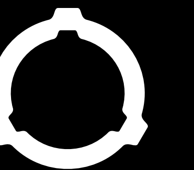
kiutra

APPLICATION NOTE | L-TYPE RAPID

I-V Characteristization



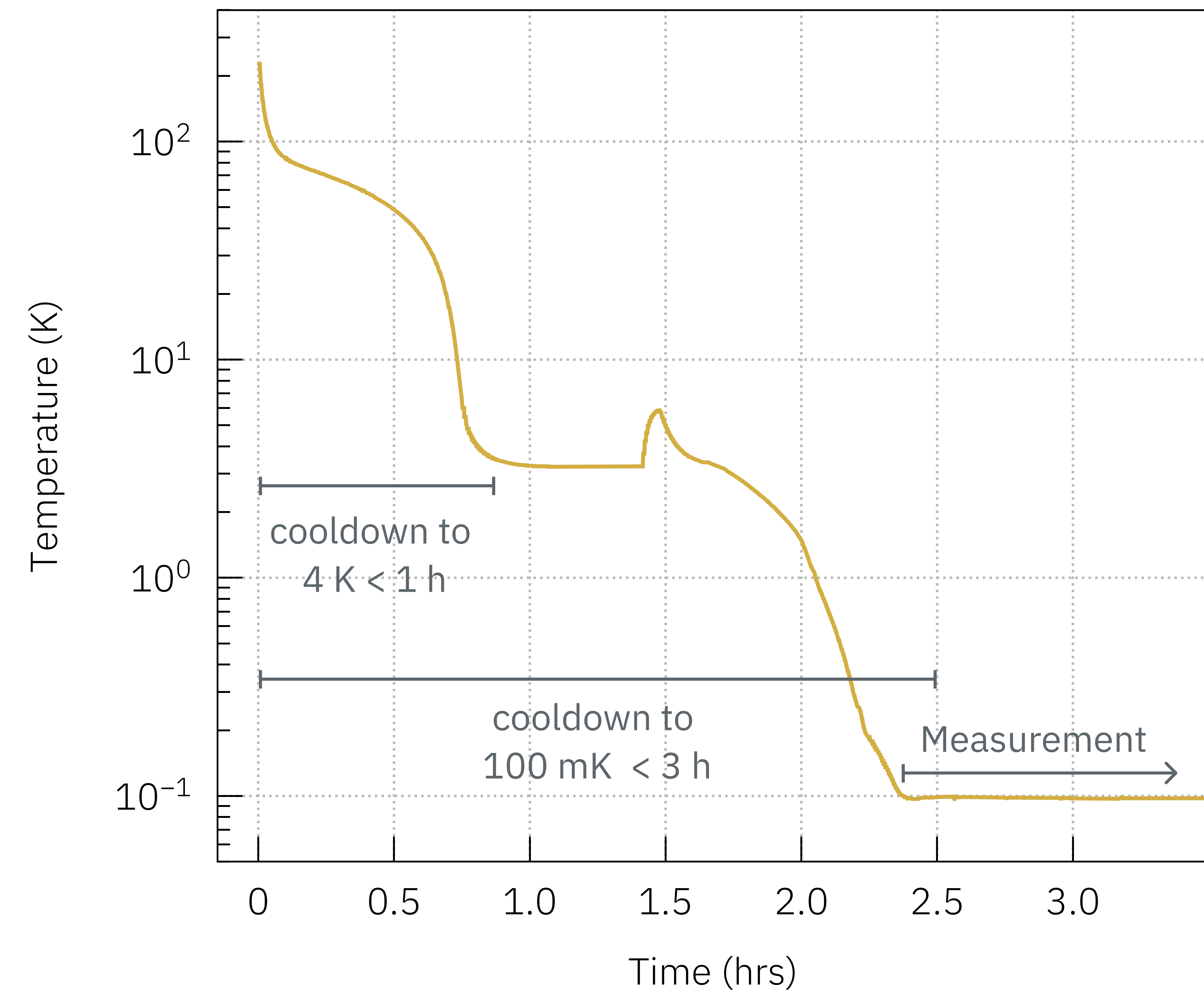
I-V characteristics at cryogenic temperatures

Electronic Devices for Quantum Technologies

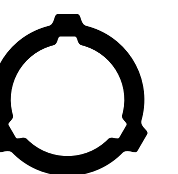
Examining I-V characteristics is a key metric in the design of new electronic devices and a standard methodology in modern semiconductor device fabrication. For the use of electronic devices in quantum technologies, the qualification and operation range needs to be extended to cryogenic temperatures. Such cryogenic measurements require expert knowledge and only allow for very limited throughput, making statistic data acquisition for modelling and verification very time consuming and cost intensive.

Fast Characterization with the L-Type Rapid

The L-Type Rapid cryostat is designed for the fast and automated characterization of material samples and quantum devices at cryogenic and mili-Kelvin temperatures. Using the automated loading process, it provides easy and fast access to cryogenic temperatures with a cooldown time of less than 1 hour to 4 K and less then 3 hours to 100 mK. Here, we demonstrate a measurement of the I-V characteristics of a common transistor at different temperatures between 4 K and 100 K and at different gate voltages.



