ARCHER

Quantum Technology: ^{12}CQ
May 2019

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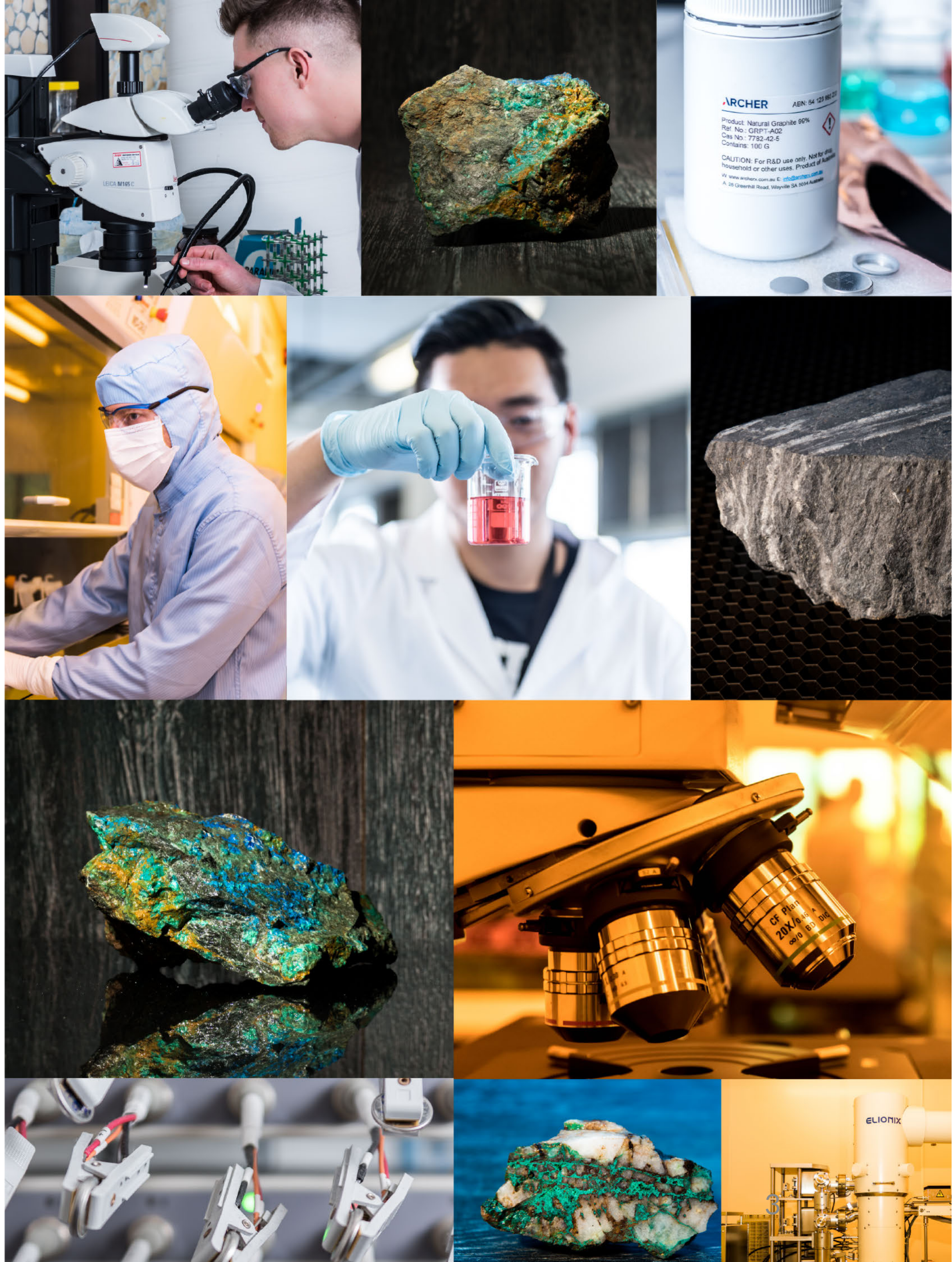
This presentation contains information which was reported in ASX announcements dated 12 December 2018, 17 January 2019 and 3 April 2019 (together the “Announcements”). All material assumptions and technical parameters set out in the Announcements continue to apply and have not materially changed. The Announcements can be viewed online at https://www.archerx.com.au.

Certain statistical and other information included in this presentation is sourced from publicly available third party sources and has not been independently verified.

Archer provides shareholders exposure to innovative technologies and the materials that underpin them.



Archer has been listed on the ASX since 2007 and owns and has exclusive rights to patents and tenement assets.

Maximising the value of our patents and tenements involves development and integration along the materials lifecycle.

