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ASX Announcement (ASX: **AXE**) 1 February 2022

Quantum information detected using mobile compatible chip technology

Highlights

- Major technical feat achieved in Archer's ^{12}CQ quantum chip development, with mobile compatible chip technology used to detect quantum information at room temperature.
- The technology advance paves the way for the implementation of complex qubit control, a fundamental requirement for quantum computing processor chips to operate.
- High electron mobility transistor ("HEMT") technology was used to detect and characterise the ^{12}CQ qubit material. HEMT devices are widely used in integrated circuits (e.g. in mobile phones).
- The Company is well-funded to progress its ^{12}CQ chip technology development with A$29 million cash and no corporate debt.
- Archer is the only ASX listed company and one of a few players in the world developing qubit processor chip technology in the semiconductor industry[†].

Archer Materials Limited ("Archer", the "Company", "ASX: **AXE**") is pleased to provide shareholders with a technical progress update on Archer's ^{12}CQ quantum computing chip technology ("^{12}CQ chip").

The Company for the first time has detected quantum information[‡] in the ^{12}CQ qubit material on-chip and at room temperature using mobile phone compatible technology. Archer and teams from EPFL have now used a single-chip integrated electron spin resonance ("ESR") detector based on a high electron mobility transistor ("HEMT") technology to detect and characterise the as-prepared ^{12}CQ qubit material in a controlled atmosphere at room temperature.

The signal characteristics obtained agreed with the well-studied, repeatable, and scientifically published results obtained from room temperature measurements performed on macroscopic ('bulk') quantities of the qubit material using continuous wave ESR instruments[‡].

The unoptimised ESR chip devices were of sufficient sensitivity to detect the electron spin in a few picolitres (picolitre is a trillionth of a litre) of qubit material at room temperature. The quantum information in the qubit material is in the form of an electron's 'spin' states. The quantum states were found to be sufficiently well preserved when operating in an on-chip environment.

[†] IBM Quantum Network: https://www.ibm.com/quantum-computing/network/members/
[‡] https://www.nature.com/articles/ncomms12232

By demonstrating the detection of electron spin quantum states using a single chip ESR detector based on HEMT, the technology paves the way for the implementation of the complex qubit control characteristics required in quantum circuits.

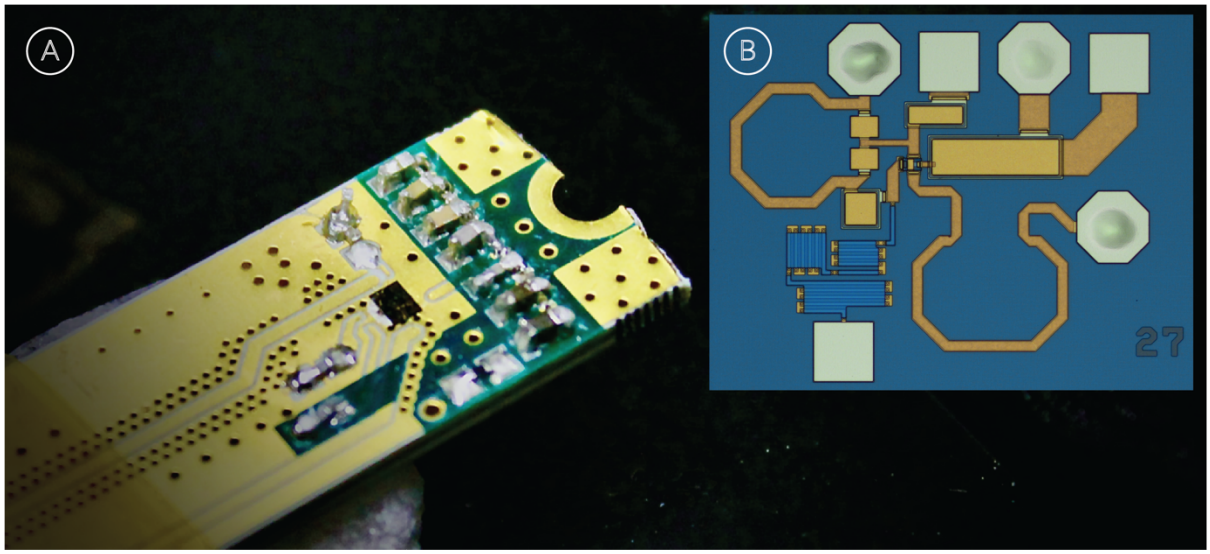

Image 1. A The integrated single chip ESR detector based on HEMT. **B** A microscope image of a region in **A** (inside the black square in the centre of the chip) of approximately 0.5mm x 0.5mm showing the miniaturised on-chip ESR componentry used to detect the quantum spin states in Archer's ^{12}CQ qubit material at room temperature.

