ASX Announcement (ASX:**AXE**) 26 June 2019

First-stage assembly of nanoscale qubit processor

Highlights

- Archer team assembles first nanoscale materials components of the 12CQ qubit processor (chip) prototype at the University of Sydney.
- Qubit processor chip components built on a silicon substrate to accelerate prototype development and facilitate the use of well-established silicon-compatible chip fabrication technology that is available at the Research and Prototype Foundry at the University of Sydney.
- Chip commercialisation to continue by prototyping materials componentry for integration to a proof-of-concept minimum viable chip product.

Archer Exploration Limited (Archer, Company) is pleased to announce that the Company has assembled the first components of a prototype qubit processor (chip) as part of its pioneering quantum technology project dubbed 12CQ (pronounced "one two cee cue", ASX Announcement 3 April 2019). The chip forms the basis of patents exclusively licensed to Archer from the University of Sydney (ASX Announcement 12 December 2018).

Commenting on the Company's 12CQ developments, Archer CEO Dr Mohammad Choucair said, "In a very short period since finalising the exclusive licence agreement with the University of Sydney, we have begun assembling prototype qubit processor [chip] components.

"The chip prototypes are being built by the Archer team at the world-class Sydney Nanoscience Hub at the University of Sydney. The Sydney Nanoscience Hub houses start-of-art facilities, such as the Research and Prototype Foundry, that are required to make 12CQ a success.

"We have started to build the chip on silicon substrates as silicon is the computer industry standard material for current classical computer chips. The compatibility of our carbon-based qubits with silicon chip substrates will aide with industry acceptance of our technology."

12CQ Prototype Componentry Assembly

The componentry assembled and shown in Fig. 1. form a prototype chip's first-stages of basic device architecture (pattern assembly) intended to allow for the quantum computing functions of the 12CQ carbon-based qubits once they are incorporated. This pattern assembly is an initial step towards fabricating a working qubit prototype representing a minimum viable product: a commercially-ready chip that can practically address and validate solutions to room-temperature quantum computing. The chip pattern assembly is a unique and unoptimised structure, subject to changing functional configurations. The chip pattern assembly is currently designed for versatile testing and validation of 12CQ's chip prototype competitive advantages (see *Quantum Technology & Archer's 12CQ Advantage*).

Silicon was used as a substrate to build the chip due to its technical and industrial advantages in semiconductor and consumer electronic device integration (see *Background and Market Summary*). The use of silicon as a chip substrate also expedites prototype development, as well-established silicon-compatible chip fabrication technology is available at the Research and Prototype Foundry in the Sydney Nanoscience Hub. Aluminium and gold electrodes were engineered to modern device component sizes compatible with the size of the ^{12}CQ qubits. The componentry may be substituted with other materials in future stages of ^{12}CQ chip development, which is a key advantage of the ^{12}CQ qubit processor chip.

Commenting on the chip componentry assembly, Archer CEO Dr Mohammad Choucair said, "The entire chip is about the size of the width of a few human hairs and designed to accommodate our nanosized qubits, that are similar in size to the main features of classical computer chips. We envision the ^{12}CQ qubit processor would fit alongside standard chips on modern day classical computing motherboards".

"Current quantum computing technology solutions can be quite rigid due to limitations posed by the qubit materials used in the chip fabrication process. We have the advantage that are our carbon-based qubits offer versatility in their handling, stability and quantum features for easy integration into modern electronics".

^{12}CQ Project at the Sydney Nanoscience Hub

The Archer team is building the ^{12}CQ qubit processor chip prototypes at the Research and Prototype Foundry within the world-class $150 million purpose-built Sydney Nanoscience Hub facility at the University of Sydney.

The Sydney Nanoscience Hub is also home to the Sydney Microsoft Quantum Laboratory (one of the largest single investment in quantum technology in Australia, and the only Microsoft experimental centre in the Southern Hemisphere being one of just three centres outside of the US in which Microsoft has invested)[†], the Sydney Quantum Control Laboratory, the University of Sydney Nanophotonic Laboratories, and quantum software company Q-CTRL. The Australian Defence Force is also accessing the facilities as part of its Plan Jericho (the development of augmented intelligence capability to protect Australia from technically sophisticated threats).

The success of ^{12}CQ involves building and testing nanoscale quantum devices at the Research and Prototype Foundry. A Facilities Access Agreement with the University of Sydney (ASX Announcement 3 April 2019) provides Archer access to a number of dedicated instruments and cleanroom facilities at the Research & Prototype Foundry. Archer's Quantum Technology Manager, Dr Martin Fuechsle, is now using these facilities and instruments to build chip prototypes after successfully completing facility induction and instrument certifications.

