8th edition of the largest European Conference & Exhibition in Graphene and 2D Materials

Graphene 2018
June 26 - 29
Dresden (Germany)

Developing **future** technical standards for the **metrology** of electrical properties of **graphene**

A. Cultrera[1], L. Callegaro, C. Cassiago, V. D'Elia, D. Serazio, M. Ortolano, M. Marzano, O. Kazakova, C. Melios, F. Raso, L. Matías, A. Zurutuza, A. Centeno, O. Txoperena, A. Redo-Sanchez, A. Kretinin, K. Sann-Ferro, A. Fabricius, G. Weking, W. Bergholz, N. Fabricius.

[1]INRIM - Istituto Nazionale di Ricerca Metrologica, Turin - Italy

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

GraCe

Developing electrical characterisation methods for future graphene electronics

Main Objectives

Validated Protocols for electrical characterization of graphene

Good Practice Guides

Technical Specification drafts to International Electrotechnical Commission

GRACE

PARTNERS

EMPIR EURAMET

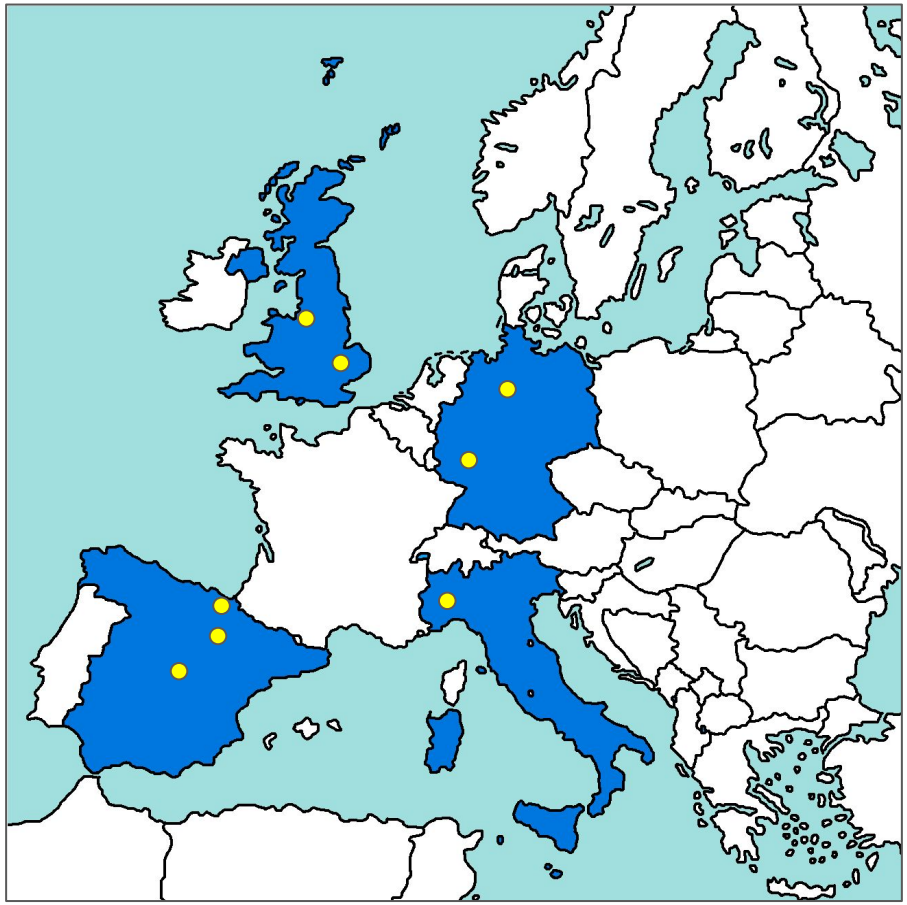
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA
Italian Metrology Institute

NPL National Physical Laboratory
British Metrology Institute

CEM CENTRO ESPAÑOL DE METROLOGÍA
Spanish Metrology Institute

MANCHESTER 1824 The University of Manchester
British National Graphene Institute



- 36 months project started in mid 2017
- Budget 600 k€

Graphenea
Graphene production

das·NANO
Terahertz spectroscopy

VDE
Standardization

ISC
Standardization

EMPIR

The European Metrology Programme for Innovation and Research, part of Horizon 2020, the EU Framework Programme for Research and Innovation.

