

# Pioneering 2D Materials for Semiconductor Industry

4 February 2021

15:00 – 17:00 CET

## Introduction to the 2D-EPL Project

Sanna Arpiainen, VTT, Finland

# 2D Experimental Pilot Line

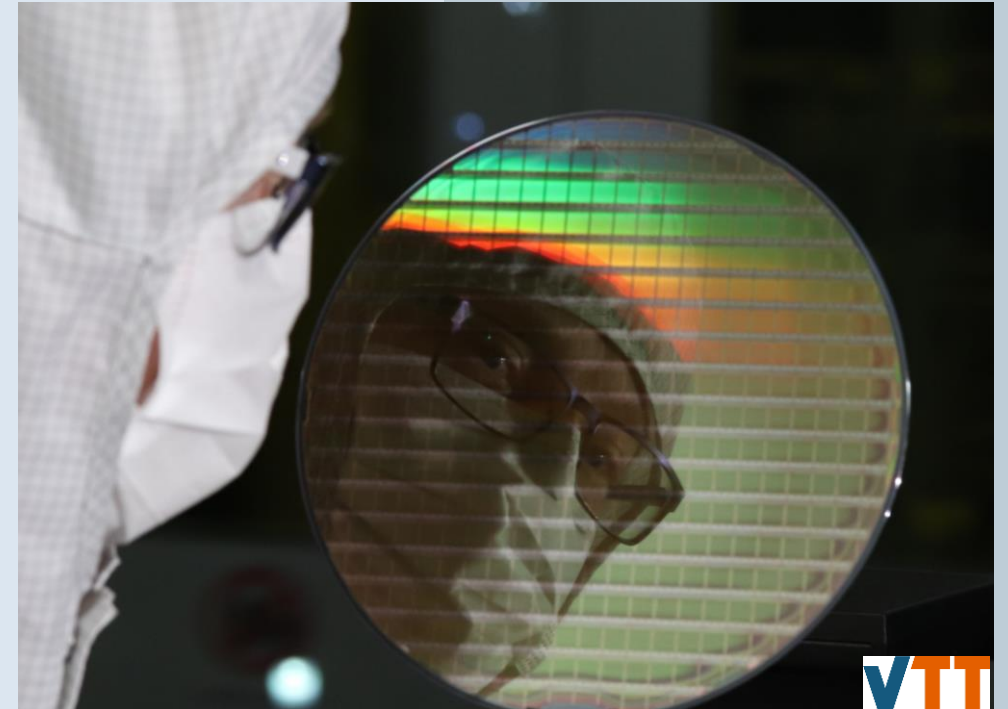
## OBJECTIVES

Develop European ecosystem for 2D material integration industry

- Tools, chemicals and processes for RTO's, IDM's and semiconductor foundries

Make 2D material integration accessible to EU companies, SMEs, start-up's and universities

- Industrial level prototyping & small scale production
  - Industrial technologies and technology providers
  - Products and customers



# 2D Experimental Pilot Line

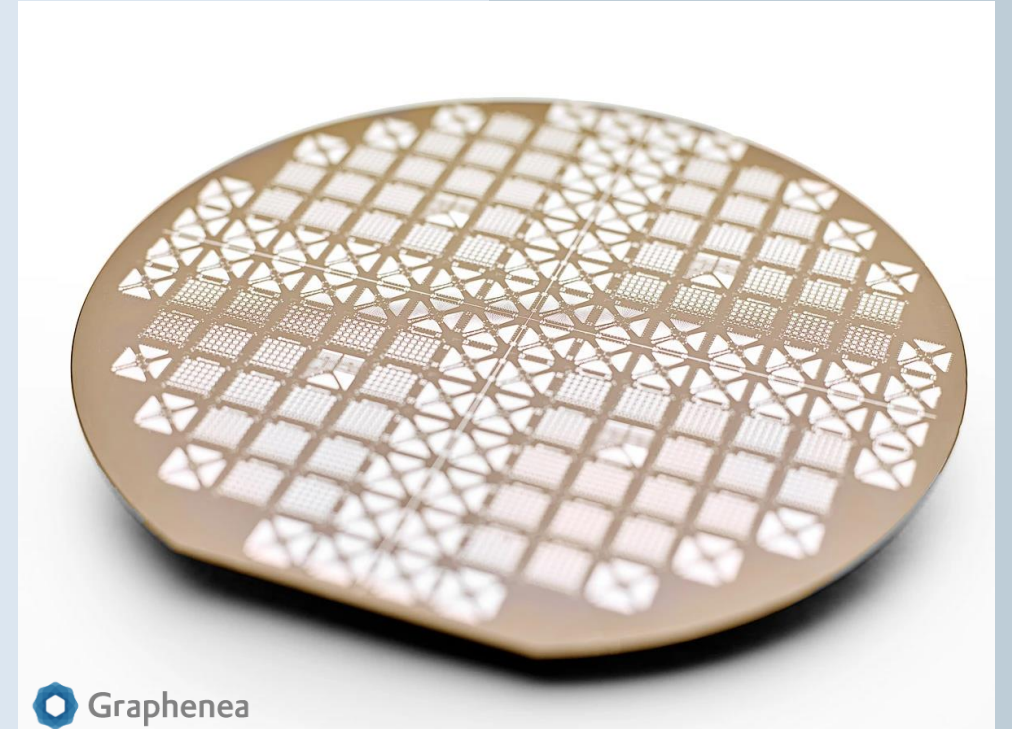
## APPROACH

### Pillar I – Prototyping from day one

- Provide processing services based on existing technologies by AMO, VTT and Graphenea
- Improve device performance and yield on polycrystalline CVD graphene at 200 mm platform