The cleanrooms at the Research and Prototype Foundry are classified at ISO Class 5 level, defined by a tightly regulated environment (temperature, humidity, and light) to provide an environment with extremely low levels of particulates. The cleanrooms mitigate the risk of the external environment destroying the fabricated devices (e.g. dust particles can be thousands of times bigger than the circuitry and can damage the components). The cleanrooms are comparable to production-level cleanrooms found in major international semiconductor chip building foundries.

[†] https://www.microsoft.com/en-au/quantum/team

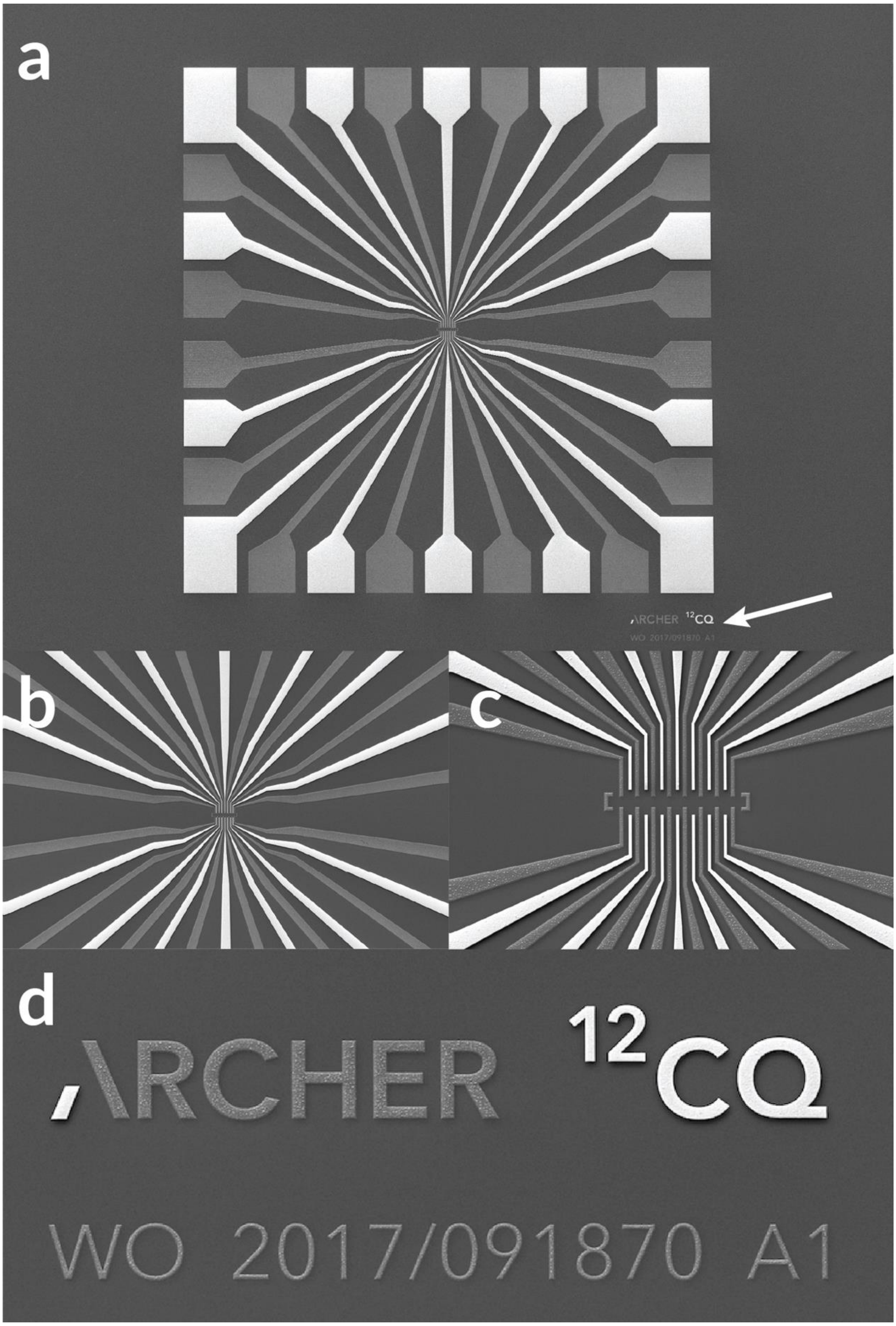

Fig. 1. a-c Electron microscopy images of the first ^{12}CQ chip prototype micron-nanoscale components patterned on a silicon wafer, at various magnifications. **d** Close-up of the region indicated by the arrow in **a** showing the Archer ^{12}CQ logo and international patent application number fabricated on the device substrate. The logo size is less than the width of a human hair.