Cooling curve of a sample puck from room temperature to sub-Kelvin operation. The fully automated loading and cooling processes take less than 3 hours.



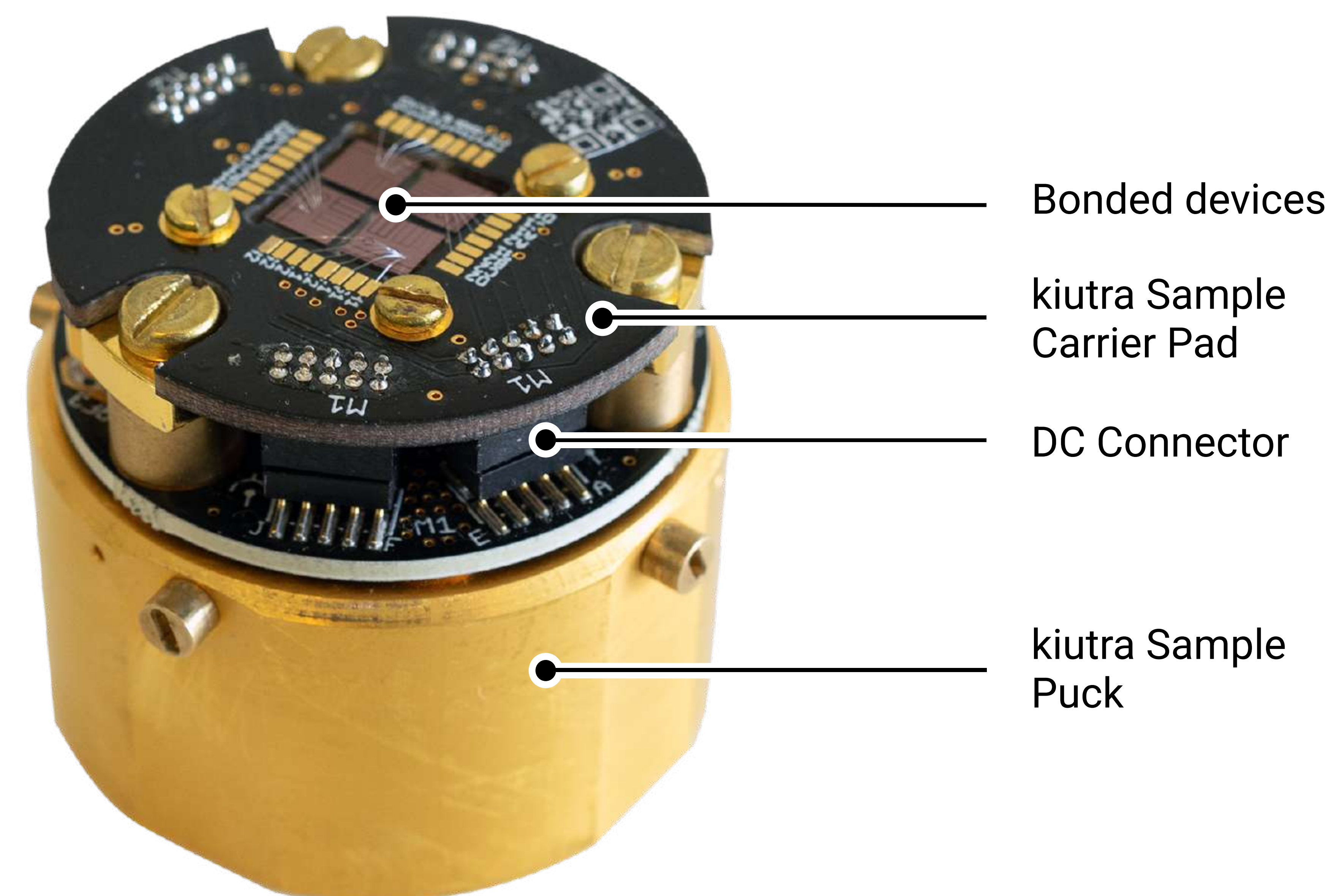
Sample Preparation

Easy-to-use puck based system

The L-Type Rapid works with an easy-to-use Puck system allowing for experiments to be prepared in advance while other measurements are running.

Devices can be bonded on a kiutra Sample Carrier Pad, a modular cryogenic sample holder. These Sample Carrier Pads are mounted onto the Puck with matching DC connectors. Using multiple pads, the operator can prepare large number of devices in advance. They can be stored ready to be loaded in the L-Type Rapid, minimizing the down time between measurements.

A Sample Puck Station can be used to check the connection at room temperature and ensure no time is wasted measuring faulty devices.



Multiple wire bonded devices on a standard kiutra Sample Carrier Pad 40.

