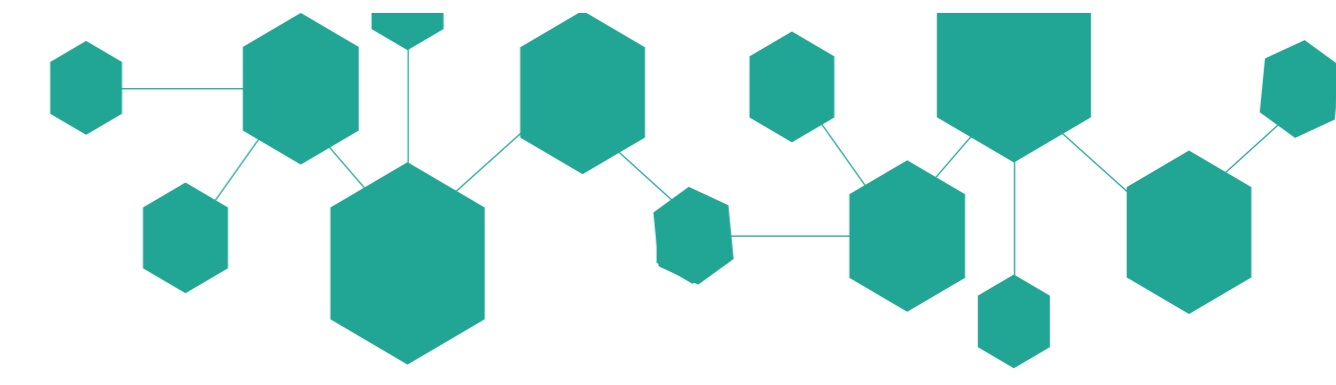




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# Graphene Industrial Forum & 2DM 2020



## EMPIR GRACE - Good Practice Guides on the electrical characterisation of graphene using contact- and non-contact methods

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### EMPIR 16NRM01 GRACE: NEED FOR THE PROJECT

The project “GRACE --- Developing electrical characterisation methods for future graphene electronics”, will deliver **novel metrology** for electrical characterisation of graphene to enable standardized measurements of future graphene-based electronics. The adoption of **graphene as an electronic industrial product** is currently limited by the inability to grow large areas of high-quality graphene with uniform and reproducible electric and electronic properties. Therefore, **accurate characterisation methods adapted to the 2D nature of graphene**, both as test samples and in production lines, are presently underdeveloped.

