

ESF Flag-ERA WS

Patrik Johansson

Graphene Flagship Vice-Director
Chalmers University of Technology
Gothenburg, Sweden

16 March 2021

graphene-flagship.eu



Funded by
the European Union



**GRAPHENE
FLAGSHIP**

1 B€ & 10 years

FET Flagships

“FET Flagships are ambitious large-scale, science-driven, research initiatives that aim to achieve a visionary goal.

The scientific advance should provide a strong and broad basis for future technological innovation and economic exploitation in a variety of areas, as well as novel benefits for society.”

Graphene Flagship – the mission

*“To take **graphene and related layered materials** from a state of raw potential to a point where they can revolutionize multiple industries. This will bring a new dimension to future technology – a faster, thinner, stronger, flexible, and broadband revolution. Our program will put **Europe** firmly at the heart of the process, with a manifold return on the EU investment, both in terms of **technological innovation and economic growth.**”*



Launch of the Graphene Flagship by Commissioner Neelie Kroes, 2013



EC Executive VP Margarethe Vestager (2020):
“the Graphene Flagship is money well spent”



Funded by
the European Union

Flagship structure

Ramp-up phase,
74-142 partners, 2013-2016

Partner
Associated member

Core Project 1
156 partners
'16-18

Core Project 2
155 partners
'18-20

Core Projects 3
≈ 170 partners
'20-23

2D-EPL
11 partners '20-24

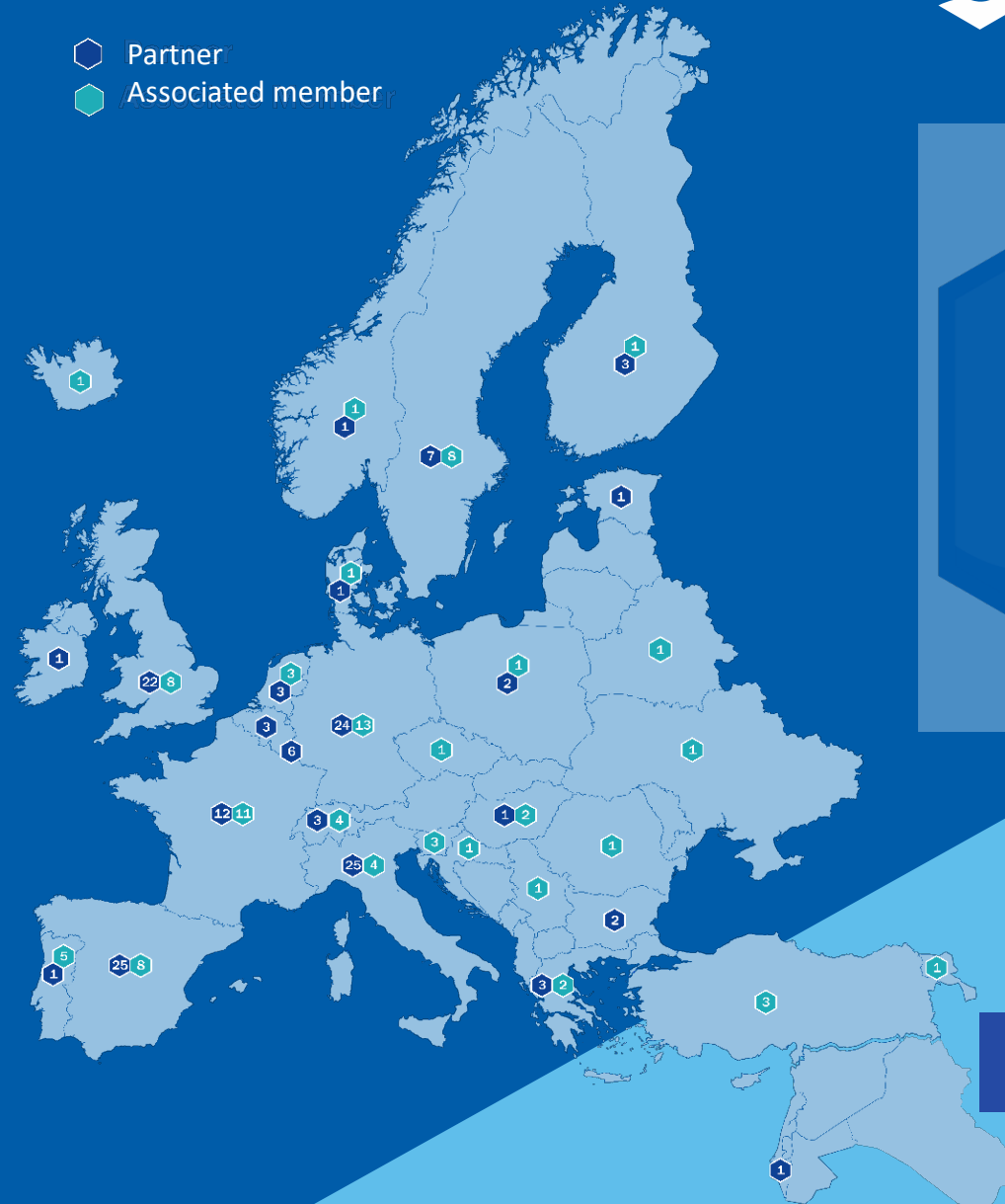
National
projects

FLAG-ERA

Regional
projects

Other EU
projects

Horizon Europe 2023-
Details still unknown



Funded by
the European Union

Flagship consortium



Type of organisation



- Enterprise
- Research organisation
- Non for profit
- SME
- Education establishment

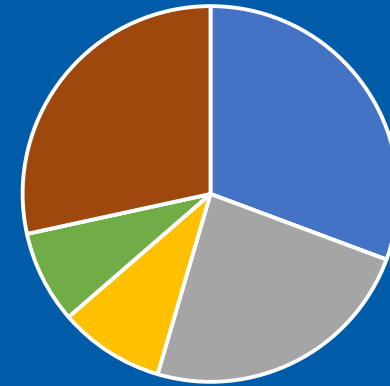
Today an even split between commercial partners and academic/research organizations

In addition:

- 36 Partnering Projects
- 101 Associated Members from 26 countries

Entry year

- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020



Demonstrated great ability for renewal:
- 28% of partners joined 2020
- Only 31% involved since the start



Funded by
the European Union

Results in numbers

- By May 2020 unless otherwise stated
- Full records of 2020 are being collected

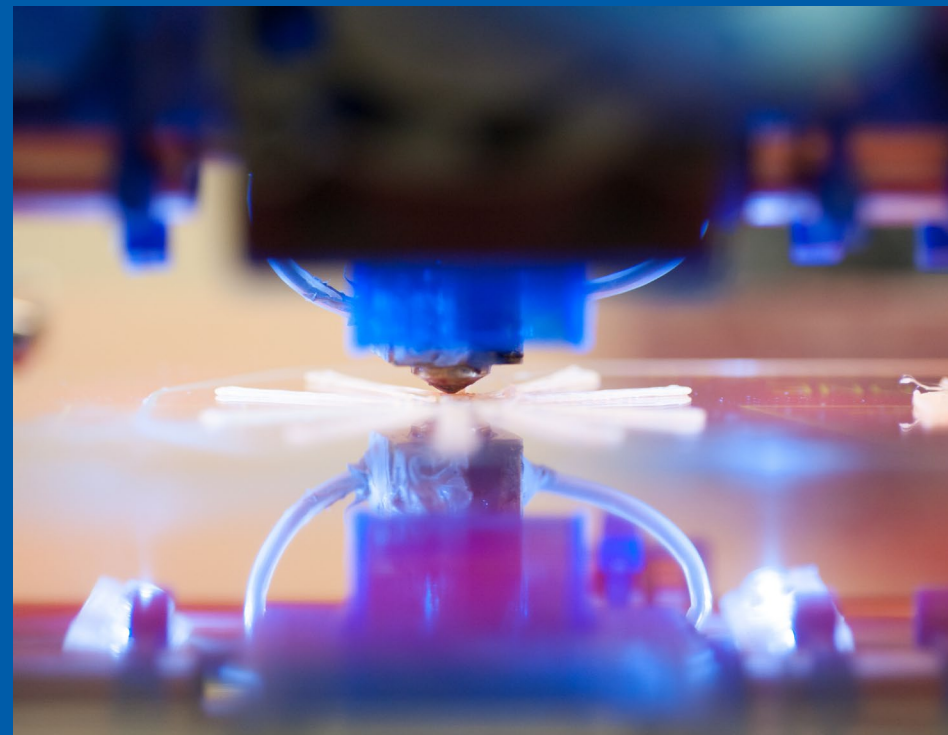
KPI	Realized since 2013
Publications (WoS 12 March 2021)	4,037
Citations (WoS 12 March 2021)	148,305
Patent applications	272
Patents	34
Prototypes	250
Products on market	76
Spin-offs established	15



Core 3

Fundamental research continues, but increased focus on commercially motivated innovative research => Boost graphene-enabled technologies to higher TRLs.

