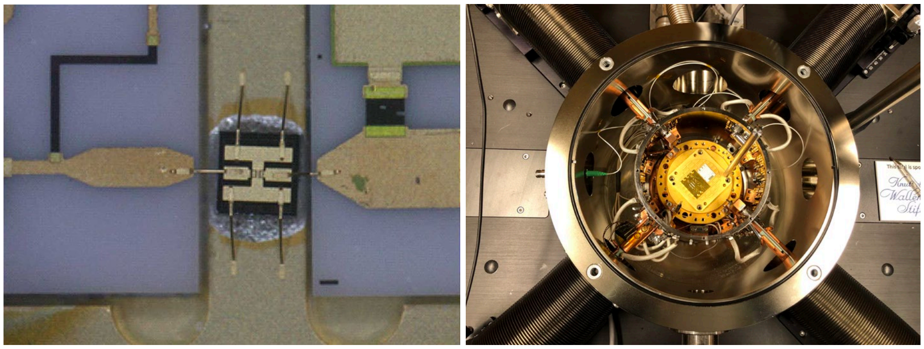
Master of Science Thesis: Characterization & Modeling of Cryogenic InP Transistors for Ultra-low-power LNA Design

Background:

InP transistors fabricated in Chalmers' cleanroom have been applied to state-of-the-art cryogenic low noise amplifiers (LNAs) used for quantum computers and radio astronomy receivers. Our transistors achieve world records noise temperature of 1.5 Kelvin at 4-8GHz with 42 dB gain in a cryogenic LNA, which has been used in all superconducting quantum computers worldwide, including Google's 54 qubits quantum computer (Arute et al., Nature Oct . 2019).



The InP transistors in LNA and the cryogenic measurement set-up

The rapid development of qubit integration in quantum computers has set a challenge for an ultra-low-power (ULP) solution for future InP transistor-based LNAs due to their cooling capability. We aim to decrease the power consumption of a single LNA to less than 100 microwatts, which is 100 times lower than the current industrial state-of-the-art product, with similar performance in the noise performance. Thus, an accurate and careful mapping of the small-signal modeling for InP transistors at cryogenic temperatures and biased at ultra-low-power conditions is needed. The characteristics and modelings of different InP transistors with varying design parameters will also benefit the optimization of more powerful cryogenic transistors.

Project goals:

The aims of this projects are:

1) To accurately characterize different design parameters of InP transistors under cryogenic (4 Kelvin) probe station, both in DC and RF conditions, at ULP bias points. After the measurements, both the small-signal model and noise parameters will be extracted from the measured data.
2) Understanding the relationship between the transistors' design parameters and their performance will help design better transistors in our cleanroom. If there is time, applying the extracted model to the new ULP LNA circuit design.

The project can be tailored for 30 or 60 credits, which may lead to an academic paper to be published.

Supervisor:

You will work with Ph.D. students and be guided by senior researchers and engineers from our industrial collaboration partner - Low Noise Factory. In addition, you will measure devices and communicate with our academic collaboration partner – Kyungpook National University in South Korea. The M.Sc. thesis will be carried out at Department of Microtechnology and Nanoscience (MC2), Terahertz and Millimeter Wave Laboratory.

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