

# Toolbox for Electrical Characterization of Graphene

**At RISE we combine our expertise in graphene and electrical metrology to offer reliable electrical characterization of graphene devices and materials.**

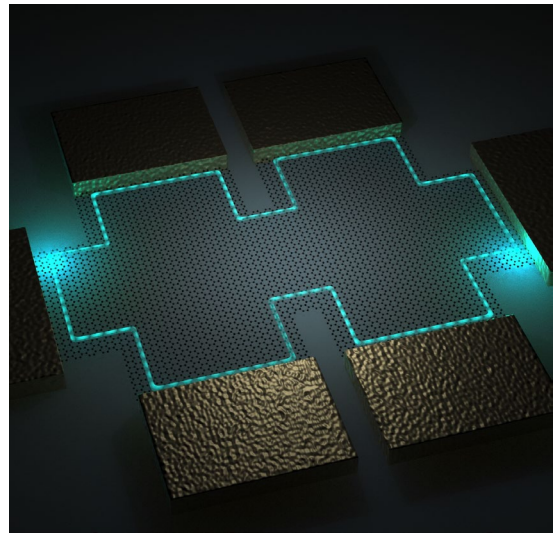
**We can help you accurately determine electrical quantities such as resistivity, carrier density, carrier mobility and more.**

To measure is to know! These famous words by Lord Kelvin encapsulate the importance of measurement science and metrology. In order to be able to verify the properties of a material, such as graphene, one must characterize it via measurements. As the national metrology institute of Sweden, we at RISE can offer accurate characterization of your material. We offer both standard measurement services, compatible with established industrial standards, and customized solutions.

## Our Characterization Methods

The table below shows our standard measurement offerings and the parameter space we work in. We can measure graphene devices with or without electrical contact pads.

If you require a more customized solution, please contact us and we can help you develop a suitable experiment in accordance with your needs.



An example of a graphene hall bar device with gold contact pads.

Method	Purpose	Environ.	Sample Size (mm)	Temp. (K)	Mag. Field (T)	Bias (A)	Rel. Error ( $k=2$ )	Misc. Info.	Standard
Quantum Hall Effect	Precision resistance measurements of quantized resistance.	Helium, low pressure or immersed in liquid	< 10x10	2 - 4.2	-12 - 12	$23 \times 10^{-6}$	$10^{-8}$		
Hall Effect	Sheet resistance, carrier density and mobility.	Helium, low pressure or immersed in liquid	< 10x10	2 - 300	-12 - 12	$< 10^{-2}$	0.05		IEC TS 62607-4-3
Hall Effect	Sheet resistance, carrier density and mobility.	Air	< 5x5	10 - 300	-2.5 - 2.5	$10^{-9}$ - $10^{-2}$	0.08		IEC TS 62607-4-3
Eddy Current	Conductivity. Completely contactless	Air	20x20 - 150x150	300	N/A	0	0.044	20 - $2 \times 10^5$ Hz	IEC TS 62607-6-9
General electrical characterization	Sheet resistance, I-V, C-V, van der Pauw	Purging with air and nitrogen	Few mm to 6 inch wafer	-65 - 150	N/A	$10^{-12}$ - $10^{-1}$	0.05		IEC TS 62607-4-3
4-point probe station	Sheet resistance.	Air	Length min: 4 Width max: 60 Diameter: 4 - 76.2 Thickness: < 10	300	N/A	$10^{-3}$ - $10^{-3}$	0.05	Probe Spacing = 1.27 mm	IEC TS 62607-4-3
Photovoltaic external/internal quantum efficiency measurements	Determine EQE/IPCE, IQE, Reflectance, transmittance	Air	From few mm up to 2 inch wafer	15-65 C	N/A	N/A	0.1	Source: 75W Xenon and 100 W Quartz halogen	