-
- 11 industry-led Spearhead Projects (30%)
 - Broad applied research (45%)
 - Basic research (15%)
 - Support services (innovation, industrialisation, dissemination and management) (10%)
-



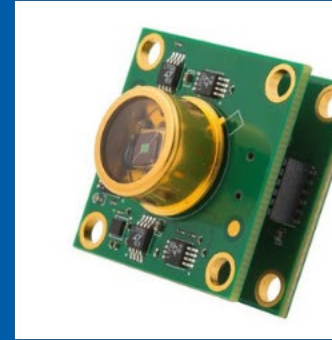
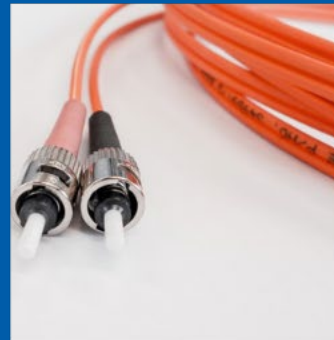
Spearhead Projects

- Several application areas
- New/improved products w. graphene/layered materials.
- Goal = maximise the impact of the Graphene Flagship in the innovation ecosystem and the European economy.



Spearhead application areas

Environment
Photonics
Energy generation
Aerospace
Automotive
Electronics



Flagship today: Core 3 & 2D-EPL (EC funded)



**GRAPHENE
FLAGSHIP**

Core 3

Core 3: 150 M€ from 1 Apr 2020 – 30 Sep 2023 (3.5 years)

**High TRL
30%**

Water filters (Medica SpA)
Car dashboard (FIAT Chrysler)
Circuit breaker (ABB)
Optical transmitter/receiver (Nokia)
Tandem solar cells (ENEL Green Power)
Aircraft cabin filter system (Lufthansa Technik)
Infrared imager (Emberion)
Automotive vision system (ICFO/Quv)
Batteries for Automotive (Varta)
Aircraft ice protection system (Airbus)
Regulatory, risk assessment, toxicology, environment (EMPA)

**2D-EPL: 20 M€
1 Oct 2020 – 30 Sep 2024 (4 years)**

To advance commercialisation

Wafer-Scale Growth
Wafer-Scale Transfer
Wafer-Scale Integration
Modules for the Industry
2D Pilot Line
Management

**Applied
Research
45%**

Health & Environment / Biomedical Technologies / Sensors
Electronic Devices / Photonics and Optoelectronics / Flexible Electronics /
Wafer-scale Integration
Energy Generation / Energy Storage / Environmental Foams & Coatings /
Composites / Production

**Basic Research
14%**

Enabling Science / Spintronics / Enabling Materials

**Admin & services
11%**

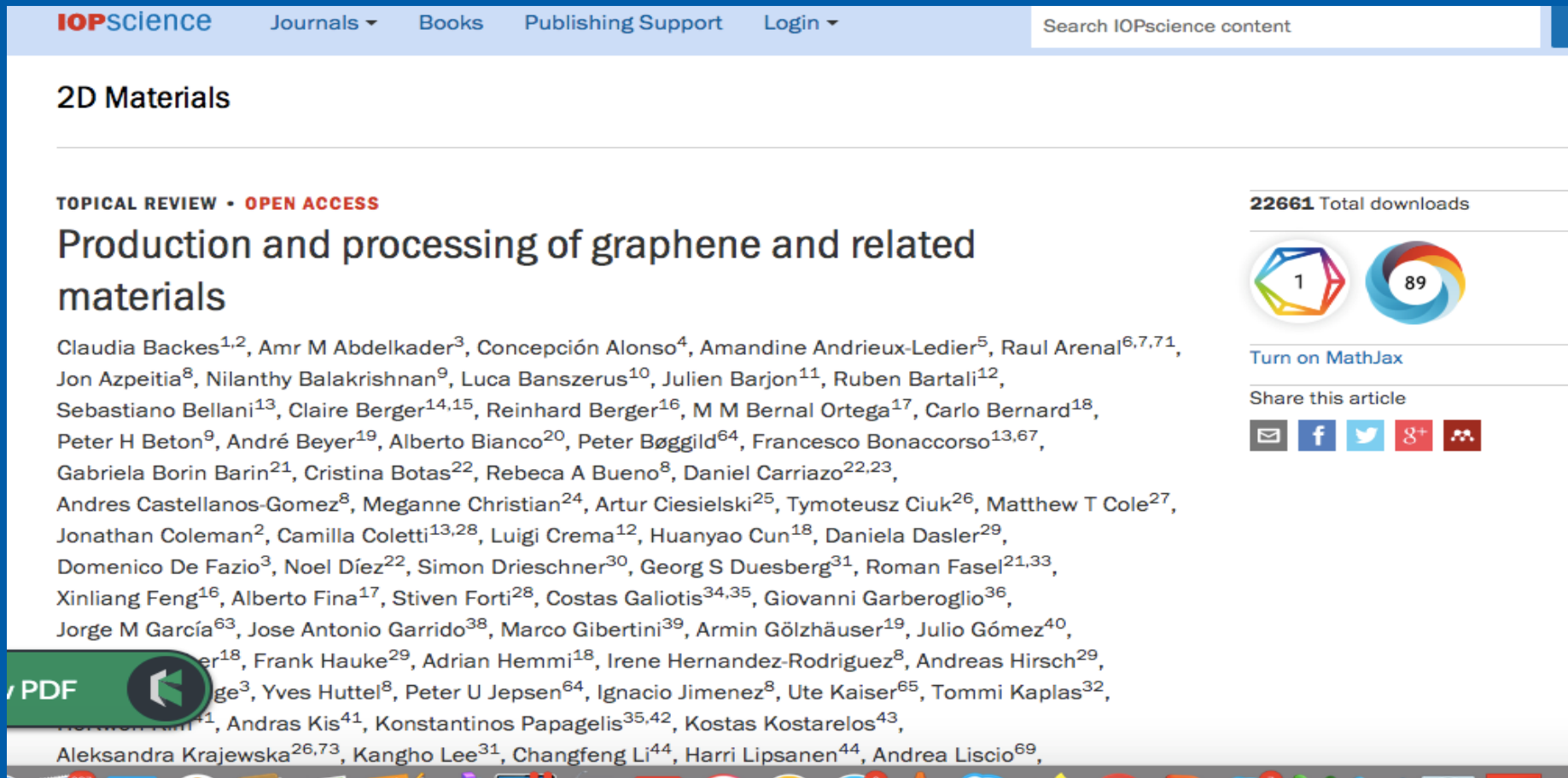
Innovation / Dissemination / Management / Industrialisation



