GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

Towards the Standardization of Graphene: The Project GRACE

F. Raso

CEM CENTRO ESPAÑOL DE METROLOGÍA

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EMPIR Program

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 is the main programme for European research on metrology. It coordinates research projects to address grand challenges, while supporting and developing the SI system of measurement units.

EMPIR follows on from the successful European Metrology Research Programme (EMRP), which issued its final call for projects in 2013. There is an increased focus within EMPIR on innovation activities to target the needs of industry and accelerate the uptake of research outputs.

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16NRM01 GRACE

Developing electrical characterisation methods for future graphene electronics

EMPIR EURAMET

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Normative ranked list			
1	16NRM01	JRP-n07	GRACE
2	16NRM02	JRP-n05	SURFACE
2	16NRM03	JRP-n03	RTNORM
2	16NRM04	JRP-n02	MagNaStand
5	16NRM05	JRP-n11	Ion gauge
6	16NRM06	JRP-n08	EMIRIM
7	16NRM07	JRP-n14	Vector SAR
8	16NRM08	JRP-n01	BRDF
9		JRP-n04	GRTn04
10		JRP-n12	TrafoLoss
11		JRP-n09	MeterEMI
12		JRP-n15	ISOWetGas
13		JRP-n13	prEN HTGHP
14		JRP-n06	NATIVE

Objectives

1. To develop an accurate and traceable approach for the electrical characterisation of graphene through the development and comparison of different methodologies for both contact measurement and non-contact electrical measurement of its properties, with traceability to the electrical SI units. This will include the improvement of established techniques as well as the development of new methods.

2. To develop a high-throughput approach for the electrical characterisation of graphene, with the development of novel methodologies for non-contact electrical characterisations and their validation with established techniques.

Objectives

3. To disseminate the metrology and methodologies established in this project in the form of Good Practice Guides (GPGs) and input to documentary standards.

4. To contribute to the standards development work of the technical committees of IEC/TC113 and CENELEC WS SGRM, through the initiation of and development of new written standards for the electrical characterisation of graphene based on the GPGs developed within the project.

Consortium

•no.	•Participant Type	•Short Name	•Organisation legal full name	•Country
•1	•Internal Funded Partner	•INRIM	•Istituto Nazionale di Ricerca Metrologica	•Italy
•2	•Internal Funded Partner	•CEM	•Centro Español de Metrología	•Spain
•3	•Internal Funded Partner	•NPL	•NPL Management Limited	•United Kingdom
•4	•External Funded Partner	•das-Nano	•das-Nano S.L.	•Spain
•5	•External Funded Partner	•Graphenea	•Graphenea S.A.	•Spain
•6	•External Funded Partner	•ISC	•ISC International Standards Consulting GmbH & Co. KG	•Germany
•7	•External Funded Partner	•UoM	•The University of Manchester	•United Kingdom
•8	•External Funded Partner	•VDE	•VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V.	•Germany

Consortium

Multidisciplinar consortium, with partners specialized in different fields

- 3 National Institutes of Metrology (INRIM, NPL and CEM): high accuracy measurements
- 1 Industrial partner(Graphenea)
- 1 Manufacturer of THz instrumentation (Das-Nano)
- 1 University, doing both research and manufacturing in graphene (UoM)
- 2 Entities working in Standarization (ISC and VDE)

Consortium

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

CEM CENTRO ESPAÑOL DE METROLOGÍA

NPL National Physical Laboratory

das·nano

Graphenea

ISC

MANCHESTER 1824 The University of Manchester

VDE

Work Packages

WP Nº	Work Package Title	Active Partners (WP leader in bold)
WP1	Traceable methods for the electrical characterisation of graphene properties	**INRIM**, CEM, NPL, Graphenea, UoM
WP2	High-throughput electrical characterisation of graphene properties	**NPL**, INRIM, CEM, das-Nano, Graphenea
WP3	Creating impact	**NPL**, all partners
WP4	Management and coordination	**INRIM**, all partners

WP1:**Traceable** methods for the electrical characterisation of graphene properties

- **Metrological Traceability**:

Property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

International Vocabulary of Basic and General Terms in Metrology (VIM)

WP1: **Traceable** methods for the electrical characterisation of graphene properties

