Superconducting Thin Film Microwave Resonators for Cryogenic Sensing

Master/Semester project

(Section: Microengineering – Physics – Electronic Engineering)

Distributed physical measurements are essential in cryogenic systems in a variety of fields. Classical sensing approaches usually present a series of inconveniences, such as feedthrough space requirement, risk of leaks, risk of electric breakdown, heat input (conduction in wires), need for thermalization, etc… Allocating large number of sensors or compensating for the absence of distributed measurement imposes important constraints in the design of the cryogenic setup.

To overcome these drawbacks, we are currently investigating new possibilities of providing measurement systems in cryogenic environments (T < 90 K) by means of superconducting RF lumped elements resonators, which can be read in large numbers on a single RF line. Such a goal would be achieved either by exploiting variations of superconducting kinetic inductance [1-2], or by designing devices able to exhibit remarkable changes of geometrical LC parameters. Furthermore, the possibility of strategically nano-structuring the devices can allow to exploit more exotic superconducting phenomena to enhance sensing performance.

This student project will contribute to enhance such resonators, by investigating thin film nano-structuration methods on different materials. Subsequently, nano-engineered devices will then be fully tested and characterized in cryogenic environments (T < 90 K) using liquid He and cryostats.

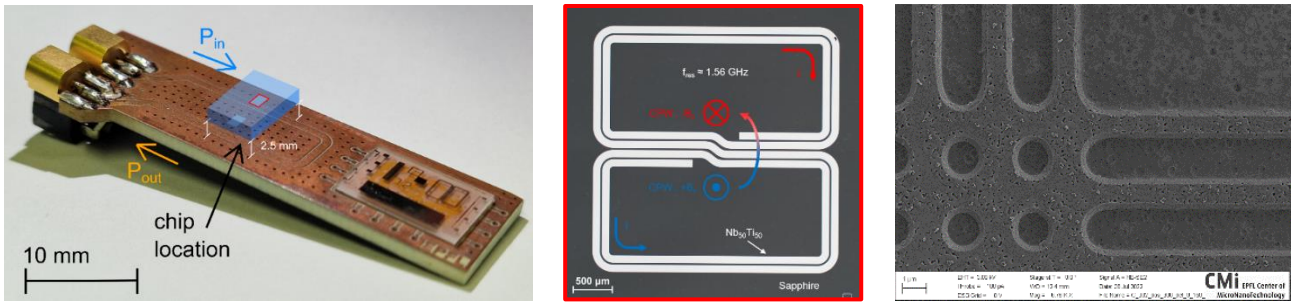

Figure 1 : *(a) schematic showing the superconducting resonator chip coupled to a standard Cu PCB; (b) optical microscope picture of a sensing device, showing the antisymmetric CPW B-field coupling of a thin film (e.g. NbTi) S-shaped Split Ring Resonator; (c) SEM picture of a test micropatterned YBCO film, courtesy of R. Russo.*

Expected tasks to be carried out during the proposed Master thesis on SC thin film resonators:

- Simulate, analyze and design superconducting RF components and resonators.
- Design, optimization and execution of process flows at EPFL's state-of-the-art CMi cleanroom:
  - Process flow conception.
  - Elaboration of microfabrication layouts.
  - Characterization of the resulting components using SEM, AFM, and other metrology tools.
- Cryo-RF characterization of finalized devices in a cutting-edge experimental setup.

The topic is highly multidisciplinary, involving aspects of condensed matter physics, RF electronics design and test, cleanroom microfabrication and materials science. At the end of the thesis the student will have gained a deep insight into sensing through superconducting phenomena, microfabrication in cleanrooms, and RF-cryo characterization.

Contact: André Chatel *(andre.chatel @epfl.ch)*
Hernán Furci (*hernan.furci@epfl.ch*)

[1] P.K. Day et al. (2003) Nature 425 817.
[2] H. Yu et al (2022) SN Applied Sciences 4:67.

École polytechnique fédérale de Lausanne

Microsystems Laboratory 1
(Prof. J. Brugger)

EPFL STI IMT LMIS1
(Batiment BM)
Station 17
CH - 1015 Lausanne

Phone : +41 21 693 90 42
E-mail : hernan.furci@epfl.ch
Office : BM 3.112