Our focus is on realising the maximum value of our assets by commercialisation at various stages of the materials lifecycle.

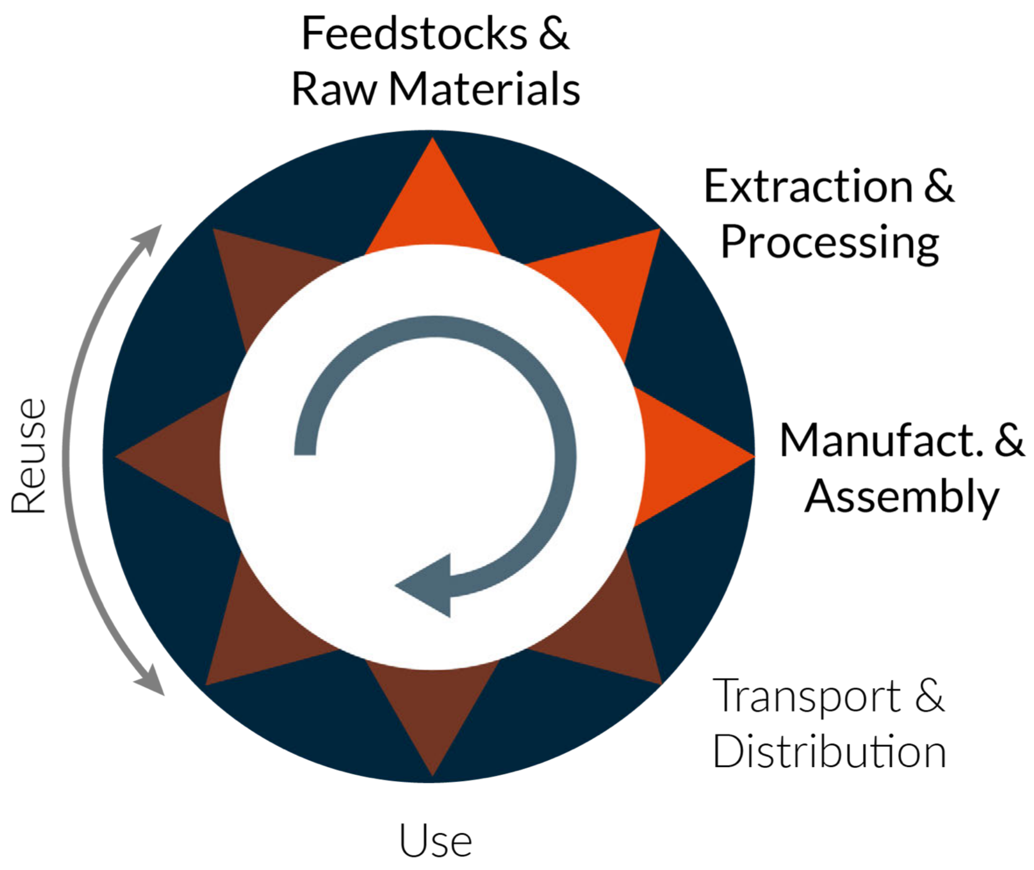


Fig 1. The materials lifecycle and focus of Archer's activities in Feedstocks & Raw Materials to Manufacturing & Assembly.

