highly fragmented, Archer Materials has both domestic and international peers. For that reason, we have looked at global big tech companies, new-age quantum computing players and semiconductor service providers listed, both listed and unlisted. However, it is imperative to note that despite some peers being significantly larger in size, none of them provide a complete quantum computing solution (Figure 12).

Figure 12: Quantum computing peer group

Big techs	Quantum computing peers
1) NVIDIA Corp. (NASDAQ: NVDA) designs and develops GPU's, CPU's and system-on-a-chip units. Additionally, it provides solutions for Artificial Intelligence and data science, data centre and cloud computing, design and visualization, edge computing, high-performance computing, and self-driving vehicles. NVDA has GPU solutions that can simulate quantum systems akin to what a few qubits could do.	**1) IonQ, Inc. (NYSE: IONQ)** engages in the development of general-purpose quantum computing systems in the United States. It offers access to quantum computers with varying qubit capacities. It provides access to its quantum computers through cloud platforms, including Amazon Web Services (AWS), Amazon Braket, Microsoft's Azure Quantum, Google's Cloud Marketplace.
2) IBM Corp. (NYSE: IBM) provides IBM Quantum Platform, an online platform allowing public and paid premium access to cloud-based quantum computing services provided by IBM. This includes access to a set of prototype superconducting quantum processors in the cloud using Qiskit Runtime. IBM recently announced a 1,000-qubit machine that will take it through to 2030 as they focus on application utility.	**2) Rigetti Computing, Inc. (NASDAQ: RGTI)** through its subsidiaries, designs and manufactures superconducting (low-temperature) quantum processors and quantum computers. Its Quantum Computing as a Service platform can be seamlessly integrated into any public, private, or hybrid cloud infrastructure. The company was founded in 2013 and is headquartered in California, USA.
3) Amazon Inc. (NASDAQ: AMZN) is a global technology company that is integrating some existing third-party quantum computing machines with its cloud solutions AWS and Amazon Braket. It offers hardware choices, programming tools and expert guidance on aligning quantum computing with diverse business solutions. It offers businesses with pay-as-you-go pricing options.	**3) D-Wave Quantum Inc. (NYSE: QBTS)** develops and provides superconducting (low-temperature) quantum computing systems, software, and services worldwide. The company offers Advantage, a fifth-generation quantum computer; Ocean, a suite of open-source Python tools; and Leap, a cloud-based service that grants real-time access to a live quantum computer. D-Wave was established in 1999 and is headquartered in Burnaby, Canada.
4) Microsoft Corp. (NASDAQ: MSFT) offers solutions across the quantum computing framework, spanning software applications to control systems and devices. Microsoft's quantum computing proposition integrates tools and capabilities, educational opportunities, and hardware suppliers to integrate with its cloud computing service Microsoft Azure Quantum.	**4) Quantinuum Inc. (Private)** is jointly owned by Honeywell (Quantum Solutions) and Cambridge Quantum Computing after their merger. The company develops both software and hardware (ion trap quantum machines) for applications in areas such as cybersecurity, chemistry, machine learning, and natural language processing. Founded in 2015, it is headquartered in Colorado, USA, and operates as a subsidiary of Honeywell International Inc (NASDAQ: HON).
5) Alphabet Corp. (NASDAQ: GOOGL) has developed software and hardware tools tailored to create quantum algorithms. Known as Quantum AI, it's suite of solutions includes a data centre, fabrication facility, research lab and workspace aimed at facilitating new advancements in quantum computing. The company claims significant breakthroughs in quantum error correction and has prototype quantum computers.	

Source: S&P Capital IQ, Pitt Street Research

Peers in the Biochip sector

For peers in the Biochip industry, we have taken into consideration global public companies as well as private companies exclusively operating in the graphene biochip space (Figure 13). Peer group valuations for the larger, more established peers have been listed in Figure 14.

Figure 13: Biochip peer group

Biochip peers

1) Thermo Fisher Scientific Inc. (NYSE:TMO) offers life sciences solutions, analytical instruments, specialty diagnostics, laboratory products and biopharma services. The company serves pharmaceutical and biotech companies, academic and research institutions, clinical diagnostic labs, government agencies as well as the environmental, industrial quality and process control sectors. Established in 1956, the company is headquartered in Massachusetts, USA. Thermo Fisher Scientific entered the biochip space through its subsidiary, Affymetrix.

