

GRACE NEWSLETTER

EMPIR | 16NRM01 | GRACE

Latest Highlights

New Paper on Scientific Reports

"Towards standardisation of contact and contactless electrical measurements of CVD graphene at the macro-, micro- and nano-scale"

In this paper we demonstrate a comprehensive methodology for the electrical characterization of graphene that covers the nano-, micro- and macro-scale. The results show strong agreement between the different characterisation methods, suggesting that standardised electrical measurements for large area graphene are feasible [1].

The Consortium

Partners:

INRIM, NPL, UoM, CEM, Graphenea, das-Nano, VDE, ISC.

Collaborators:

Politecnico di Torino

Stakeholders:

(new entries)

NIST (US), LNE (FR), FORTH (GR), Universidad de Salamanca (ES), Graphene-Xt (IT), Hellenic Metrology Institute (GR), Institute of Nanoscience and Nanotechnology "Demokritos" (GR), [University of Aveiro \(PT\)](#), [IMDEA Nanociencia \(ES\)](#).

Are you a potential GRACE stakeholder? [Join us!](#)



Developing electrical characterisation methods for future graphene electronics

Good Practice Guides on the electrical characterization of graphene published soon

Two open access Good Practice Guides, almost ready to be released, will be published by the GRACE consortium in a few weeks. They are respectively entitled:

- Good Practice Guide on the electrical characterisation of graphene using contact methods.
- Good Practice Guide on the electrical characterisation of graphene using non-contact and high-throughput methods.

These guides will provide protocols for determining the electrical properties of graphene sheets on insulating substrates using contact and non-contact methods

contact	non-contact
in-line four point probe	Scanning Kelvin Probe
van der Pauw method	Microwave Resonator
Electrical Resistance Tomography	Time-Domain THz Spectroscopy
CoPlanar Waveguides	

Fig. 1 - Electrical characterisation methods investigated by GRACE

Depending on the methodology the properties that can be measured are the electrical sheet resistance, the concentration and mobility of charge carriers. Each chapter will give advice to understand the measurement principle, how to implement it to perform reliable measurements traceable to the International System of Units, and hints to express the corresponding measurement uncertainty.

The GPGs will be available on the GRACE website by April 2020

<http://empir.npl.co.uk/grace/>



Upcoming Events

Final Project Meeting:

UPDATE (March 24): due to the covid-19 outbreak the GRACE final meeting (June 2020) will be organised in streaming.

Possibly the scientific part of it will be open to public.

More detail will follow on the project website!

The GRACE Project

The **GRACE project**, now at month 31 of its span, is developing accurate and reproducible electrical characterisation methods suitable for graphene, both as test samples and in production lines developing measurement protocols and good practice guides.

Past Newsletter Issues

Find the past issues here:
<http://empir.npl.co.uk/grace/news-and-events/>

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D5 deliverable done: Comparison Report

The project deliverable *D5* has been submitted to MSU. The comparison report correlates several of the characterisation methods investigated by the project consortium.

A subset of the samples from the batch characterised during the project GRACE have been measured by several partners, in both research labs and industrial environment.

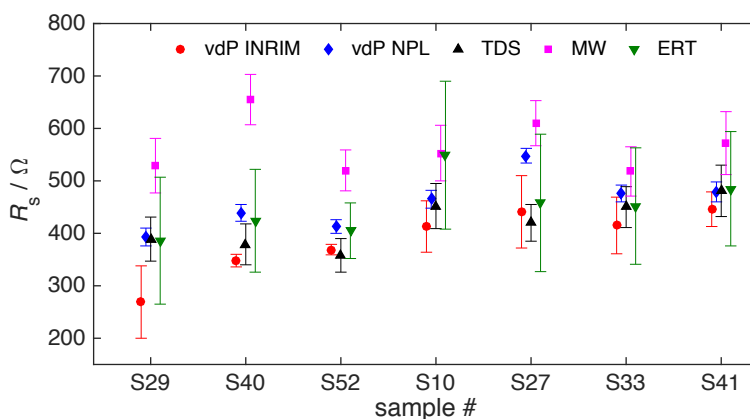


Fig. 2 - Sheet Resistance R_s of several graphene samples measured with different techniques.

The quantity used for this comparison is the sheet resistance R_s , which is estimated from each technique according to its measurement principle.

The samples were measured in a quite long time span, from Oct. 2017 to Jan. 2020. The correlation of the results reported in Fig. 2 is substantial, and almost all values reported are compatible within the measurement uncertainty. This can be considered a very positive outcome of the research carried out during the course of the project, since gives support to the measurement protocols defined and tailored for graphene within GRACE, protocols that will be described in the upcoming GPGs.

References:

[1] Melios, Christos, et al. "Towards standardisation of contact and contactless electrical measurements of CVD graphene at the macro-, micro-and nano-scale." *Scientific Reports* 10.1 (2020): 1-11.

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