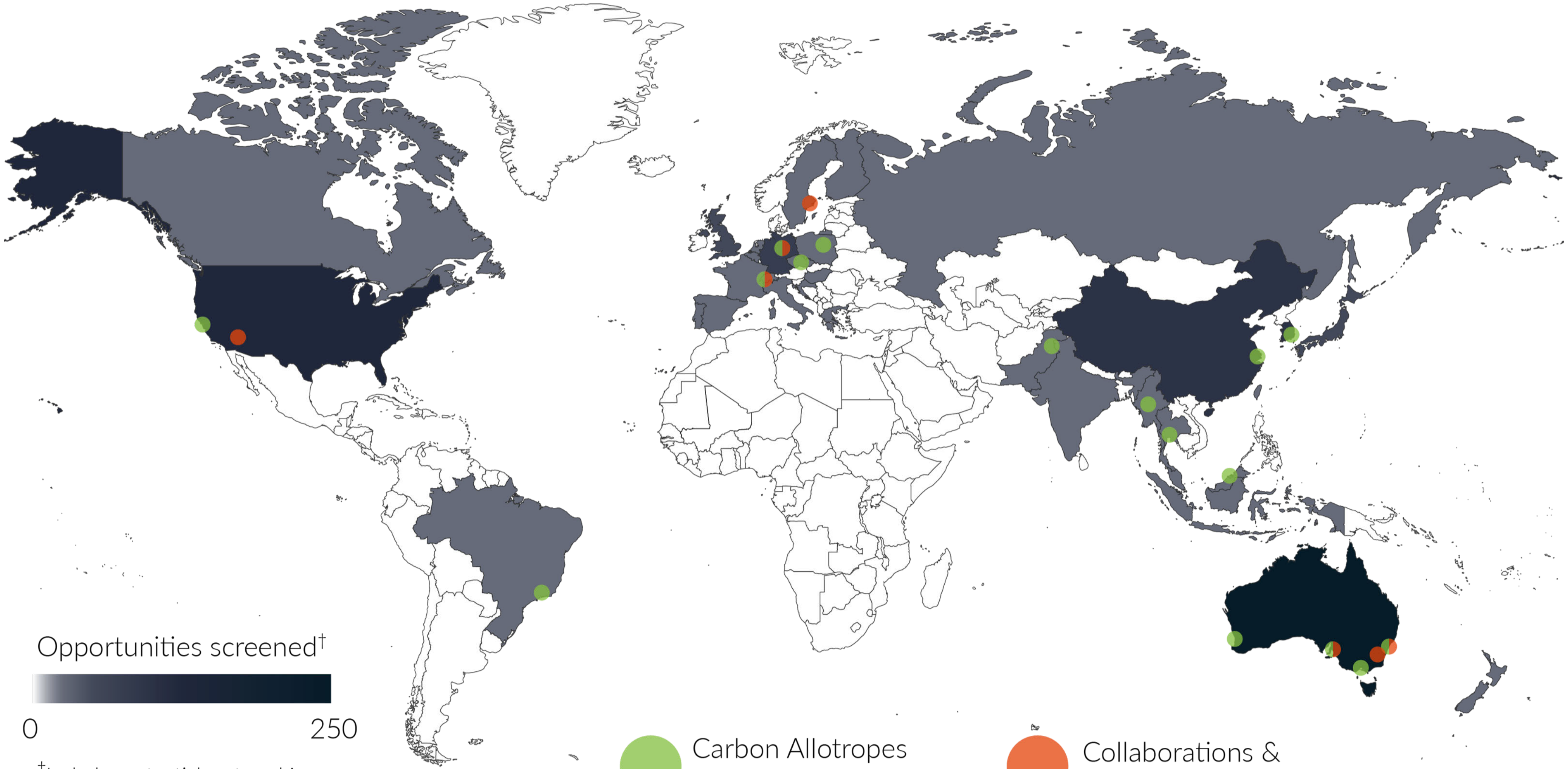
Archer affiliate preparing carbon electrodes with materials from Carbon Allotropes' inventory.

The acquisition of Carbon Allotropes enabled Archer to expand on its market position

Archer's growth involves contributing to complex global challenges. These challenges require access to materials that are the basis of modern electricity, healthcare, and computing. Both developed and underdeveloped markets' needs are underpinned by advances in technology and the paradigm shifts that accompany them. Archer is uniquely positioning to meet these needs through its advanced materials & technology.

The acquisition of Carbon Allotropes in late 2017 spearheaded Archer's global reach. This brought to Archer world-class expertise, a diverse advanced materials inventory, and access to over $150m in product research and development infrastructure. This has allowed us to rapidly identify, evaluate and respond to market opportunities for acquisitions, partnerships, and growth.

Current Presence in Growth Markets



†Includes potential partnerships, offtake, licencing and sales.


Quantum
Technology


Reliable
Energy


Human
Health

Significant Developments in 2018-2019

Quantum Technology

- Archer obtains exclusive licence to quantum technology IP (QTIP)
- QTIP patents lodged in Australasia, the US, and EU
- Pioneering quantum physicist Dr Martin Fuechsle joins Archer
- Access agreements signed with the Sydney Nanoscience Hub and [12]CQ commences

