Enabling technologies for large-scale cryogenic quantum computers: parametric amplifiers

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Superconducting parametric amplifiers have been widely adopted in cryogenic radio-frequency measurement laboratories worldwide. Operating near the quantum limit of added noise, these devices enable, e.g., single-shot readout of superconducting qubits. In this talk, we will present VTT's development of amplifiers based on niobium Josephson junction technology [1], along with various demonstrated applications in experimental quantum science and technology. Our primary device concept is a travelling wave parametric amplifier (TWPA, see Fig. 1) consisting of a transmission line where the centre conductor is composed of Josephson elements called Super-conducting Nonlinear Asymmetric Inductive eLements (SNAILs). The non-linearity of the Josephson inductance allows a 3-wave mixing process where the energy of a strong microwave pump tone is transferred to a weak signal. The pump is at twice the signal frequency, which is beneficial: quantum squeezing can be studied [2], and the pump power can be prevented from reaching the gain stages that follow the TWPA. A magnetic flux bias line has been fabricated on the TWPA chip. It provides homogeneous, static flux biasing for all the SNAILs and negligible fringing fields around the miniaturized device package (Fig. 2).

References

[1] Leif Grönberg et al., *Supercond. Sci. Technol.* **30**, 125016 (2017).
[2] M. R. Perelshtein, K. V. Petrovnin, V. Vesterinen, et al., *Phys. Rev. Appl.* **18**, 024063 (2022).

Figures

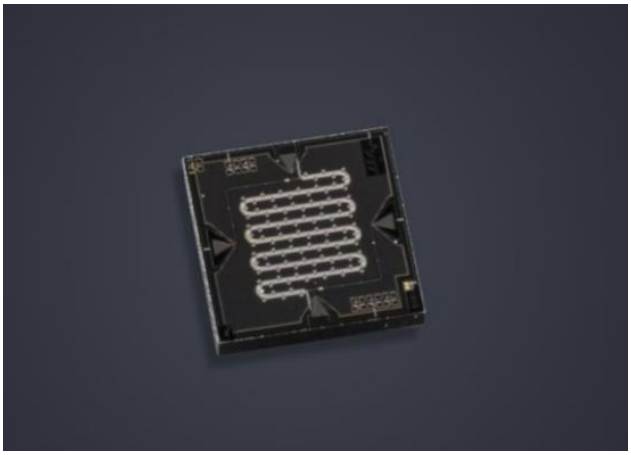

Figure 1: Photograph of a travelling wave parametric amplifier microchip. The chip size is 5 mm square.

Figure 2: Photograph of a travelling wave parametric amplifier in a connectorized microwave package. The dimensions are 17.7 mm x 21.7 mm x 13.4 mm.