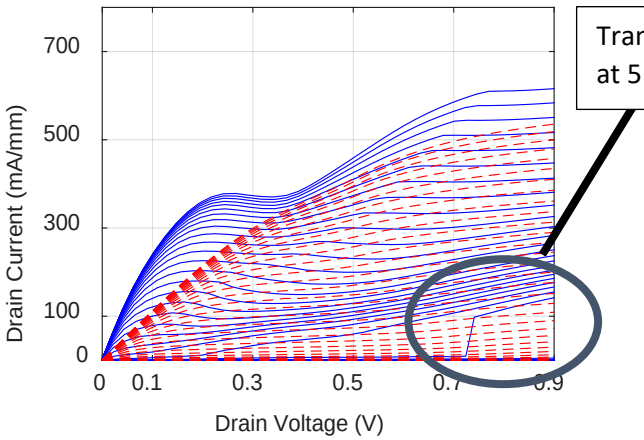
Diploma /MSc Work at MC2 – Year 2019

On the origin of the electrical instability in ultra-low-noise transistors

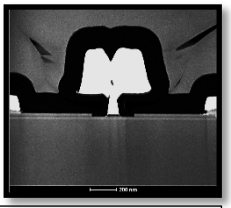
In some electronics applications such as quantum computers, amplification of extremely weak signals below 1 femtowatt is needed. Such sensitivity in an amplifier can only be achieved by cooling the electronics to low temperatures at 5-15 K. Unfortunately, transistors in the amplifier sometimes exhibit electrical anomalies when operated under cryogenic conditions. One example is an unexpected jump in the output current at a certain drain voltage as illustrated below. This behavior will make design of a read-out circuit such as a low-noise amplifier merely impossible. It is therefore important to solve and understand this electrical anomaly occurring in the transistor.

In our group, we recently demonstrated an efficient design methodology using a so-called source air-bridge geometry for stabilizing the low-noise transistor at cold temperatures. However, the origin of the anomaly is still not clear. In the scientific literature, several explanations have been proposed: Odd-mode oscillations due to asymmetry in the source contacts, low-frequency dispersion, or terahertz emission phenomena. In this diploma work, the student will investigate the instability by electrical measurements at cold temperatures for several type of low-noise transistor designs with different geometries, materials or processing. Low-frequency dispersion will be studied by a spectrum analyzer. From the data, the student will be able to make systematic observations and draw conclusions on the mysterious cryogenic instability in low-noise transistors. If solved, this will mean a significant breakthrough for the design of ultra-low noise amplifiers.

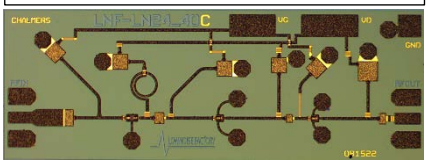
The device studied is the best low-noise transistor known, the InP high-electron mobility transistor. A spin off company from our group, Low Noise Factory AB (www.lownosefactory.com) is successfully commercializing the technology. This diploma work will be made in GHz Centre (www.chalmers.se/ghz) involving Low Noise Factory and other companies meaning frequent interactions with industry for the Master student.



Transistor instability at 5 Kelvin!



Ultra-low noise transistor using high-speed InGaAs channel



Low noise amplifier chip fabricated at MC2

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