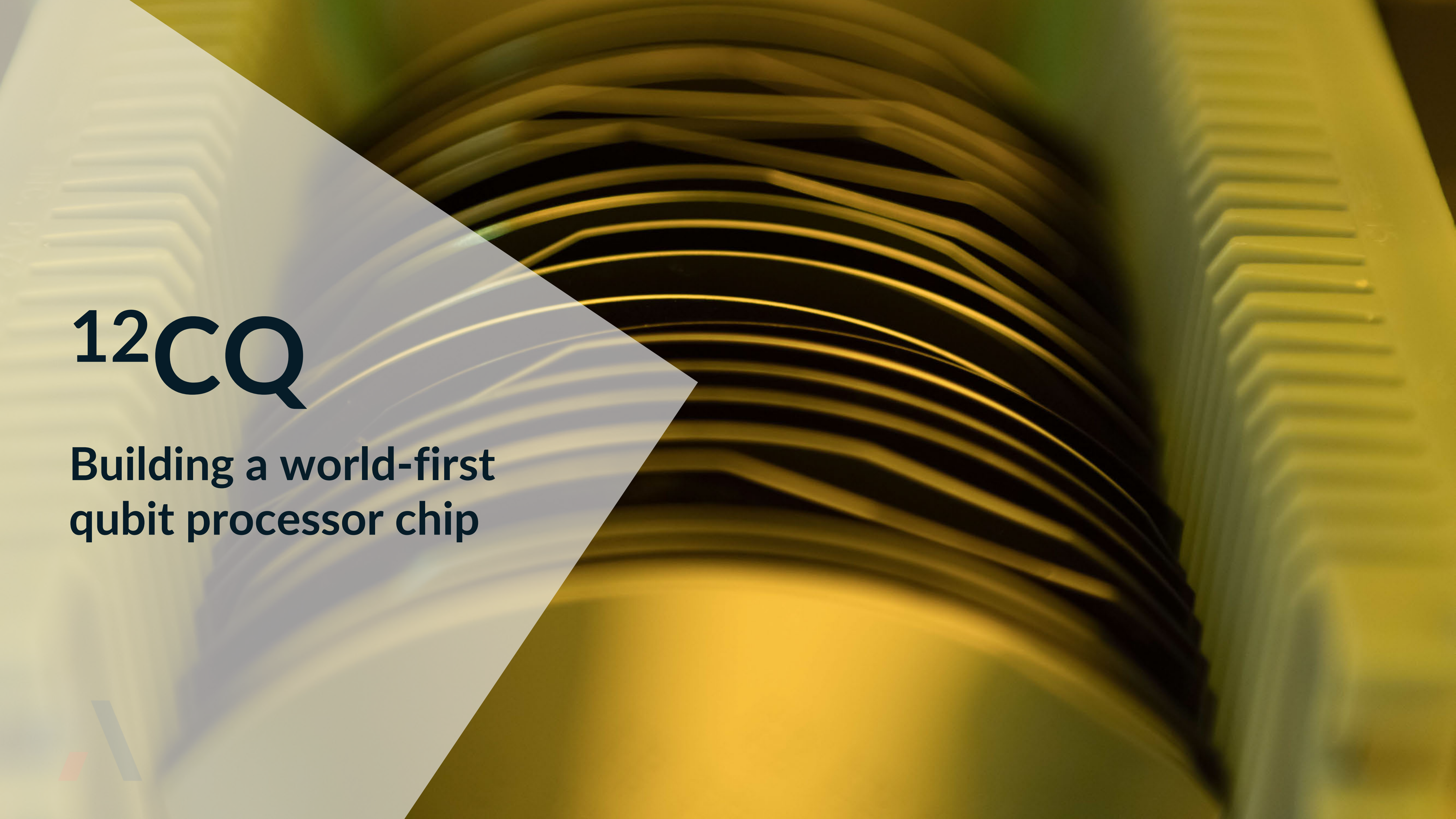
Reliable Energy

- Collaboration & access agreements with UNSW
- Full-cell Li-ion batteries produced with Campoona graphite in-line with industry state-of-art requirements
- Spherical graphite produced from Campoona graphite matching market requirements for Li-ion batteries

Human Health

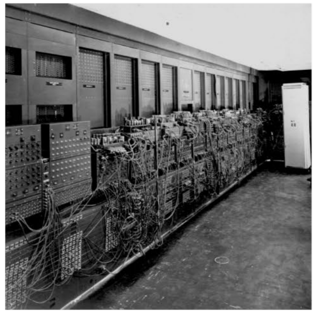
- Graphene inks prepared with the University of Adelaide for printed biosensing technologies
- Provisional patent lodged for graphene-ink biosensing technology
- Material transfer agreement signed with German biotech
- Human antibodies printed on graphene biosensors

Archer's key value-add activities: Acquisitions & Partnerships | Materials & Tech. Development | Commercialisation

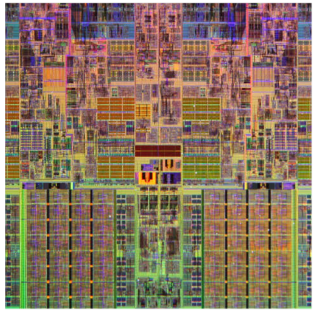

^{12}CQ
Building a world-first qubit processor chip

Hallmarks of the Computing Economy

- Large computing systems gave way to portable, miniaturised devices with integrated componentry: materials innovation still disrupts the industry and central to growth.
- Successful companies are founded and led by highly skilled people with scientific knowledge, IP, and deep technical expertise competing against large, highly resourced organisations.
- Devices solved problems for government and businesses. Integration & miniaturisation allowed for widespread consumer use, in-turn requiring more computing power.
- Powerful microprocessors are reaching the fundamental limits of transistor fabrication and size with non-linear improvements in scale.
- Quantum computers are currently large rigid systems useful for a limited set of problems for government and businesses, with no standard chip componentry architectures.
- Over time the industry has not consolidated, rather, remaining dynamic and rife with merger & acquisition activity which is important in catalysing industry growth.



