# Fabrication and characterization granular Aluminum (grAl) superconducting devices

## Master project

### General Information

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**Starting date:** Summer 2024
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### Motivation

High-kinetic inductance (high-$L_k$) superconducting technology plays a key role for a large range of applications, such as low-temperature sensors, quantum bits, and superconducting electronics mostly used for qubit or sensors readout purposes [1—4]. Differently from Josephson junctions, high-$L_k$ thin films have advantages in terms of power handling and magnetic field resilience, which make them an interesting alternative for many applications where large magnetic fields are involved, such as quantum dots. Due to their intrinsically less nonlinear nature when compared to junctions, high-$L_k$ films are also perfectly suited for parametric amplification purposes [4].
Among these materials, granular Aluminum (grAl) has demonstrated impressive capabilities in terms of internal quality factors as well as inductivity of the films, which makes it an interesting material system for a variety of high-$L_k$ applications. Recently, even qubits based on grAl have been developed [5,6] thanks to their ease of fabrication and very large nonlinearity.

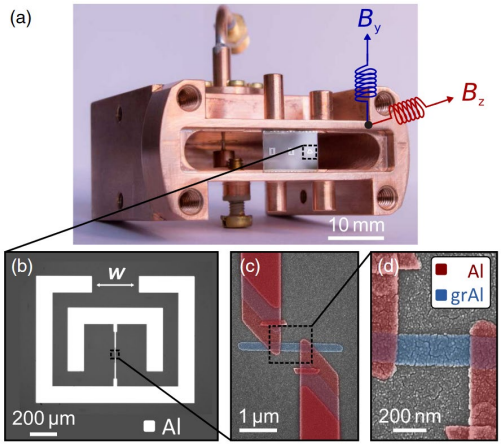


**Fig 1** Image of a transmon qubit with grAl nonlinear element [5]

### Description

The project is going to aim the model, design and test readout resonators and superconducting components in grAl material platform. The project will consist of three main phases:

1. **Preparation and Characterization**. In the first months, the student will learn about grAl and fabrication techniques, how to characterize the films and how to simulate and tune the main design parameters of superconducting resonators.
2. **Design**. The student will focus in designing and fabricating the readout resonators, potentially to couple with other platforms.
3. **Testing**. The chip will then be tested in a LD250 dilution refrigerator, a cryogenic systems capable of reaching temperatures in the range of 10 mK.

### Tasks

- Literature search
- Devices modeling on SONNET and/or COMSOL
- PA design and fabrication
- Experimental characterization of PA

[1] P. Day et al., *Nature* **425**, 817–821 (2003).
[2] G. N. Gol'tsman et al., *Appl. Phys. Lett.* **79**, 705 (2001).
[3] J. Koch et al., *Phys. Rev. A* **76**, 042319 (2007).
[4] B.H. Eom et al., *Nature Physics* **8**, 623–627 (2012).
[5] P. Winkel et al., *Phys. Rev. X* **10**, 031032 (2020).
[6] D. Rieger et al., *Nature Materials* **22**, 194-199 (2023)