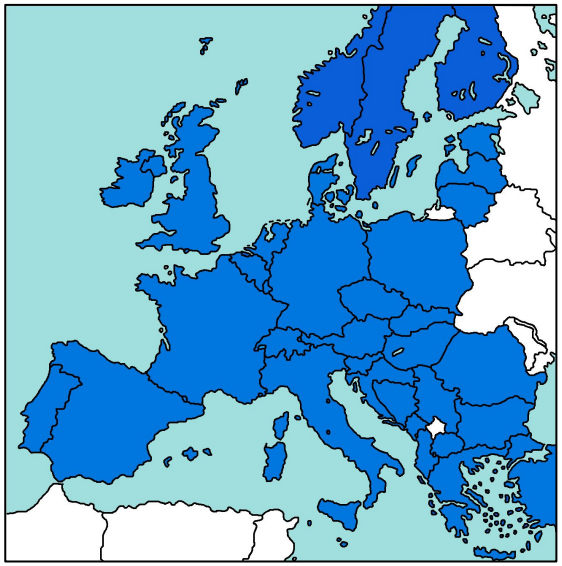
EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

- EMPIR calls, launched between 2014 and 2020
- Total budget 600 M€
- Article 185 of the European Treaty

EMPIR Targeted Programs

HEALTH
ENERGY
ENVIRONMENT
INDUSTRY
STANDARDISATION
FUNDAMENTAL METROLOGY
CAPACITY BUILDING
DISSEMINATION



EURAMET

EUROPEAN ASSOCIATION OF NATIONAL METROLOGY INSTITUTES

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IN SUMMARY

Large area
Industrial graphene

Contact methods

Non-contact methods

Validated and traceable protocols for the measurement of sheet resistance, carrier mobility and concentration, work function.

International Electrotechnical Commission

Technical Specifications drafts to IEC

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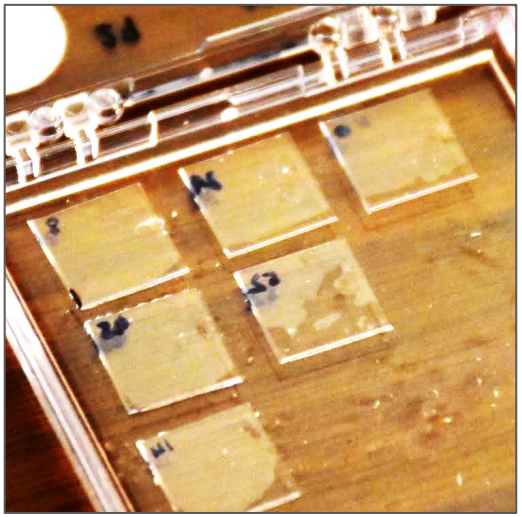
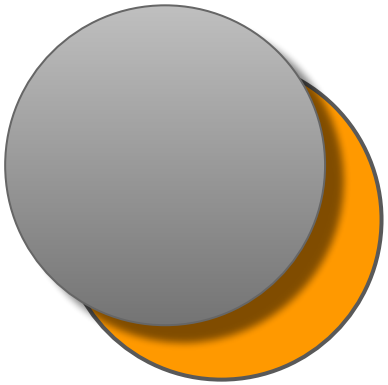
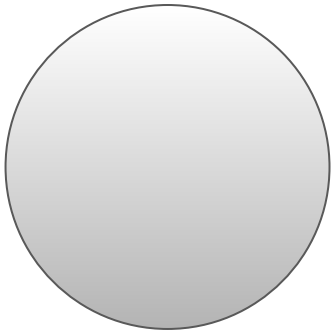
SAMPLES