ENIAC. Copyright Everett Historical Collection.



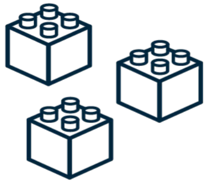
Die-shot of Intel Core i7 CPU. Copyright Intel Corp.

D-Wave system. Copyright D-Wave Systems Inc. (Media Resources)

- ***1946.*** Electronic Numerical Integrator And Computer (ENIAC)
- ***1947.*** Transistor demonstrated to replace the vacuum tube triode
- ***1958.*** First ever integrated circuit built by Jack Kilby, using Ge and Al
- ***1968.*** Intel founded by Gordon Moore **(PhD Chemistry)** and Robert Noyce **(PhD Physics)**
- ***1975.*** Microsoft founded by Bill Gates and Paul Allen
- ***1976.*** Apple Computer Company founded by Steve Jobs, Steve Wozniak and Ronald Wayne
- ***1980s.*** The start of the personal computer (PC) era and home gaming consoles
- ***1990s.*** The internet is invented and portable devices offer unprecedented connectivity
- ***2010+***. Quantum computing systems and prototype processor chips emerge
- ***2019.*** Billions of transistor structures inside a CPU in mobile devices

Classical Computing vs. Quantum Computing

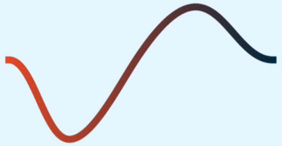
‘Classical Bit’
Processable information in a binary 0 or 1 state
e.g. electronic signal
⚐ *Static*



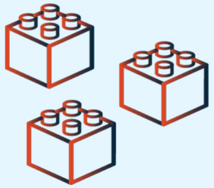
Semiconductor Materials
Key to transistor development & the basis of modern technology
e.g. silicon
⚐ *Atomic Limits*

Central Processing Unit (CPU)
Critical device inside computing devices & responsible for performance and function
⚐ *Moore’s Law*

Modern Computers
As smartphones, tablets, and PCs converge they require increasingly powerful CPUs and components
⚐ *Technology Function*



‘Qubit’
Processable information in a quantum ‘superposition’ state
e.g. electron spin, light
⚐ *Lifetimes & Control*



‘Qubit’ Materials / Qubits
The tangible physical basis of quantum computing technology
e.g. superconductors, silicon
⚐ *Temperature & Stability*

‘Qubit’ Processor Unit (QPU)
The most crucial hardware device component, and ‘brain’ of the quantum computer
⚐ *Integration & Fabrication*

Quantum Computers
Represent incredibly powerful parrallel computing & currently in development
⚐ *Impractical & Limited Ownership*

Successful development of Archer's ^{12}CQ chip could enable widespread ownership of quantum computing powered technology

1 **World-record room-temperature qubit stability**

Archer is using the only reported conducting material capable of stable and robust quantum information processing at room temperature[1].

2 **Simple to integrate quantum materials**

No need for cryogenic temperatures, well-defined crystals, atomic manipulation, or the use of metals; all key technological barriers to current qubit chip development.

3 **Best-in-class chip prototyping and testing**

The chip forms the most crucial hardware component of a universal quantum computer to function under practical conditions to allow on-board mobile device integration.

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

Archer staff operating quantum device fabrication instruments at the Sydney Nanoscience Hub.

Archer staff preparing quantum devices and chip fabrication at the Sydney Nanoscience Hub.

Successful commercialisation of Archer's ^{12}CQ chip technology could catalyse a global multibillion dollar industry

$30b

Forecast size of quantum computing industry in 2022[2]

$715b

Global semiconductor industry revenue[3]

70%

Of semiconductor manufacturing located in Asia[3]

50%

Global quantum computing funding in EU, North America, AU[4]

$4b

Revenue in Australian consumer electronics market[5]