Next Steps

The technical development at the heart of ^{12}CQ is a world-first. During Q1 FY2020, Archer intends to continue technology de-risking value-added development of the ^{12}CQ qubit processor chip by completing the next stages of component assembly towards a proof-of-concept prototype chip at the Research and Prototype Foundry at the University of Sydney.

The prototype chip validation is required to establish a minimum viable product solution that can address industry problems of room-temperature quantum computing operation and ready integration into modern electronics.

During this time, Archer will seek to establish commercial partnerships with highly resourced and skilled organisations including software developers and hardware manufacturers, that could allow the opportunity for product scale, knowledge and technology transfer, and product integration and distribution channels.

Image 1. Looking into the cleanroom of the University of Sydney's Research & Prototype Foundry, a Core Research Facility which is supported by the Australian National Fabrication Facility (ANFF), and the Australian Government's National Research Infrastructure for Australia (NCRIS).

Background and Market Summary

Quantum Technology & Archer's ^{12}CQ Advantage

Quantum computers represent the next generation of powerful computing[1]. They consist of a core device (chip) made from materials capable of processing quantum information (qubits) necessary to solve complex calculations. One of the biggest challenges to wide-spread use by consumers and businesses involves keeping the qubit stable at room-temperature while integrating into electronic componentry. The development of quantum computers is envisioned to impact industries reliant on computational power, including finance, cryptocurrency and blockchain.

During his previous employment at the University, Archer CEO Dr Mohammad Choucair invented the first material known to overcome both the limitations of sub-zero (cryogenic) operating temperatures and electronic device integration for qubits. The conducting carbon material was able to process qubits at room temperature[2]. This has the potential to reduce commercial barriers to quantum computing and make it globally accessible. The patented device incorporating these materials forms the subject of IP that was exclusively licenced from the University of Sydney by Archer (ASX Announcement 12 December 2018), and the materials are available in Archer's wholly owned subsidiary Carbon Allotropes.

Market and Key Growth Catalysts

According to McKinsey[3], in 2015, Australia (5%), the EU (35%), and North America (30%), made up 70% of A$2.4bn (€1.5bn) world spend on high-value quantum computing R&D. Morgan Stanley forecasts that quantum technology could double the value of high-end computers to US$10 billion by 2027.[4-5] Investment bank Goldman Sachs predicts that by 2021, quantum computing could become a $US29 billion industry[6], while the Boston Consulting Group[7] highlighted the dependence of the market size on achieving technical milestones over the coming decades.

Globally, quantum computing forms part of the mature semiconductor and electronic parts manufacturing industry (SEPMI)[8]. The SEPMI is a US$500 billion+ revenue market, with approx. 70% of manufacturing concentrated in Asia. Approximately 40% of costs in the market relate to materials, and the industry sees margins of approximately 10-20%. There are few companies with large market share including Samsung, Intel, and Qualcomm, giving rise to potential opportunities for mergers and acquisitions (consolidation) based on disruptive technology integration.

About Archer

Archer provides shareholders exposure to innovative technologies and the materials that underpin them. The Company has a focused strategy targeting globally relevant materials markets of human health, reliable energy, and quantum technology.

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http://eepurl.com/dKosXI

[1] Philipp Gerbert and Frank Rueß. Boston Consulting Group. November 2018. https://www.bcg.com/en-au/publications/2018/next-decade-quantum-computing-how-play.aspx
[2] Choucair et al. Nature Communications 7, Article number: 12232 (2016) https://www.nature.com/articles/ncomms12232
[3] Appears in: https://www.economist.com/news/essays/21717782-quantum-technology-beginning-come-its-own
[4] A Quantum Leap Toward a Computing Revolution. Morgan Stanley. Oct 2017. https://www.morganstanley.com/ideas/quantum-computing
[5] Quantum Computing – Weird Science or the Next Computing Revolution? Morgan Stanley. August 2017.
[6] Quantum Computers: Solving problems in Minutes, not Millennia. Goldman Sachs. February 2018. http://www.goldmansachs.com/our-thinking/pages/toshiya-hari-quantum-computing.html
[7] Matt Langione, Corban Tillemann-Dick, Amit Kumar, and Vikas Taneja. Boston Consulting Group. May 2019. https://www.bcg.com/publications/2019/quantum-computers-create-value-when.aspx
[8] Global Semiconductor and Electronic Parts. IBISWorld Industry Report. May 2018.