Real-time millikelvin thermometry in a spin qubit architecture

Victor Champain
V. Champain, V. Schmitt, B. Bertrand, H. Niebojewski, L. Hutin, R. Maurand, X. Jehl, C. Winkelmann, S. De Franceschi, B. Brun
Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Pheliqs, Grenoble, France
Victor.champain@cea.fr

In the worldwide efforts to build the first useful quantum processor, semiconductor quantum dots[1] are attracting increasing interest owing to their scalability prospects[2]. In this approach, the qubits can be encoded in the spin degree of freedom of individual electronic charges localized in gate-defined potential wells. Recent works indicate that the heat generated by the manipulation and read-out of qubits constitutes a bottleneck for the efficient operation of large-scale quantum processors[3,4]. We present time-domain temperature measurements in the immediate environment of a semiconducting spin-qubit architecture. We take advantage of the temperature dependence of quantum capacitances in a silicon nanowire quantum dot array, which we read out via a radio-frequency tank circuit. Using two measurement configurations, we access the temperatures of both the local electron and phonon heat baths, respectively, with a noise equivalent temperature of 3 mK/√Hz , possible futures improvements of which are discussed. We illustrate (Fig.1) the time-domain capabilities of this thermometry technique by detecting the µs-scale temperature variations in response to short microwave bursts. This work represents a starting step towards the understanding and mitigating of the detrimental impact of dissipation on spin based quantum processors.

References

[1] D. Loss et al, Physical Review A, 57 (1998) 120.
[2] L. Vandersypen et al, npj quantum Information, 3 (2017) 34
[3] B. Undseth et al, Arxiv, 2304.12984 (2023)
[4] W. Lawrie et al, Arxiv, 2109.07837 (2021)

Figures

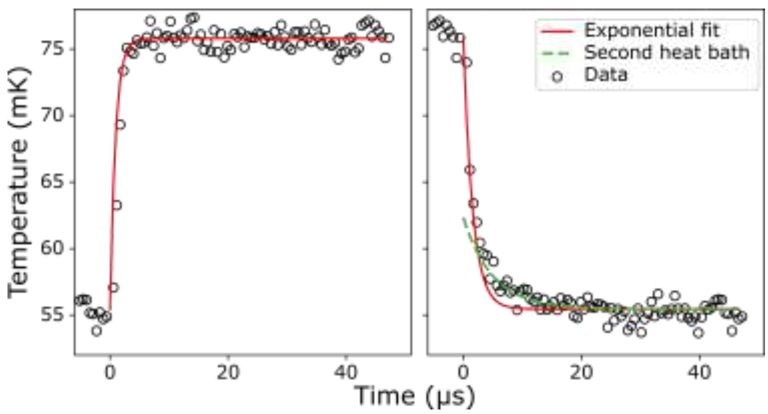

Figure 1: Real-time thermometry. Recording of the phonon temperature in a silicon nanowire, while (left panel) and after (right panel) irradiating a microwave burst as used for qubit manipulation.