- Task 1.1: Graphene sample preparation
- Task 1.2: Contact methods for the characterisation of graphene (van der Paaw, four probes in-line, ERT, CPW measurements)
- Task 1.3: Traceable non-contact methods for the characterisation of graphene (SPM methods and mw resonance technique)

WP2: High-throughput electrical characterisations of graphene properties

- Task 2.1: Development of high-throughput electrical characterisation methods (application in our industrial partner Graphenea)
- Task 2.2: Validation of electrical characterisation methods (interlaboratory comparison, comparison of traceable and high throughput methods)

WP3: Creating impact

- Task 3.1: Good practice guides (one for traceable methods and another for high throughput methods)
- Task 3.2: Knowledge transfer
- Task 3.3: Training (two workshops, organized by NPL and VDE for discussion of GPG's)
- Task 3.4 Uptake and exploitation

WP3: Creating impact

Task 3.2: Knowledge transfer

- Website: http://empir.npl.co.uk/grace/
- Papers to high impact peer-reviewed scientific journals
- Presentations in conferences
- Stakeholders Committe (Is there somebody interested?)
-

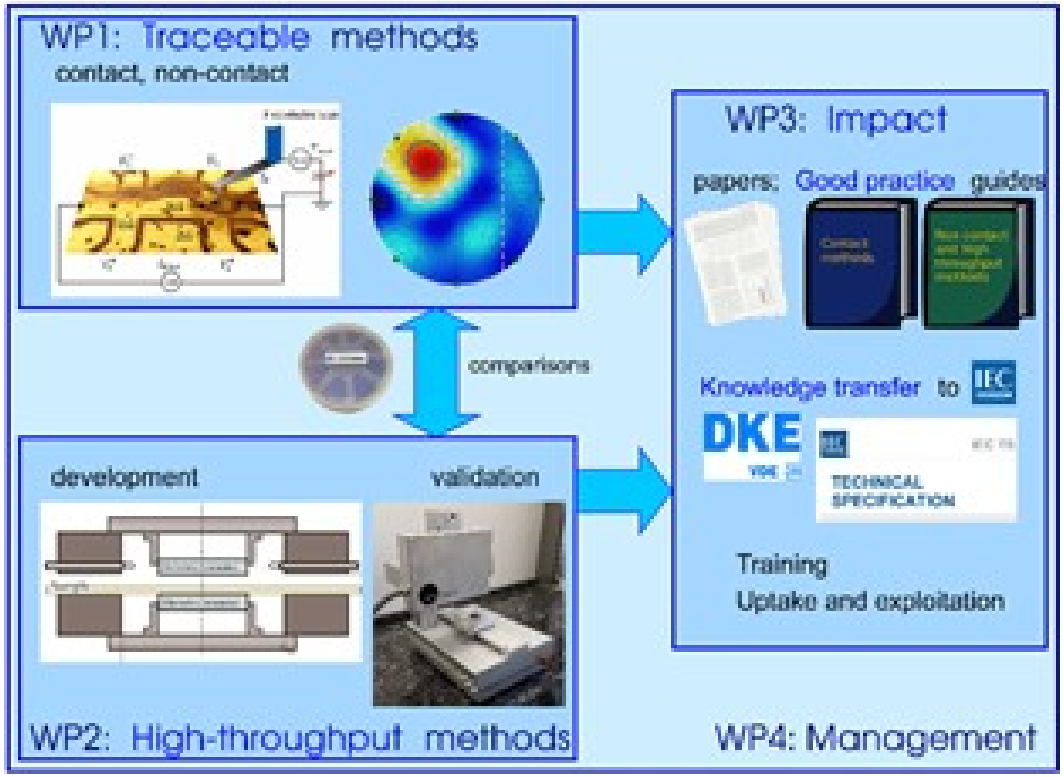
WP3: Creating impact

Task 3.2: Knowledge transfer

- Information to Standardization Committees and Workgroups, for instance IEC TC113 and TC119 and CENELEC WS SGRM
- Elaboration of one documents suitable as working drafts for new technical specifications for contact methods and another one for non contact and high throughput methods, both submitted to IEC TC113 by VDE

Work Packages

The relationship between the four packages of the project



Thank you for your attention