Spin-based quantum processing leveraging industry-standard silicon CMOS manufacture

Andrew Dzurak[1,2]

[1] *Diraq, Sydney, Australia*
[2] *UNSW, Sydney, NSW 2052, Australia*

andrew@diraq.com

In this talk I will discuss the advantages and challenges facing the development of quantum computers employing spin-based quantum processors that can be manufactured using industry-standard silicon CMOS technology, which is the technology underpinning our company Diraq. I will begin by discussing the development of SiMOS quantum dot qubits, including the demonstration of high-fidelity single-qubit gates [1], the first demonstration of a two-qubit logic gate [2], and assessments of silicon qubit fidelities [3,4]. I will then explore the technical issues related to scaling a CMOS quantum processor [5] up to the millions of qubits that will be required for fault-tolerant QC, including the use of global microwave fields capable of controlling millions of qubits [6] and demonstrations of silicon qubit operation above one kelvin [7,8]. I will also present very recent results obtained on qubits fabricated at imec using standard CMOS manufacture on 300mm silicon wafers, including randomized benchmarking of single qubit gates indicating single-qubit control fidelities of $F_{1Q} > 99.9\%$. I will conclude by discussing the technology roadmap for our company Diraq as we work towards the goal of developing fault-tolerant quantum computers that are compact and which will have much lower power requirements than competing qubit technologies.

References

[1] M. Veldhorst et al., Nature Nanotechnology 9, 981 (2014).
[2] M. Veldhorst et al., Nature 526, 410 (2015).
[3] H. Yang et al., Nature Electronics 2, 151 (2019).
[4] W. Huang et al., Nature 569, 532 (2019).
[5] M. Veldhorst et al., Nature Communications 8, 1766 (2017).
[6] E. Vahapoglu et al., Science Advances 7, eabg9158 (2021).
[7] H. Yang et al., Nature 580, 350 (2020).
[8] J.Y. Huang et al., Nature 627, 772 (2024).