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Advanced **R**esearch on **C**ryogenic **T**echnologies for **I**nnovative **C**omputing

ARCTIC - Deliverable report

D2.3- Initial version of TCAD simulation deck for 28 nm FDSOI

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About ARCTIC

The rise of quantum technology has opened the eyes of the ICT industry with respect to cryogenics. It is considered an enabler bringing in quantum functionalities and enhanced system performance and we are observing a massive growth of cryogenics from coolers to cryogenic electronics and photonics. ARCTIC is a joint effort of top European RTOs, industrial fabrication facilities, and leading application partners (23 industrial among which 14 SMEs, 7 RTO, 6 academic), sharing the vision to take a joint EU step towards the era of cryogenic classical and quantum microsystems. We aim to close the gap between qubit research and interfacing control machinery, highly needed for scaled-up quantum systems. The main goal of ARCTIC is to develop scalable cryogenic ICT microsystems and control technology for quantum processors. The technologies developed will have applications in many fields from sensing to communication, leading to important cross-fertilization that will strengthen the forming European ecosystem on cryogenic classical and quantum microsystems. ARCTIC will advance semiconductor technologies and materials, and tailor these for QT requirements and cryogenic applications. Multi-scale physics and data-driven models, cryogenic PDK modelling, device characterization, circuit design activities will support the development of cryogenic microelectronics. We will develop quantum processor platforms and broaden the applicability of microelectronic devices and circuits for cryogenic operation by developing cryo-compatible ultra-low loss substrates and thin-films, microelectronic and photonic circuits, semiconductor packaging and heterogeneous-integration techniques and benchmark the developed technologies.

Scientific and Industrial ARCTIC-demonstrators and applications are driving our developments enabling the European industry to maintain and expand its leading edge in semiconductor components and processes and QT and strengthen sustainable manufacturing technologies

ARCTIC consortium members

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Publishable summary

TCAD is routinely employed in the development and path-finding of new technologies. However, while current TCAD solutions are mature for room temperature and above, the availability of tools for the simulation of cryogenic and quantum devices remains scattered.

As part of the ARCTIC project, Global TCAD Solutions will employ its simulation tools and capabilities to investigate the applicability and usability for the modelling ultra-cold devices. This report details a simulation deck designed to showcase the TCAD simulation of a 28 nm FD-SOI device in the cryogenic temperature regime. It includes both a highly customizable structure template and a simulation setup that demonstrate the configuration of a simulation of transfer characteristics utilizing the quasi-Fermi Transport (QFT) formalism – an alternative transport formalism to the standard drift-diffusion that is better suited to tackle the case of numerically challenging ultra-low carrier concentrations. These typically occur in wide band-gap systems, heavily depleted devices and at cryogenic temperatures as shown here. Furthermore, the inclusion of exponential band-tail states in a numerically accurate and efficient way is demonstrated.

This deliverable, which will be made available to project partners for internal use within the project, thus represents both a valuable output in and of itself – as it can be used to dissect and understand experimental measurements generated during the project – and serves as a demonstration of the typical cryo-simulation capabilities, that can then be leveraged by both the consortium and GTS's industry customers.

A second iteration of this deliverable is planned for M36 of this project and is aimed to include not just additional models (including field-activated dopants and an investigation of carrier mobility) but to be experimentally validated and to incorporate insights related to cryogenic defects and impurities generated during the on-going course of the project.