2) Bio-Rad Laboratories, Inc. (NYSE:BIO) manufactures and distributes life science research and clinical diagnostic products in the United States, Europe, Asia, Canada and Latin America. The company's major products include reagents, laboratory apparatus, instruments, test systems, informatics systems, test kits and specialised quality controls. Founded in 1952, the company is headquartered in California, USA.

3) Becton Dickinson (NYSE:BDX) develops, manufactures, and sells medical supplies, devices, laboratory equipment, and diagnostic products for healthcare institutions, physicians, life science researchers, clinical laboratories, pharmaceutical industry, and the general public worldwide. The company was founded in 1897 and is headquartered in Franklin Lakes, New Jersey.

4) Roche (SWX:ROG) engages in the pharmaceuticals and diagnostics businesses in Switzerland, Germany, the United States, and internationally. The company offers pharmaceutical products in several therapeutic areas and provides in vitro tests for the diagnosis of various diseases, such as cancer, cardiovascular, diabetes, Covid-19, hepatitis, human papillomavirus, and other diseases. In addition, the company supplies diagnostic instruments and reagents. Roche Holding AG was founded in 1896 and is headquartered in Basel, Switzerland.

5) Nutcracker Therapeutics, Inc. (Private) develops and operates a biotech platform for mRNA therapeutics, producing mRNA and delivery vehicle formulations on single-use biochips. The company was incorporated in 2017 and is headquartered in California, USA.

6) Encapsulate (Private) develops automated tumour-on-chip systems that personalize clinical treatment regimens for cancer patients by determining the most effective approach. The company was founded in 2018 and is headquartered in Connecticut, USA.

Source: S&P Capital IQ, Pitt Street Research

Figure 14: Peer Valuation Multiples

Company Name	Total Enterprise Value (A$m)	EV/Revenue			EV/EBITDA		
		LTM	2023F	2024F	LTM	2023F	2024F
NVIDIA Corporation	2,343,137	33.2x	26.2x	16.9x	67.2x	47.3x	31.9x
IonQ, Inc.	2,750	NM	NM	46.6x	NM	NM	NM
Rigetti Computing, Inc.	160	7.0x	9.1x	6.3x	NM	NM	NM
D-Wave Quantum Inc.	205	16.1x	13.2x	5.7x	NM	NM	NM
Thermo Fisher Scientific Inc.	377,359	5.6x	6.0x	5.8x	22.5x	23.8x	22.8x
Bio-Rad Laboratories, Inc.	14,056	3.3x	3.6x	3.4x	16.9x	18.4x	17.3x
Average	486,225	**12.2x**	**11.2x**	**12.5x**	**30.1x**	**25.4x**	**20.4x**
Median	134,399	**7.0x**	**9.1x**	**6.0x**	**22.5x**	**23.8x**	**18.5x**

Source: Capital IQ, Pitt Street Research

Relevant ASX-listed peers are valued higher than Archer Materials

We have looked at several Australian semiconductor companies listed on the ASX (Figure 15) given that we think these are Archer Materials' closest peers when it comes to investors' perception and comparables:

- **Weebit Nano (ASX: WBT)** is an Israel-based developer of advanced semiconductor memory technology. The company is dedicated to developing non-volatile memory using Resistive RAM (ReRAM) technology. This technology offers high-performance and low-power memory solutions for a variety of new electronic products, including smartphones, robotics, autonomous vehicles, fifth generation (5G) communications and artificial intelligence. Weebit Nano currently has a market capitalisation of A$654m.
- **BrainChip Holdings (ASX: BRN)** develops software and hardware-accelerated solutions for artificial intelligence (AI) and machine learning applications. The company primarily focuses on the development of the Akida Neuromorphic Processor, designed to provide ultra-low power and high-speed AI at the edge for various applications, including vision and audio. BrainChip also offers MetaTF, a tool used for creating, training and testing neural networks, and it supports the development of systems for Edge AI using its Akida event domain neural processor. BrainChip currently has a market value of A$294m.
- **4DS Memory (ASX: 4DS)** is an Australia-based semiconductor company specialising in the development of non-volatile memory technology, known as Interface Switching resistive random-access memory (ReRAM), designed for gigabyte storage-class memory. 4DS Memory currently has a market capitalisation of A$126m.
- **AudioPixels (ASX:AKP)** is an Israel-based developer of MEMS devices for the reproduction of audio, i.e. small speakers for wearable devices. The company has been working on the development of these MEMS for many years and has yet to successfully deliver a commercially viable product. AudioPixels is currently valued at A$219m.