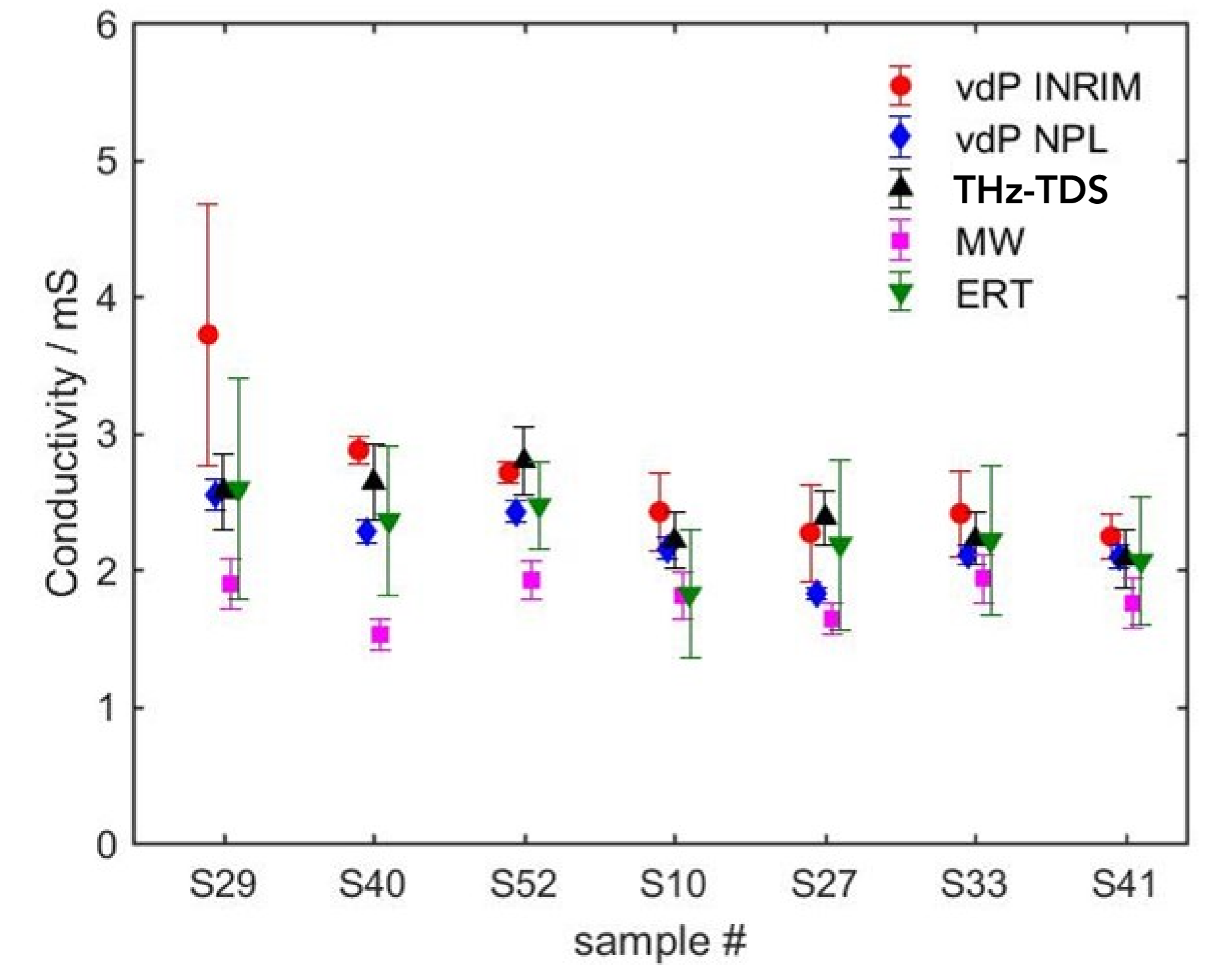
### THE PARTNERS



### INVESTIGATED METHODS

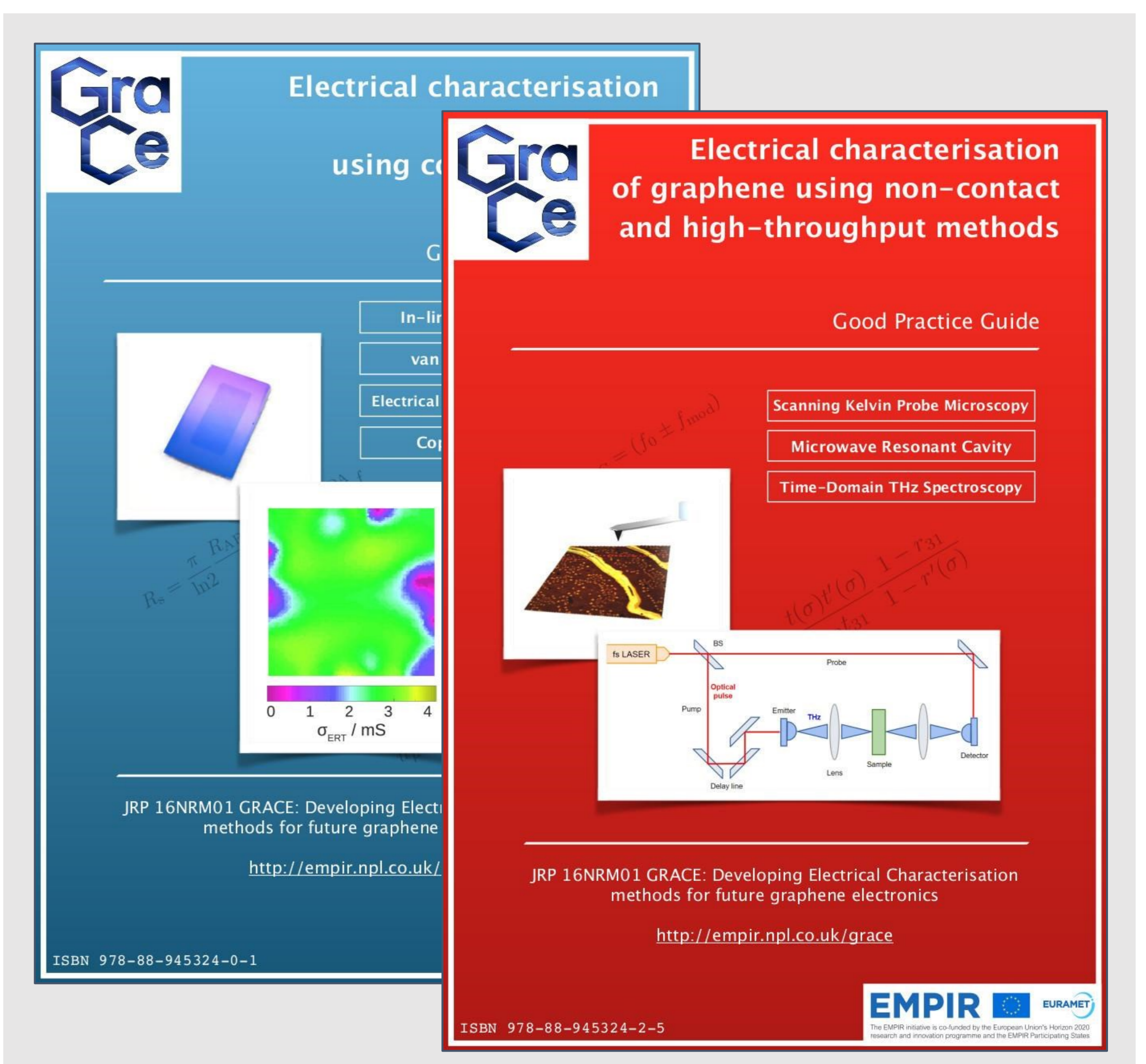
contact	non-contact
Four in-line Point Probe (4PP)	Scanning Kelvin Probe Microscopy (SKPM)
van der Pauw (vdP)	Microwave Resonator (MW)
Electrical Resistance Tomography (ERT)	THz Time-Domain Spectroscopy (THz-TDS)
Coplanar Waveguide (CPW)	

### INTER-LABORATORY COMPARISON



**Inter-laboratory comparison** of the measurement of the conductivity of a set of seven CVD graphene samples on quartz substrate, cut from the same wafer. The value of the conductivity measured with the different methods are strongly correlated. The different numerical values measured are due to the fact that actually each technique has a different “measurand”. The correct expression of uncertainty for each method is mandatory to assess the compatibility of the results.

### GOOD PRACTICE GUIDES



**Electrical characterisation of graphene** can be approached using methods already employed for thin film materials. The extraordinary thinness of graphene makes the proper application of established methods difficult. These GPGs [1,2] contribute to reliable and comparable specifications of graphene as an industrial product.

Available online at: [www. http://empir.npl.co.uk/grace/](http://empir.npl.co.uk/grace/)

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### CONTACT PERSON

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### REFERENCES

- [1] 16NRM01 EMPIR GRACE consortium, “Good Practice Guide on the electrical characterisation of graphene using contact methods”, 2020, Edited by A. Fabricius, A. Catanzaro and A. Cultrera, ISBN: 978-88-945324-0-1.
- [2] 16NRM01 EMPIR GRACE consortium, “Good Practice Guide on the electrical characterisation of graphene using noncontact and high throughput methods”, 2020, Edited by A. Fabricius, A. Cultrera and A. Catanzaro, ISBN: 978-88-945324-2-5.