Funded by
the European Union

Some highlights

Authoritative white-paper on 2D materials



IOPscience Journals Books Publishing Support Login Search IOPscience content

2D Materials

TOPICAL REVIEW • OPEN ACCESS

Production and processing of graphene and related materials

Claudia Backes^{1,2}, Amr M Abdelkader³, Concepción Alonso⁴, Amandine Andrieux-Ledier⁵, Raul Arenal^{6,7,71}, Jon Azpeitia⁸, Nilanthy Balakrishnan⁹, Luca Banszerus¹⁰, Julien Barjon¹¹, Ruben Bartali¹², Sebastiano Bellani¹³, Claire Berger^{14,15}, Reinhard Berger¹⁶, M M Bernal Ortega¹⁷, Carlo Bernard¹⁸, Peter H Beton⁹, André Beyer¹⁹, Alberto Bianco²⁰, Peter Bøggild⁶⁴, Francesco Bonaccorso^{13,67}, Gabriela Borin Barin²¹, Cristina Botas²², Rebeca A Bueno⁸, Daniel Carriazo^{22,23}, Andres Castellanos-Gomez⁸, Meganne Christian²⁴, Artur Ciesielski²⁵, Tymoteusz Ciuk²⁶, Matthew T Cole²⁷, Jonathan Coleman², Camilla Coletti^{13,28}, Luigi Crema¹², Huanyao Cun¹⁸, Daniela Dasler²⁹, Domenico De Fazio³, Noel Díez²², Simon Drieschner³⁰, Georg S Duesberg³¹, Roman Fasel^{21,33}, Xinliang Feng¹⁶, Alberto Fina¹⁷, Stiven Forti²⁸, Costas Galiotis^{34,35}, Giovanni Garberoglio³⁶, Jorge M García⁶³, Jose Antonio Garrido³⁸, Marco Gibertini³⁹, Armin Götzhäuser¹⁹, Julio Gómez⁴⁰, Frank Hauke²⁹, Adrian Hemmi¹⁸, Irene Hernandez-Rodriguez⁸, Andreas Hirsch²⁹, Ignazio Jimenez⁸, Ute Kaiser⁶⁵, Tommi Kaplas³², Andras Kis⁴¹, Konstantinos Papagelis^{35,42}, Kostas Kostarelos⁴³, Aleksandra Krajewska^{26,73}, Kangho Lee³¹, Changfeng Li⁴⁴, Harri Lipsanen⁴⁴, Andrea Liscio⁶⁹