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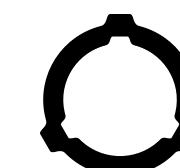


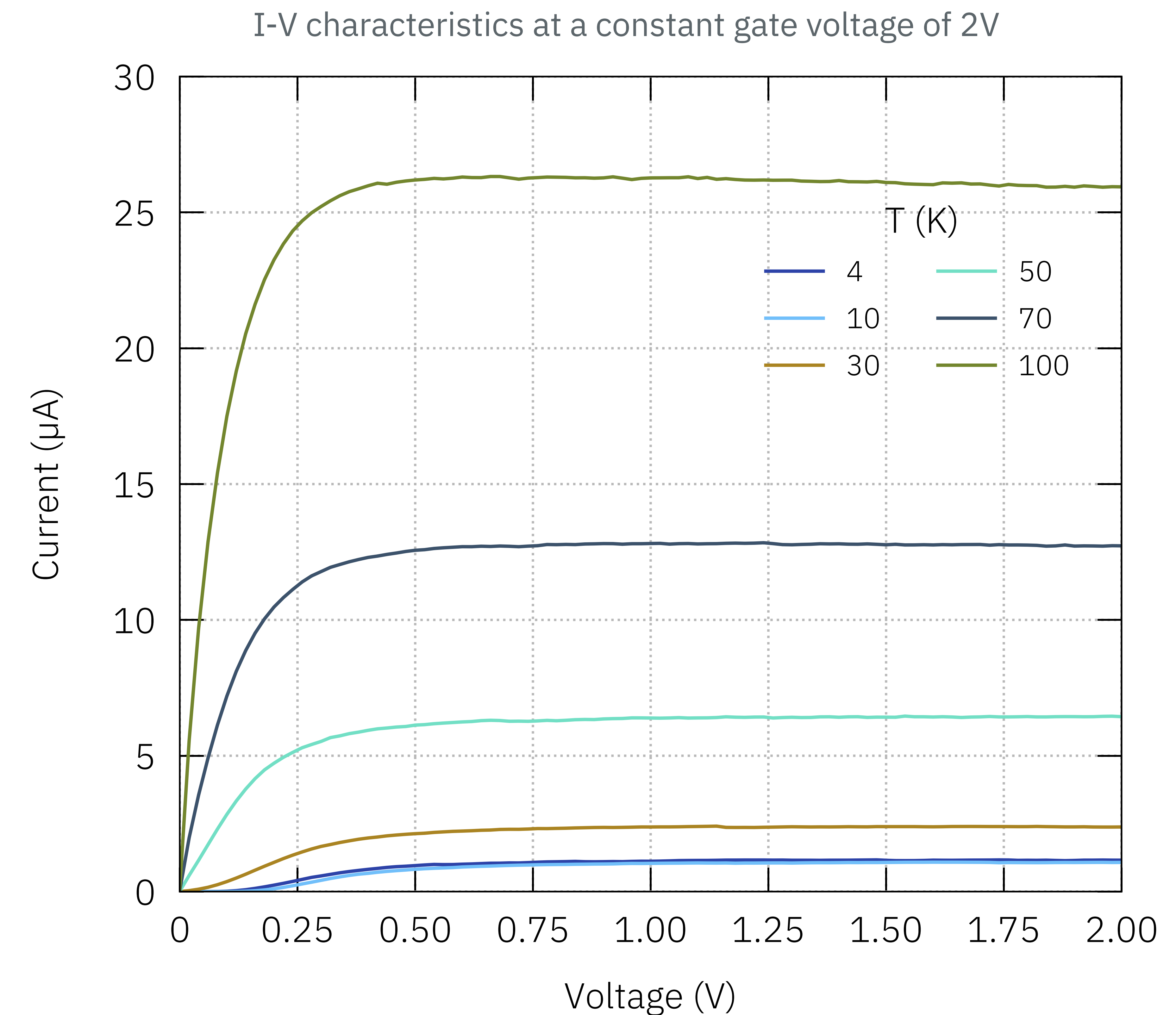
Measurement

Experimental Setup

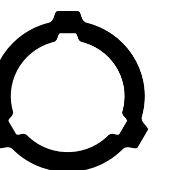
To record the I-V characteristics of this transistor, we used a kiutra L-Type Rapid fast characterization cryostat in combination with a 2-Channel Source Measure Unit (Keithley 2612B), used to generate the I-V curve, in combination with a QDevil QDAC-I multi channel high-precision voltage source for the application of varying gate and bias voltages.

Results

To collect the I-V curves, different temperatures between 4 K and 100 K were stabilized using the L-Type Rapid's automated temperature control. Subsequently the I-V curve for the source/drain path was collected using a four-point technique in a pulsed measurement by setting a voltage in increasing steps and measuring the current. This was repeated for various gate voltages to determine both IV and gate characteristics of the device. Typical I-V behavior of a transistor with decreasing saturation currents at decreasing temperatures was observed. The temperature dependence of the IV Curve for a specific gate voltage is shown in the figure on the right.



Temperature dependence of the I-V characteristics of a transistor measured using a pulsed voltage sweep from 0V - 2V and at a constant gate voltage of 2V.



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