HAL
open science

Wafer-level characterization of industrial grade Si-based qubit devices.

Emmanuel Chanrion, L.C. Contamin, B. Cardoso Paz, B. Martinez Diaz, B. Bertrand, H. Niebojewski, V. Labracherie, A. Sadik, A. Catapano, M. Cassé, et al.

To cite this version:

Emmanuel Chanrion, L.C. Contamin, B. Cardoso Paz, B. Martinez Diaz, B. Bertrand, et al.. Wafer-level characterization of industrial grade Si-based qubit devices.. SiQEW 2023 - Silicon Quantum Electronics Workshop 2023, Oct 2023, Kyoto, Japan. 2023. cea-04533121

HAL Id: cea-04533121

https://cea.hal.science/cea-04533121v1

Submitted on 8 Apr 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Wafer-level characterization of industrial grade Si-based qubit devices.

Emmanuel Chanrion[1], L.C. Contamin[1], B. Cardoso Paz[2], B. Martinez Diaz[1], B. Bertrand[1], H. Niebojewski[1], V. Labracherie[1], A. Sadik[1], A. Catapano[1], M. Cassé[1], E. Nowak[1], Y.-M. Niquet[3], F. Gaillard[1], T. Meunier[2], P.-A. Mortemousque[1], M. Vinet[2],

[1]Univ. Grenoble Alpes, CEA, Leti, F-38000 Grenoble, France

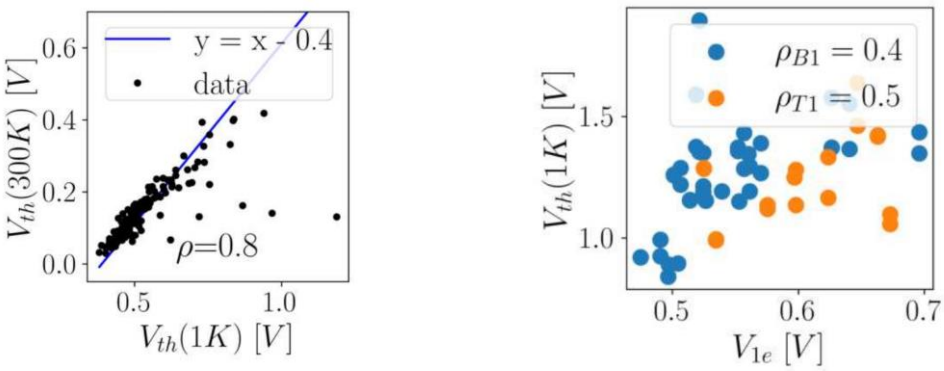
[2]Quobly, France

[3]Univ. Grenoble Alpes, CEA, Irig, F-38000 Grenoble, France

Efforts in improving the quality and number of solid-state spin qubits within a single device are currently hindered by the lack of large-scale characterization tools. Such tools are routinely available for "transistor-like" room-temperature characterization, but quantum-dot measurements at 1K are crucial to obtain specific information about the spin-qubit confinement and provide meaningful feedbacks to the process integration.

Here, we present the characterization of Si-based spin qubit devices at the wafer level at both 300K and 1K. We propose a methodology to evaluate such devices in a 3-step characterization protocol: 300K "transistor-like" metrics informative on material quality and process variability, 1K transistor and quantum dot metrics in the many-electron and in the few-electron regime.

We compare these different metrics to show their relevance, and discuss automation efforts for the analysis. Thanks to this large-scale characterization, we study the correlations between (i) 300K and 1K transistor-like metrics, and (ii) 1K transistor-like and quantum-dot properties. In particular, we show how the transistor threshold-voltage evolve with the temperature and how it relate to the voltage for which the first electron enters the quantum-dot. We discuss the correlation conditions and how they can help to speed up the characterization process.



Left panel: Correlations of constant-current threshold voltage at 300K and 1K for different devices of a same wafer. **Right panel:** Correlations between the threshold voltage in the transistor regime and the voltage for which the first electron enters the quantum-dots.