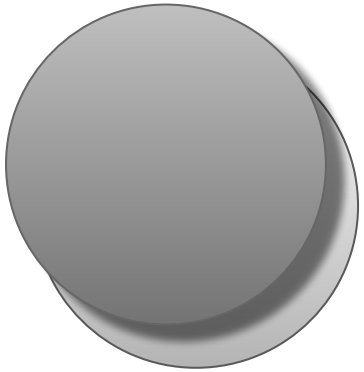
diced samples



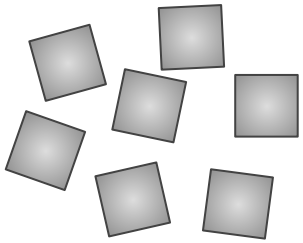
CVD graphene
grown on copper



quartz wafer



graphene transferred
on quartz



diced samples
1 cm x 1 cm

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METHODS

Samples will circulate among the partners for multiple characterisation

Chemical Vapour Deposited graphene

contact methods

- in-line four-contact probe
- van der Pauw method
- Electrical Resistance Tomography
- CoPlanar Waveguides

non- contact methods

- Scanning Kelvin Probe Microscopy
- Microwave Resonant Cavity — **fast throughput**
- Time Domain terahertz Spectroscopy — **fast throughput**

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METHODS

Preliminary results

Chemical Vapour Deposited graphene

contact methods

- in-line four-contact probe
- **van der Pauw method**
- **Electrical Resistance Tomography [1]**
- CoPlanar Waveguides

non- contact methods

- Scanning Kelvin Probe Microscopy
- Microwave Resonant Cavity
- **Time Domain terahertz Spectroscopy**

fast throughput

fast throughput

[1] A. Cultrera, L. Callegaro, *IEEE Trans. Instrum. Meas.*, 65 (9), 2101-2107, 2016

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SUMMARY, WORK IN PROGRESS and FUTURE WORK

- Preliminary results show good match between very different methods 
- Other available methods, measurements still ongoing 

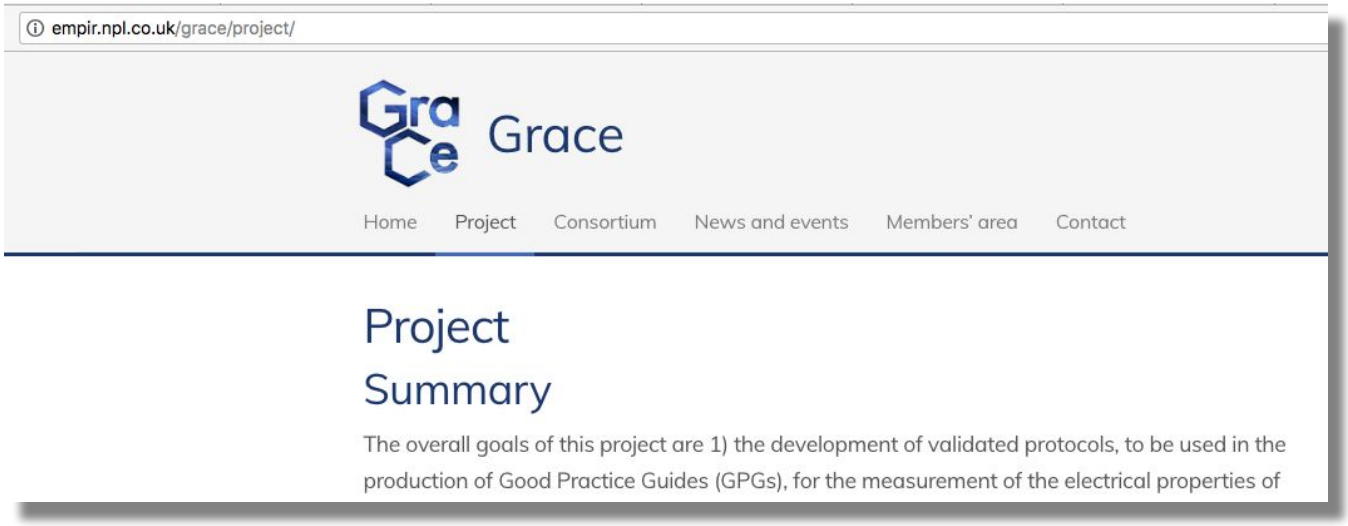
- Future work: new tests on different substrates, production-line testing of fast throughput methods, uncertainty expression 

- IEC will receive technical specifications drafts from the partners 

Developing electrical characterisation methods for future graphene electronics

Find more info and the **publishable summary** at:

http://empir.npl.co.uk/grace/project



Interested in joining as stakeholder/collaborator ?
Mail to < a.cultrera@inrim.it >

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