N°23: Radio-Frequency reflectometry at low temperature on silicon quantum dots

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Radiofrequency reflectometry (Fig. 1a) offers an elegant way to probe features often inaccessible by electrical transport measurement. This measurement monitors a resonant circuit (Fig. 2a), which is affected by subtle changes in the device under test impedance [1].

During this practical, we will first learn how a radiofrequency mixer works to combine low and high frequency signals at room temperature, and study this component using a spectrum analyzer. We will study in details the circuit of a low-temperature RF amplifier.
Finally, we will introduce and use radio-frequency reflectometry technique on a high-frequency resonator to measure a CMOS device at cryogenic temperature (~ 4K). This will allow us to investigate Coulomb blockade and quantum effects arising in these devices. Fig. 1c shows such low-temperature stability diagram of a multi-gate CMOS device. This forms the basis of Silicon-based spin qubits [2,3].

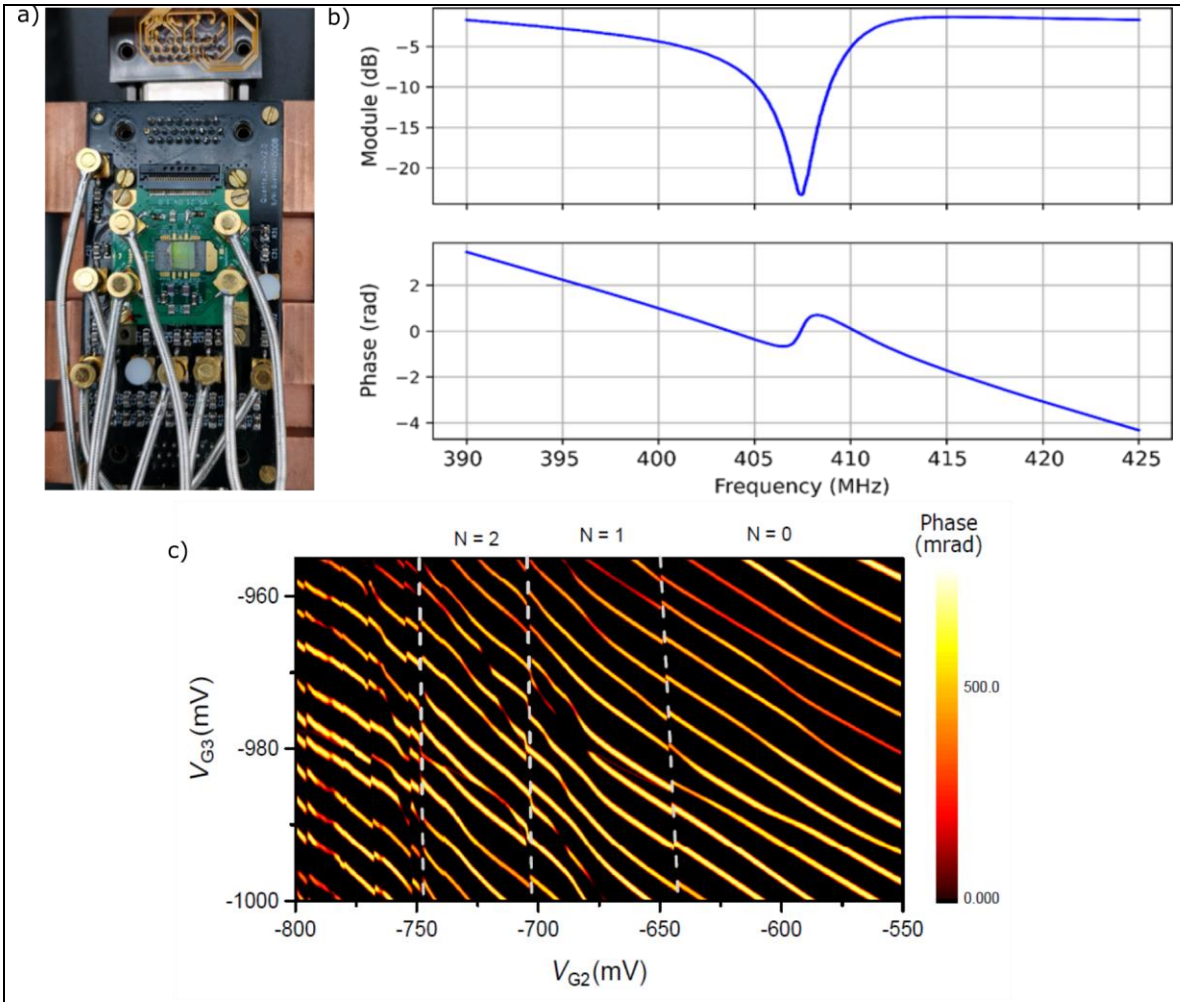

Figure 1: Setup, resonant circuit characteristics and stability diagram of a multi-gate device at low temperature, probed by reflectometry.

[1] Crippa et al., Level Spectrum and Charge Relaxation in a Silicon Double Quantum Dot Probed by Dual-Gate Reflectometry, Nano Letters 17, 1001 (2017) http://dx.doi.org/10.1021/acs.nanolett.6b04354
[2] R. Maurand et al., A CMOS silicon spin qubit, Nature Communications 7, 13575 (2016) http://dx.doi.org/10.1038/ncomms13575
[3] N. Piot et al., "A single hole spin with enhanced coherence in natural silicon," Nature Nanotechnology 17, 1072 (2022).