

## Cryogenic Instrumentation Developed for the Characterization of advanced CMOS technologies down 250 mK

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# ZEA-2

# Introduction

Modern cryogenic systems are used for multiple experiments in different fields which allow reaching temperatures below 4.2 K. They are used in research and development areas that range from astrophysics detectors, superconductivity, quantum computer to cryo-electronics below 1 K [1]. The cryogenic instrumentation for electronic characterization is used to investigate physical phenomena taking place in active and passive electron devices at low temperatures (4.2-250 mK). Similar arrangement might be useful in development of readout electronics used for quantum bits ("qubits") [2, 4]. The CMOS technology characterization at low temperature is limited due by the maximum cooling power capacity of the system allowed. Therefore, in order to maintain this cooling power capacity as low as possible, the use of optimized sample holder and an adequate cabling [5, 6] is necessary to perform transistor DC characterization.

#### Temperature cryostat profile



#### <u>Cryogenic system</u>



**Fig. 1** Cryogenic system setup for characterization of CMOS technologies.

Fig. 4 Typical cooldown and warm up curves measured at the main 4 K cold plate, the thermal table located at 4 cm above the 4 K plate and the thermal table and 7.5 cm height, respectively.

#### Transistor measurements







characterization.



Fig. 5 Measured Id-Vd ang Id-Vg curves obtained at 3.1 K from the P type FinFET teststructure, fabricated in a commercial 14 nm CMOS technology. A Vds correction was performed following a Kirchhoff analysis of the entire electrical system aiming at the compensation due to the manganin-wire series resistance, also described in [7].

### <u>Conclusions</u>

We have designed and integrated a 4 K closed-cycle cryogenic system which includes a <sup>3</sup>He fridge capable to reach 250 mK and prepared all the necessary instrumentation to do be able to perform CMOS technology characterization at sub-Kelvin temperatures. Initial measurements of FinFet transistors were performed and it was demonstrated that the system is promising for further studies of this and other technologies for novel applications such as quantum computing.

#### <u>Acknowledgements</u>

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