88%

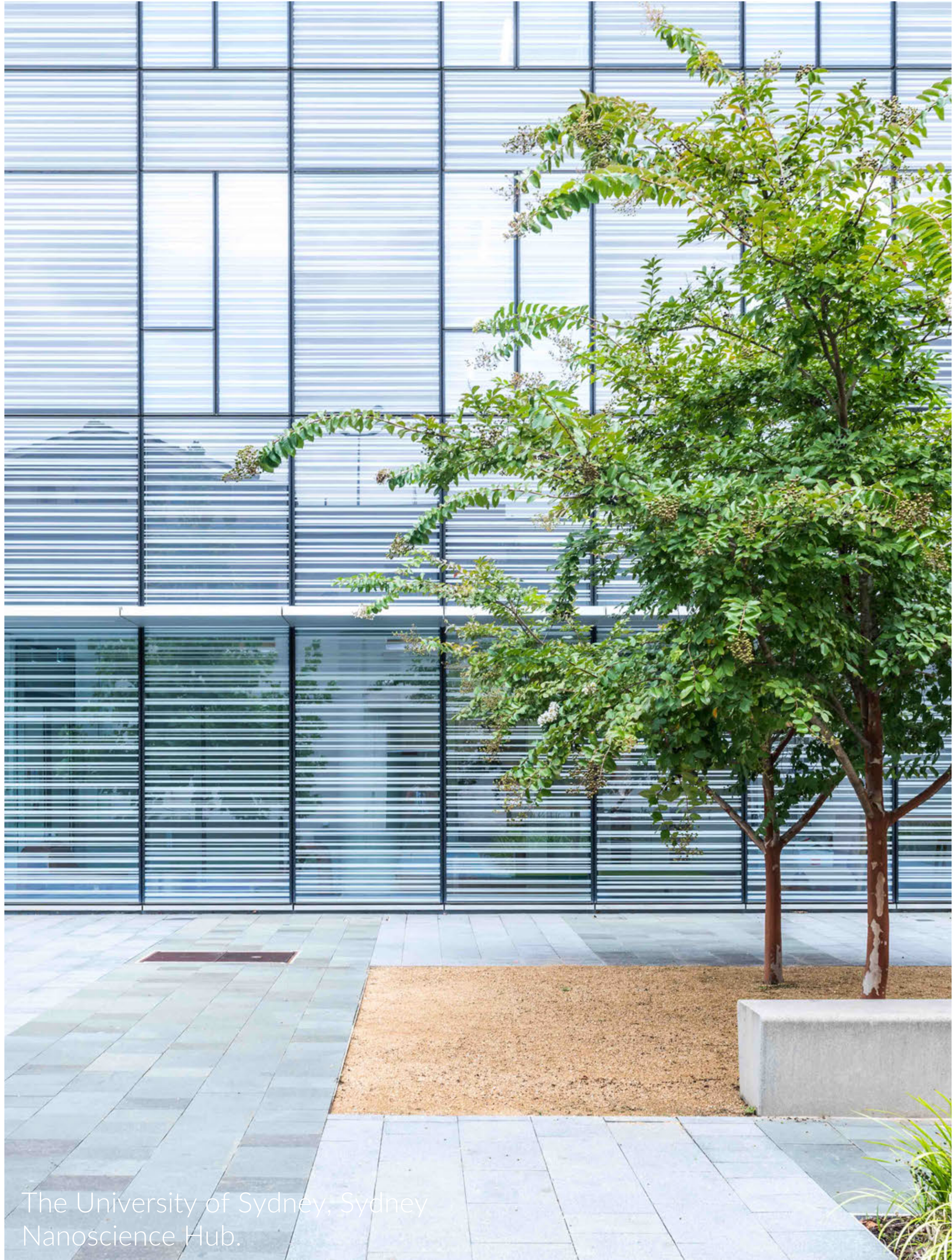
Australians now own a smartphone[5a]

[2]Quantum Computers: Solving problems in Minutes, not Millennia. Goldman Sachs. Feb 2018. http://www.goldmansachs.com/our-thinking/pages/toshiya-hari-quantum-computing.html
[3]Global Semiconductor and Electronic Parts. IBISWorld Industry Report. May 2018.
[4]https://www.bcg.com/en-au/publications/2018/next-decade-quantum-computing-how-play.aspx
[5]Statista. Consumer Electronics. 2019. https://www.statista.com/outlook/251/107/consumer-electronics/australia
[5a]Deloitte. Mobile Consumer Survey. 2017. http://landing.deloitte.com.au/rs/761-IBL-328/images/tmt-mobile-consumer-survey-2017_pdf.pdf

Archer has exclusive international rights to develop and commercialise breakthrough quantum computing technology

Globally registered patents are exclusively licensed to Archer by the University of Sydney. The basis of the patent IP, the ^{12}CQ qubit processor, represents the means to establishing commercial operations in global markets. Patents would be valid until 2035 and are filed in the EU, US, Australia, China, Japan, Hong Kong, and South Korea. Material components critical to ^{12}CQ are available in the inventory of Carbon Allotropes.