22661 Total downloads

1 89

Turn on MathJax

Share this article

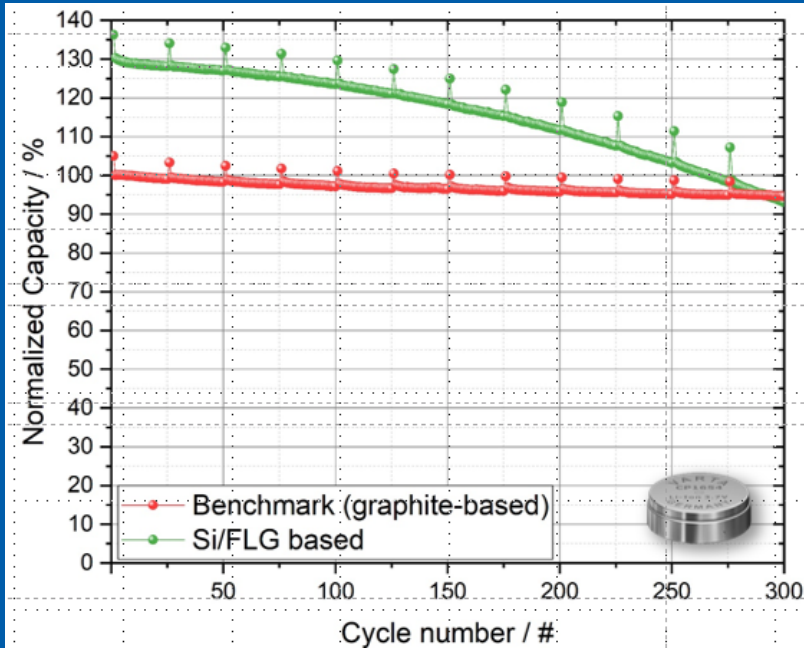
PDF



Funded by
the European Union

Some highlights

High-Energy CoinPower® Cell



SH5 partners have developed a high-energy silicon/graphene prototype with +30% capacity and +25% energy vs. SoTA graphite based LIB cells

<https://www.mynewsdesk.com/graphene-flagship/pressreleases/graphene-enabled-silicon-based-lithium-ion-battery-boosts-capacity-by-30-percent-2979279>

Applications



In-Ear Headset



Smart Key



Fitness Tracker



Insulin Patch

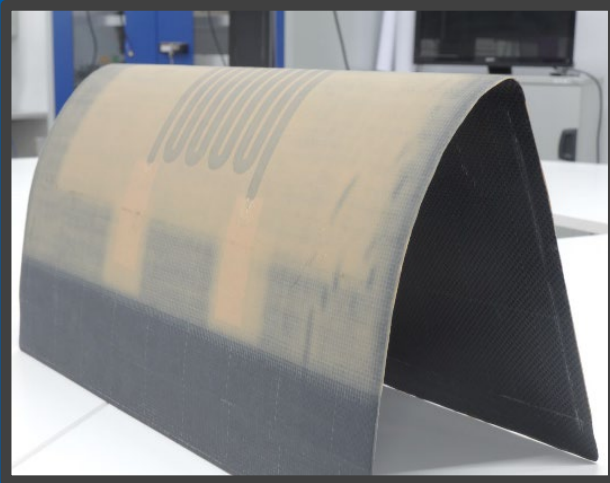
- ✓ 40% thinner anode
- ✓ 30% improved capacity
- ✓ 25% improved energy
- ✓ 65% usable capacity @2C
- ✓ Competitive Cost (€/kWh)
- ✓ Comparable temperature range



Funded by
the European Union

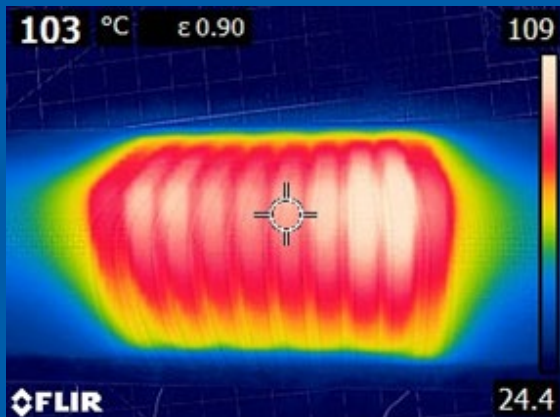
Some highlights

De-/Anti-icing Demonstrator for airplanes



- Co-curing of graphene serpentine in complex SA LE shape
- No issues identified with complex LE shape
- Confirmation of heating capability in curved shape
- Patent submitted: 14739 - Graphene flexible paper for IPS - patent CO-55907 V5. # 19382383.8.