Commenting on the recent progress, Archer CEO Dr Mohammad Choucair said: "Archer's ^{12}CQ chip development is unique as we have the potential to enable quantum powered mobile devices. Our technology advance provides direct proof to support this exciting possibility.

"HEMT technology is well-established and widely used in the semiconductor industry, so its use in the development of qubit control devices is consistent with the Company's strategy to make the ^{12}CQ chip compatible with modern electronics."

HEMT devices

Archer and collaborators from EPFL have used high electron mobility transistor ("HEMT") technology to detect and characterise the as-prepared ^{12}CQ qubit material in a controlled atmosphere at room temperature.

The single-chip resonator was developed at EPFL, and manufactured by semiconductor company OMMIC using existing foundry processes and facilities, near Paris, France.

HEMT devices are widely used in integrated circuits, for example in mobile phones, and are well-known in the semiconductor industry due to their low power consumption (the HEMT based ESR detector chip device referred to in this Announcement consumed approximately 90 µW of power at room temperature operation).

The HEMT technology was initially utilised for the ESR chip in part to confirm the advantages of low power consumption offered by a HEMT for the qubit measurements, and the chip having simplified integrated electronics to a single transistor.

Archer previously showed ^{12}CQ single qubit compatibility by integrating with silicon substrates (ASX ann. 22 Feb 2021) and intends to consider silicon CMOS based ESR detectors in future development.

Validation of prior work

In collaboration with EPFL, the Company for the first time has detected quantum states[§] in the ^{12}CQ qubit material on-chip and at room temperature using mobile phone compatible technology.

The coherent control of quantum information in qubit materials is the fundamental requirement for quantum logic operations that are the basis of *any* quantum computing qubit processor hardware.

For potential development and use of Archer's qubit materials in practical quantum processor chip devices, it is significant to demonstrate the room temperature detection of quantum information using mobile-compatible device technology.

The scientific breakthrough made in 2016[‡] to realise Archer's ^{12}CQ qubit material demonstrated the detection and manipulation of the electron spin quantum state *and* the deliberate and coherent electron spin rotations in a bulk quantity of the qubit material. This was direct proof validating the potential usability of the qubit material for quantum information processing ("QIP") applications.

However, the miniaturisation of qubit materials and integration with appropriate quantum control electronics using semiconductor components to realise on-chip QIP devices is a significant challenge.

Archer recently advanced in this domain with collaborators in Sydney, Australia, with the Company reporting the first indication of on-chip qubit control in its ^{12}CQ qubit material using developed devices operating at low temperatures (ASX ann. 12 Jul 2021).

EPFL

Archer is working in parallel with colleagues at various facilities at the world-class institute EPFL (École Polytechnique Fédérale de Lausanne), located in Switzerland, on *qubit control* (ASX ann. 28 Jan 2020 and 12 Oct 2020). EPFL is one of the world's leading technology research institutions[**].

Operationally, working with teams at EPFL allows Archer to take advantage of the time zone difference between Europe and Australia, to effectively and efficiently address several aspects of the ^{12}CQ chip technology development 'around the clock'.

About Archer

Archer is a technology company developing advanced semiconductor devices, including processor chips that are relevant to quantum computing. Archer is developing the ^{12}CQ chip, a world-first qubit processor technology, that could allow for quantum computing powered mobile devices ('QPMDs'). For more information, please view Archer's webinar with IBM.

[§] https://www.nature.com/articles/ncomms12232
[**] https://rapport-annuel.epfl.ch/en/2020

The Board of Archer authorised this announcement to be given to ASX.

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