A Facilities Access Agreement with the University of Sydney, provides Archer access to the $150m Research & Prototype Foundry at the Sydney Nanoscience Hub: comprehensive world-class infrastructure comparable to production-level facilities found in major international semiconductor chip building foundries required to successfully build prototypes of the ^{12}CQ qubit processor chip.



The University of Sydney, Sydney Nanoscience Hub.


Dr Mohammad Choucair (right) and Dr Martin Fuechsle (second left) in the Sydney Nanoscience Hub cleanroom.

Global pioneers in nanotechnology and quantum computing are leading Archer's ^{12}CQ Project

Dr Mohammad Choucair *FRACI FRSN GAICD* joined Archer in December 2017 as CEO. PhD in Chemistry (UNSW). Inventor of the ^{12}CQ qubit processor. Founder of Carbon Allotropes. Former World Economic Forum Global Councillor for Advanced Materials. RACI Cornforth Medallist for the most outstanding Chemistry PhD in Australia. Honorary Fellow of the University of Sydney. Virgin Australia Top 10 Australian Stars (2016).

Dr Martin M. Fuechsle joined Archer in February 2019 as Quantum Technology Manager. PhD in Physics (UNSW). 10 years experience in building quantum computing devices and technology. Australian Institute of Physics Gold Medallist for the most outstanding Physics PhD in Australia. Inventor of the single-atom transistor. Member of the Australian delegation at the Lindau Meeting of Nobel Laureates (2008).

^{12}CQ: Commercial Pathway

TRL*

- **2012.** ^{12}CQ's qubit material invented (1)
- **2013-15.** Basic principles of quantum computing observed in ^{12}CQ's qubit material
- **2016.** Basic principles of quantum computing in ^{12}CQ's qubit material validated & reported (2)
- **2019.** ^{12}CQ commences building prototype qubit processor devices (3)
- 4-9*

CRL*

- **2015.** Provisional patent registered related to ^{12}CQ's qubit processor
- **2016.** Patent Cooperation Treaty application filed for ^{12}CQ's qubit processor
- **May 2018.** Institutional Agreement signed between University of Sydney and EPFL for ^{12}CQ's IP assignment
- **Jun 2018.** Patents filed in US, EU and Australasia for ^{12}CQ's qubit processor
- **Dec 2018.** Archer exclusively licences ^{12}CQ's IP from University of Sydney
- **Apr 2019.** Archer signs Access Agreements to build the ^{12}CQ processor prototypes at the Sydney Nanoscience Hub

TRL of Current Quantum Computing Technology**

1	Topological (e.g. Microsoft)
3	Silicon (e.g. Silicon Quantum Computing)
3	Photonic (e.g. Xanadu)
4	Trapped Ion (e.g. IonQ)
5	Superconducting (e.g. IBM, Rigetti, D-Wave, Intel)

Current Global Investment^

China	+$3b
US	+$1.3b
EU	+$1.1b
UK	+$0.4b
AU, CA, ISR	+$0.1b

First Sales of Quantum Computers^^

D-Wave	+$10m per unit
Customers	Lockheed Martin, Google, Volkswagon Los Alamos National Laboratory, Oak Ridge National Laboratory

*Archer self assessed Technology Readiness Level and Commercial Readiness Level. See Appendices.
**BCG assessed TRL; examples may currently vary in TRL. See: ^https://www.bcg.com/en-au/publications/2018/next-decade-quantum-computing-how-play.aspx and https://www.bcg.com/publications/2019/quantum-computers-create-value-when.aspx ^^www.dwavesys.com

Quantum Computing for Finance

Why use Quantum Computers?	To implement Quantum Algorithms (software) that provide substantial speed-ups in processing over classical computers and the possiblility to solve problems that classical computers find extremely difficult or impossible		
Questions	Which assets should be included in an optimal portfolio?	How does one detect opportunity across different assets?	How does one estimate the risk and return of a portfolio?
Problems	Dynamic portfolio optimisation; maximum return with minimal risk *e.g.* hedging vs. diversification	Financial prediction; forecasting and the distribution of returns *e.g.* volatility	Risk randomness; estimations based on incomplete knowledge of the market *e.g.* derivatives
Solutions	Quantum Optimisation	Quantum Machine Learning	Quantum Simulations
Hardware Challenges for General Use	Room-temperature stability; only works at sub-zero temp.	Many algorithms require a universal quantum computer; qubits limited	Room-temperature stability; qubits limited
Quantum Hardware Used	Quantum Annealers; e.g D-Wave chips 512 and 1152 qubits[6] D-Wave 2X[7]	Four-qubit NMR test bench[9], D-Wave Quantum Annealer[10], Rigetti Machine*	IBM Q Experience[12]
Examples	Optimal Trading Trajectory[6] Optimal Arbitrage Opportunities[7] Optimal Feature Selection in Credit Scoring[8]	Data Classification[9,10] Regression (for forecasting)* Principal Component Analysis* Neural Networks[11]	Pricing of derivatives* Monte Carlo Sampling (Value at Risk; Conditional Value at Risk)[12]

Quantum Computing Impact on Blockchain

'Quantum-proof' Blockchain
Blockchain a distributed public ledger, i.e. a digital tool using cryptography to protect information.