Evaluation / testing of SA LE demonstrator @ RT



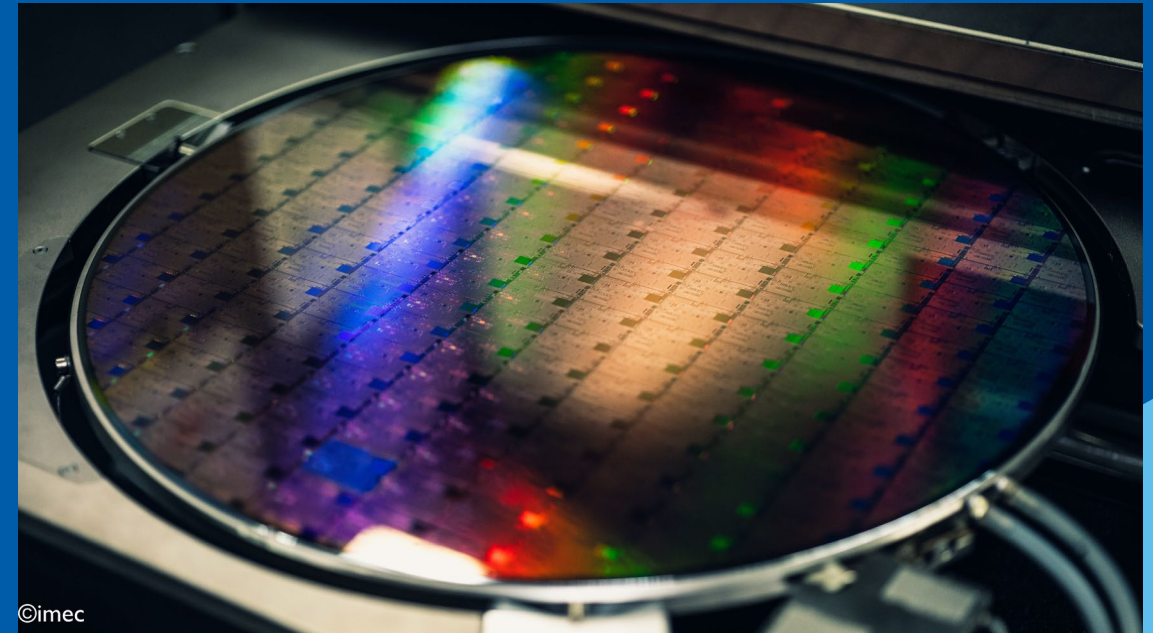
- Different voltages: 10, 20, 30, 50 & 85 V
- Sheet resistance: 20 Ω
- Homogeneity ok, but can be improved (hotter areas)
- Good / quick heating:
 - 70°C in 60 sec by 30 V & 1.5 A
 - 50°C in 30 sec by 85 V & 4.0 A
- Maximum specific power: 13 kW/m² by 85 V & 4.0 A