Figure 15: Valuations of ASX-listed peers

Company	Ticker	#shares	Share Price	Market Cap (A$ m)
Weebit Nano	WBT	188.044	3.48	654.4
BrainChip	BRN	1839.25	0.16	294.3
AudioPixels	AKP	29.2	7.50	219.0
4DS Memory	4DS	1749.1	0.072	125.9
BluGlass	BLG	1528	0.05	76.4
Revasum	RVS	118.6	0.13	15.4
BlueChiip	BCT	787.1	0.013	10.2
Average				***199.4***
Archer Materials	**AXE**	**254.85**	**0.31**	**79.0**

Source: Market Research Future, Pitt Street Research

Potential for Archer Materials to rerate towards peer valuations

Weebit Nano and BrainChip are arguably substantially further along the development and commercialisation path than Archer Materials, which warrants their higher valuation compared to Archer Materials' current valuation.

Archer Materials' peers are valued substantially higher.

However, when it comes to technology development, both companies have once been where Archer Materials is now. And both companies have gone through their respective arduous R&D processes with trial and error, and have come out the other end of the tunnel with initial products. In other words, we believe there is clear scope for expansion of Archer Materials' valuation to levels that these peers are valued at.

Both 4DS Memory and AudioPixels still have substantial development work to do, yet both are valued at least 60% higher than Archer Materials. Again, we believe there is scope for a higher valuation of Archer Materials' shares.

Semiconductor M&A activity in the last 5 years

For completeness sake, we have also looked at Merger & Acquisition deals in the global semiconductor industry in the last five years to provide the reader with a sense of deal valuations (Figure 16). The average valuation for these deals is an Enterprise Value (EV)/Revenue of 3.7x. However, most of these deals have been done prior to the current interest rate hiking cycle, which has driven down valuations in the last 24 months. In other words, we believe that valuations for new M&A will likely be lower in the current environment. Archer Materials is currently a pre-revenue company so these valuations may only apply at a later stage of company growth and maturity.

Figure 16: Recent transactions in the semiconductor sector in the last five years

Target/Issuer	Buyers/Investors	Buyer ticker	Announcement Date	Transaction Closure date	Total Transaction Value (US$m)	Implied EV/Revenue (x)
Mikron PJSC	Transit Service Trading House LLC	NA	27-Jul-22	27-Jul-23	6.5	2.31x
Intrinsix Corp.	CEVA, Inc.	(NASDAQ : CEVA)	10-May-21	31-May-21	30.5	1.44x
Dialog Semiconductor Plc	Renesas Electronics Corporation	(TSE : 6723)	8-Feb-21	30-Aug-21	5,592.4	4.23x
Xilinx, Inc.	Advanced Micro Devices, Inc.	NA	27-Oct-20	14-Feb-22	32,951.8	11.33x
Nanjing Micro One Electronics Inc.	Shanghai Belling Co., Ltd.	(SHSE : 600171)	19-Oct-19	6-Aug-20	48.4	2.05x
Sankalp Semiconductor Pvt. Ltd.	HCL Technologies Ltd.	(NSE : HCLTECH)	9-Sep-19	10-Oct-19	24.1	1.27x
Cypress Semiconductor Corp.	Infineon Technologies AG	(XTRA : IFX)	3-Jun-19	16-Apr-20	9,793.8	4.12x
Intermolecular, Inc.	Merck KGaA	(XTRA : MRK)	6-May-19	20-Sep-19	72.4	1.60x
Mellanox Technologies, Ltd.	NVIDIA Corporation	(NASDAQ : NVDA)	11-Mar-19	27-Apr-20	6,926.8	6.34x
Phenitec Semiconductor Corp.	Torex Semiconductor Ltd.	(TSE : 6616)	14-Dec-18	28-Feb-19	7.7	0.20x
Advanced Semiconductor Corp. Ltd.	Shanghai GTA Semiconductor Co., Ltd.	NA	30-Oct-18	25-Jan-19	273.2	1.36x
Renesas Electronics America Inc.	Renesas Electronics Corporation	(TSE : 6723)	10-Sep-18	29-Mar-19	6,923.6	8.27x
MEDIAN					**172.8**	**2.18x**
AVERAGE					**5,220.9**	**3.71x**

Source: S&P Capital IQ, Pitt Street Research

Valuation range of $0.60 to $1.00

Based on what the market is currently willing to pay for 4DS Memory and AudioPixels, Archer Materials'most relevant peers at the moment, we believe its shares have the potential to rerate to a range of $0.60 to $1.00 in the medium term if and when the right share price catalysts materialise (see below).