The World Economy
By 2025, 10% of global GDP is estimated to be stored using blockchain technology[13].

Digital Currency
Blockchain is the basis of crypto-currencies; it is used in finance, manufacturing, healthcare & logistics

Time Horizon
Quantum computers may be able to break blockchain's cryptographic codes within a decade[14].

Securing Digital Currency Assets
Quantum computation can break existing blockchain codes; however quantum-safe encryption is being developed.

Future of the Internet
Quantum computation can in turn be used for enhanced security (quantum-cryptography) and could lead to an inherently secure quantum internet.

13. B. Marr. How Blockchain Technology Could Change The World. Forbes, 27 May 2016.
14. A. K. Fedorov, E. O. Kiktenko, A. I. Lvovsky. Nature. Quantum computers put blockchain security at risk. 22 November 2018. Vol. 563. Page 465 https://www.nature.com/articles/d41586-018-07449-z

The Path Forward

The next 12 to 18 months

1 **Value-added Development**

Build a commercial prototype qubit processor chip to advance from a TRL of 2 towards 4 by assembling the functional components of the chip at the Sydney Nano-science Hub.

2 **Commercialisation**

Establish commercial partnerships with highly resourced organisations, that would allow the opportunity for product scale, knowledge and technology transfer, integration, and product distribution.

3 **Grow our Global Presence**

Successfully prosecute patent applications in Australia, the US, EU, China, Japan, Republic of Korea, and Hong Kong, to provide the commercial freedom to operate in these markets.

Archer staff inspecting quantum device instrumentation at the Sydney Nanoscience Hub.

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Appendices

(Slide 16)

Commercial Readiness Level

1 IP requirements identified
2 Secured entry to sub-sectors of market
3 Minimum viable product solution
4 Customer problems validated
5 Customer relationships established
6 Revenue model verified
7 Prototype solution validation
8 Growth model realisation
9 Customers acquired

Technology Readiness Level

1 Scientific research begins
2 Basic principles observed & reported
3 Proof-of-concept validation
4 Basic technology elements integrated
5 Validation in relevant environment
6 Prototype demonstration (controlled)
7 System prototype demonstration (operational)
8 Systems integration at scale
9 System validation

References (Slide 17)

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*Proposed in Reviews in Physics, vol. 4, 100028 (2019) https://www.sciencedirect.com/science/article/pii/S2405428318300571

Glossary

Materials	The tangible, physical basis of all technology. This includes speciality materials, advanced materials, minerals, ores, textiles, etc.
Qubit	A portmanteau for ‘quantum bit’, the fundamental unit of quantum information often used interchangeably to describe a material isolating the qubit. Examples of qubits include superconducting, photonic, topological, spin, and trapped ion.
Quantum Information	The information stored in or represented by the physical state of a quantum mechanical system.
Qubit Processor Chip	The central processing unit of a quantum computer, comprised of a number of qubits.
Quantum Computer	A computer which uses qubits to store and process information.
Algorithm	A process or set of rules to be followed in calculations or operations by a computer; processor chips are built to execute algorithms.
Software	A set of instructions or programs instructing a computer to do specific tasks.
Hardware	The physical components of a computer or other electronic system.
Intellectual Property	Intangible property resulting from creative processes, such as inventions, & may be protected by patents, copyrights, or trademarks.
Patent	A form of intellectual property protection that gives the owner the right to exclude others from making, using, or selling an invention for a period of time.
Tenement	A license, permit or lease providing rights to explore for and/or extract minerals and metals under the surface of an area of land.
Technology Readiness Level	A framework of estimating the technology maturity of a project or development.
Commercial Readiness Level	A framework that tests assumptions that influence the commercial and market conditions beyond technology maturity.
Cryptocurrency	A digital currency in which encryption is used to regulate the generation of currency units and verify the transfer of funds.
Blockchain	A system in which a record of transactions is maintained across many computers that are linked in a network.
Semiconductors	A material with electrical conductivity between that of an insulator and that of most metals.
Semiconductor Foundry	A semiconductor fabrication plant where devices such as integrated circuits or ‘chips’ are manufactured.
Cryogenic Temperature	Very low temperature, typically the freezing point of gases like nitrogen (-210°C) or helium (-272°C) or below.