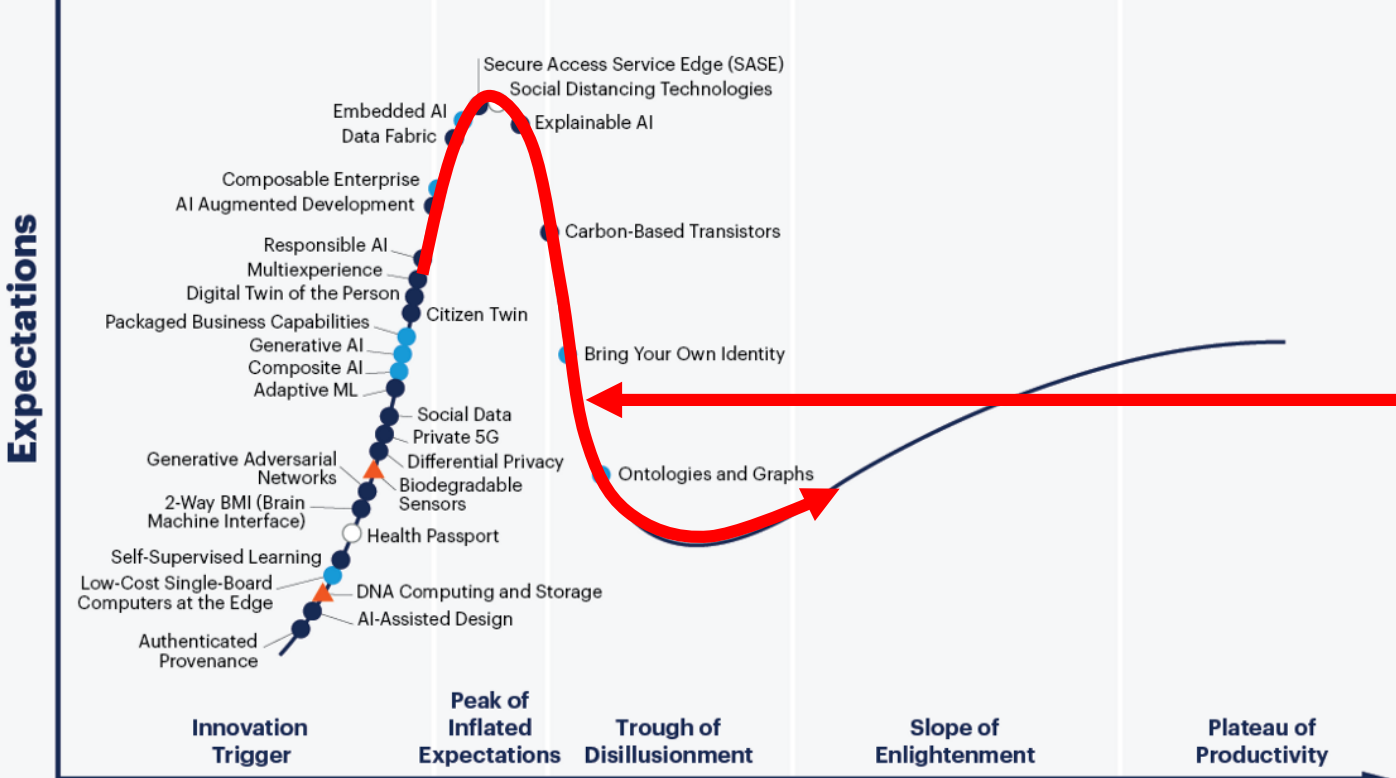
Some highlights

Launch of experimental pilot line: 2D-EPL

- Started 1 Oct 2020, On-line K-O 8 Oct.
- 11 partners from Belgium, Finland, Germany, Spain and the UK.
- Already attracts large industrial interest.
- Industrial Advisory Board of 10 European companies.
- Targets:
 - higher production capacity
 - reduced variability (large at lab scale)
 - improved yield (low at lab scale)



Where are we as a technology?



Graphene

Plateau will be reached:

- less than 2 years
- 2 to 5 years
- 5 to 10 years
- ▲ more than 10 years
- ⊗ obsolete before plateau

As of July 2020

gartner.com/SmarterWithGartner

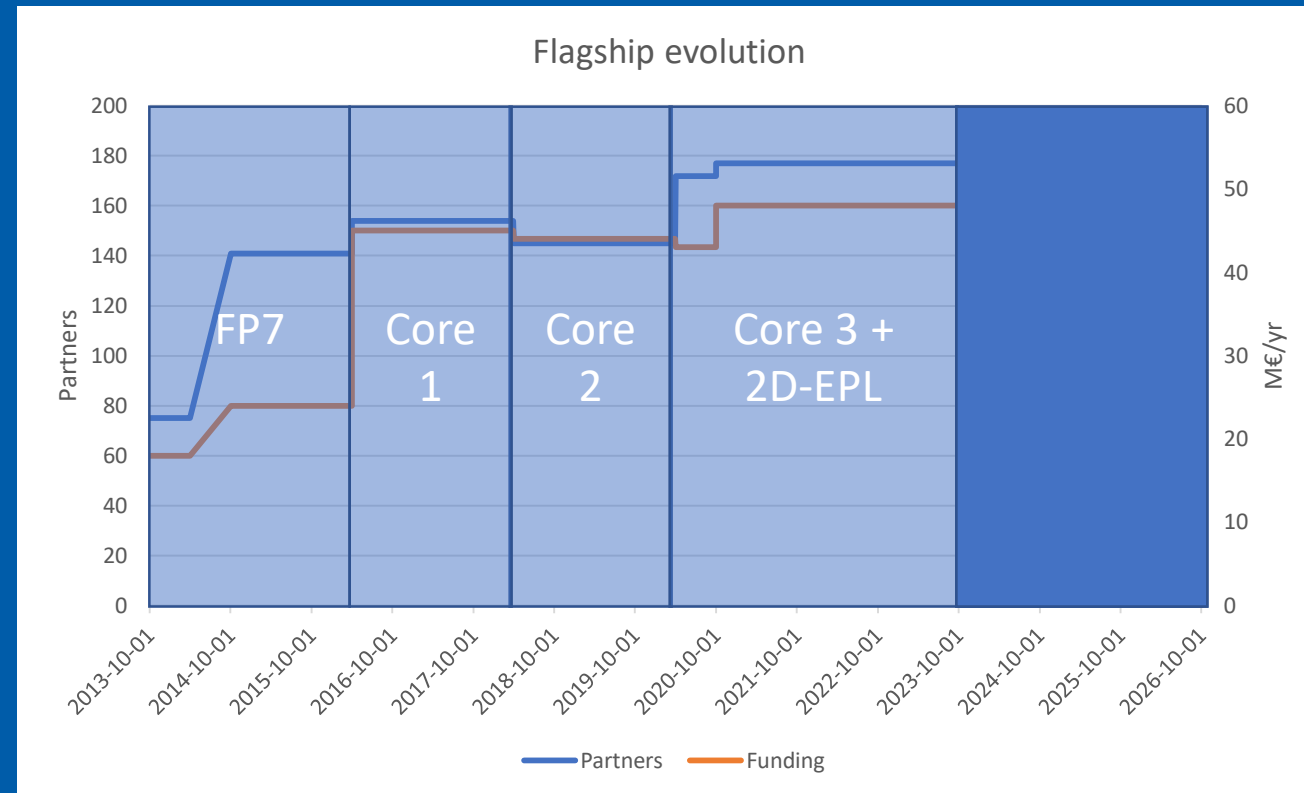
Source: Gartner
© 2020 Gartner, Inc. and/or its affiliates. All rights reserved. Gartner and Hype Cycle are registered trademarks of Gartner, Inc. and its affiliates in the U.S.