Key share price catalysts

Although we believe commercialisation of the ^{12}CQ quantum computing chip is realistically 5-7 years away, while the Biochip could potentially be commercialised in much less time than that, we see several catalysts for shareholder value creation in the short to medium term.

1. The continued achievement of technology development milestones of both ^{12}CQ and the Biochip will be the key value drivers.
2. Additionally, potential development partnerships with leading technology and life sciences companies will likely provide validation of Archer Materials' technologies, which in turn would be a major share price catalyst, in our view.
3. The expansion of the company's IP portfolio. The existing portfolio underwrites much of the current valuation, and its potential expansion (through the plugging in of additional technologies) could help grow the company's valuation.

Some way to go yet, but partially de-risked

We believe Archer Materials is well-positioned to continue and eventually complete the development of the ^{12}CQ chip and Biochip technologies to the point where both are commercially viable products, albeit that we expect the development timelines for the Biochip to be substantially shorter than for the ^{12}CQ chip.

While there are obviously execution and investment risks (see below), in our view, the company has partially de-risked itself through:

- The competitive advantages its technologies have over many of its peers,
- The development work that has been done to date,
- The patent protection it has secured through granted and pending patents,
- Inroads the company has made with multiple foundry partners for production of test chips for ^{12}CQ and Biochip, and
- The experience and network of CEO Dr Mohammad Choucair.

In conclusion, if the share price catalysts above indeed materialise, we believe there is clear share price upside for Archer Materials given current valuation levels for relevant ASX-listed peers and the extent to which the company has been de-risked to date.

Key risks

We believe the following are the main risks associated with an investment in Archer Materials:

- **Development risk**: The road to a viable commercial product is still long for Archer Materials' ^{12}CQ technology and, to a lesser extent, for its Biochip technology. A lot of development and engineering work still must be done, which brings with it risk of technical failures, or at the very minimum extended development periods. This is true for most, if not all, emerging semiconductor technologies.
- **Technology transfer risk**: Once Archer Materials reaches the point where one of its technologies has become commercially viable, the technology will need to be transferred to manufacturing partners. Typically, these transfers take longer than expected given that manufacturing partners operate commercial fabs that leave little room for trial runs of new types of chips. In other words, technology transfers usually don't have the highest priority in commercial fabs.
- **Key man risk**: We believe that Dr. Mohammad Choucair, with his extensive scientific background and networks, is the main driving force behind the development of Archer Materials' technologies. If, for whatever reason, Dr. Choucair was no longer able to lead the company's product development and commercialisation efforts, we believe completion of both projects would be in very serious jeopardy.
- **Small cap risk**: As the investment climate in 2022 and 2023 has shown, investing in small caps is not for the faint-hearted. Pre-revenue and cash flow-negative small caps in particular have been hit hard as interest rates were jacked up by Central Banks around the world. Although current market consensus seems to be that interest rates will be cut starting sometime in 2024, that is not a given, which means that small cap valuations may stay depressed for longer than currently anticipated.
- **Funding risk**: Archer Materials is pre-revenue and will likely remain pre-revenue until the Biochip is successfully commercialised, which means the company will have to rely on outside funding through debt and/or equity until that time. Although the company had over $21m in cash per 31 December 2023 and no debt, market conditions may remain adverse for pre-revenue small caps for some time to come, which may limit Archer Materials' ability to raise sufficient capital on acceptable terms.