Funded by
the European Union

Evolution of the Graphene Flagship

- Consortium of varying size:
 - 75-177 partners
 - 18-48 M€/yr
- The total EC funding within H2020 will be 401 M€ - vs. 500 M€ announced 2010.
- The member states have funded activities related to the Graphene Flagship by a comparable amount.
- We have become much more industrial; today 50% commercial partners vs. initially 20%



OBS 6 months extension due to Covid-19

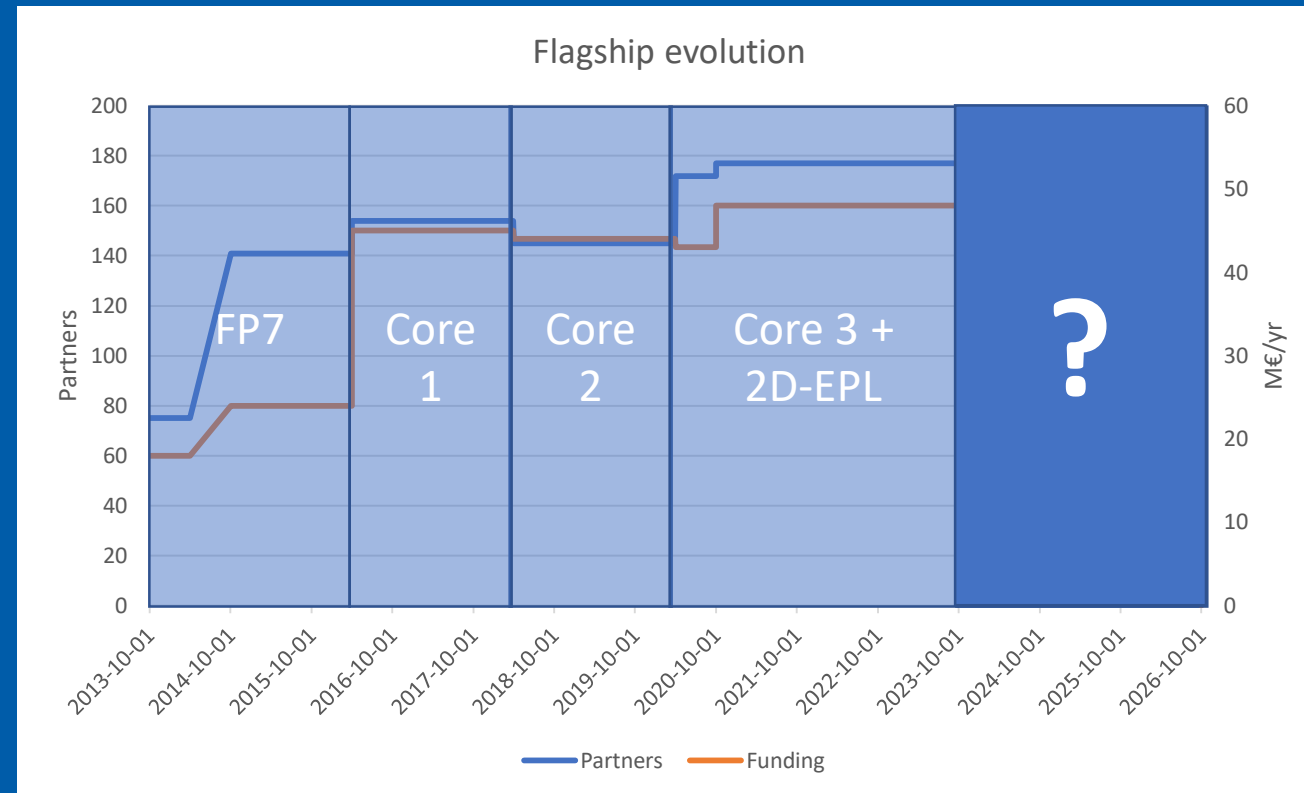


Funded by
the European Union

Evolution of the Graphene Flagship

- Horizon Europe:
Four S&T calls directed to the Graphene Flagship + one for a Coordination and Support Action (CSA):
 1. Electronics, photonics and sensors
 2. Energy storage & harvesting
 3. Biomedical applications
 4. Composites, coatings and foams
 5. CSA: governance, dissemination, innovation, standardization and roadmap

- Current draft budget: 42.7 M€



OBS 6 months extension due to Covid-19



Funded by
the European Union

Thank you for your attention!



Funded by
the European Union