Appendix I - AXE leadership team

Figure 17: AXE's Board members and senior management

Name and Designation	Profile
Greg English Executive Chairman	• Greg English has been Chairman of the Board since 2008. Greg is the co-founder of Archer Materials, listing the company on the Australian Securities Exchange in 2007, and overseeing Archer's transition to an advanced semiconductor company. • He has more than 25 years of engineering and legal experience and has held senior roles for Australian and multinational companies.
Kenneth Williams Non-Executive Director	• Ken Williams has more than 30 years' experience in corporate finance and over 20 years directorship experience. He has held senior finance executive positions with leading ASX companies and specialises in treasury and financial risk management. His extensive experience spans mergers, acquisitions, divestments, and corporate reconstructions. • A Fellow of the Australian Institute of Company Directors, Mr Williams was the Independent Chair of Statewide Super, is Chair of Barton Gold Holdings, a Director of the Lifetime Support Authority of SA, Chair of Nova Systems; and is Deputy Chancellor of the University of Adelaide.
Bernadette Harkin Non-Executive Director	• Bernadette Harkin has over 20 years of experience working as a business technologist across strategy, sales, marketing, operations, and delivery for multinational Information Technology companies including IBM, Avanade, and CGI. This includes 3 years at IBM where Bernadette served as a board member for IBM Philippines. • Bernadette's experience covers technology areas of Cloud, Analytics, Mobility, AI, and Security, and her international experience spans leadership within large corporate governance structures and the start-up of new businesses.
Mohammad Choucair CEO	• Dr Mohammad Choucair was appointed Chief Executive Officer on 1st December 2017. Dr Choucair has a strong technical background in nanotechnology and has spent the last decade implementing governance, control and key compliance requirements for the creation and commercial development of innovative technologies with global impact. • Dr Choucair served a 2-year mandate on the World Economic Forum Global Council for Advanced Materials and is a Fellow of both The Royal Society of New South Wales and The Royal Australian Chemical Institute. • He has a strong record of delivering innovation and has been recognised internationally as a forward thinker.
Damien Connor CFO and Company Secretary	• Damien Connor was appointed Company Secretary and Chief Financial Officer on 1 August 2014. Damien performs the financial and accounting role in the company as well as the secretarial duties. • Damien is an experienced Company Secretary and CFO, with over 20 years finance and accounting experience. • He has been a member of the Institute of Chartered Accountants since 2002 and is a Graduate Member of the Australian Institute of Company Directors and a Member of the Governance Institute of Australia.

Appendix II – Glossary

Analyte - a substance whose chemical constituents are being identified and measured.

Bit – or binary digit is the minimum unit of binary information stored in a computer system.

Carbon nanosphere – The nanostructured carbon material of approximately 50 nanometres in size used in the ^{12}CQ chip.

Electron spin – The intrinsic angular momentum possessed by an electron. A quantum property that contributes to the magnetic properties of atoms and is crucial in quantum mechanics.

Enzyme – Proteins that help speed up metabolism, or the chemical reactions in our bodies**.**

Graphene Field Effect Transistor (GFET) – A transistor composed of graphene.

Moeity – A part of a molecule that is given a name because it is identified as a part of other molecules as well.

Nucleic acids – Large biomolecules that play essential roles in all cells and viruses.

Nucleic Acid Sequence – The order of nucleotides in DNA.

Quantum - The principles of quantum mechanics that are leveraged to perform computations, in the context of the phenomena of superposition and entanglement of quantum states.

Qubit (or quantum bit) – The basic unit of information in quantum computing, which can exist in multiple states simultaneously due to phenomena like superposition and entanglement, allowing for complex computations to be executed differently than classical computers.

SO (signal oligonucleotide) – Oligonucleotides in general are short, single or double-stranded DNA or RNA molecules. The signal oligonucleotide is the one that is used by Biochip to identify and diagnose diseases.

THS (toehold sequence region) – the overhanding region of a DNA strand which is complementary to a third strand of DNA, referred to as the 'invading strand'.

Appendix III – Analyst Qualifications

Marc Kennis, lead analyst on this report, has been an equities analyst since 1996.

- Marc obtained an MSc in Economics from Tilburg University, Netherlands, in 1996 and a postgraduate degree in investment analysis in 2001.
- Since 1996, he has worked for various brokers and banks in the Netherlands, including ING and Rabobank, where his focus has been on the technology sector, including the semiconductor sector.
- After moving to Sydney in 2014, he worked for several Sydney-based brokers before setting up Pitt Street Research, an issuer-sponsored equity research firm.

Nick Sundich is an equities research analyst at Pitt Street Research.

- Nick obtained a Bachelor of Commerce/Bachelor of Arts from the University of Sydney in 2018. He has also completed the CFA Investment Foundations program.
- He joined Pitt Street Research in January 2022. Previously he worked as a financial journalist at Stockhead for over three years.
- While at university, he worked for a handful of corporate advisory firms.

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