### Pillar II – Towards generic integration platform

- Single crystalline growth of 2D materials
- Automated transfer tools for up to 300 mm
- Planarization based generic platform
- Photonics, electronics and sensor modules





EUROPRACTICE

Pillar 1

200mm runs & pilot line development

Internal dev run

MPW run

MPW run

MPW run

Pillar 2

200/300 mm module development

Development of module & platform

Development of tools

MPW

2020

2021

2022

2023

2024

2025

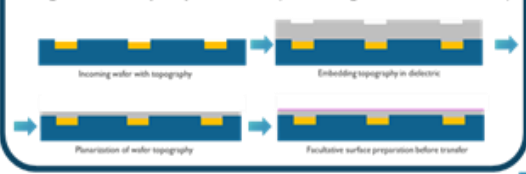
MPW run schedule not correct, see current plan from slides 8 & 9

**2D** PILOT LINE



Funded by  
the European Union

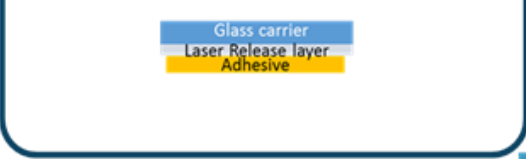
Target wafer preparation (existing infrastructure)



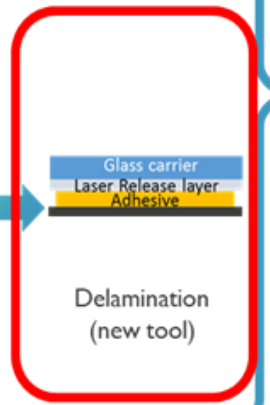
2D material growth (new reactors)



Carrier stack preparation (existing infrastructure)



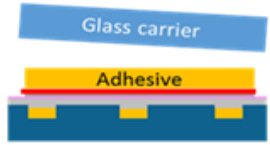
Temporary bonder (existing infr.)



Delamination (new tool)



Permanent vacuum bonder (existing infr.)



Laser release (existing infr.)



Solvent clean (existing infr.)



Residual plasma clean (existing infr.)



Residual plasma clean (existing infr.)



Oxide HM + active litho (existing infr.)



HM etch + strip (existing infr.)



Active patterning (existing infr.)



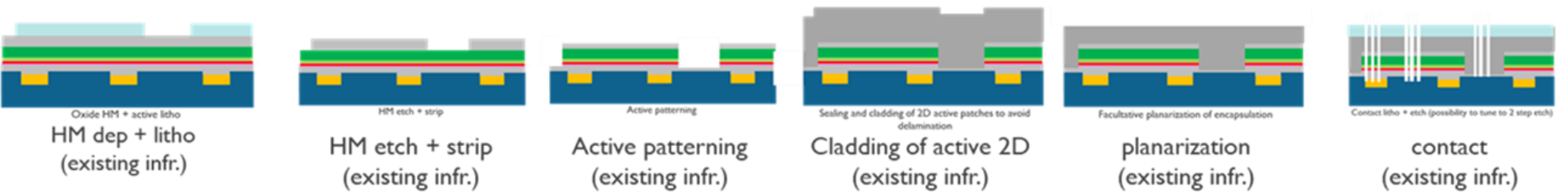
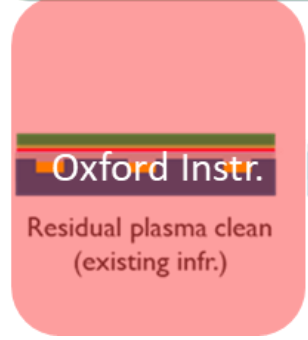
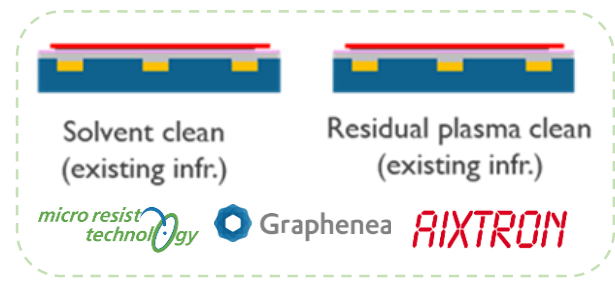
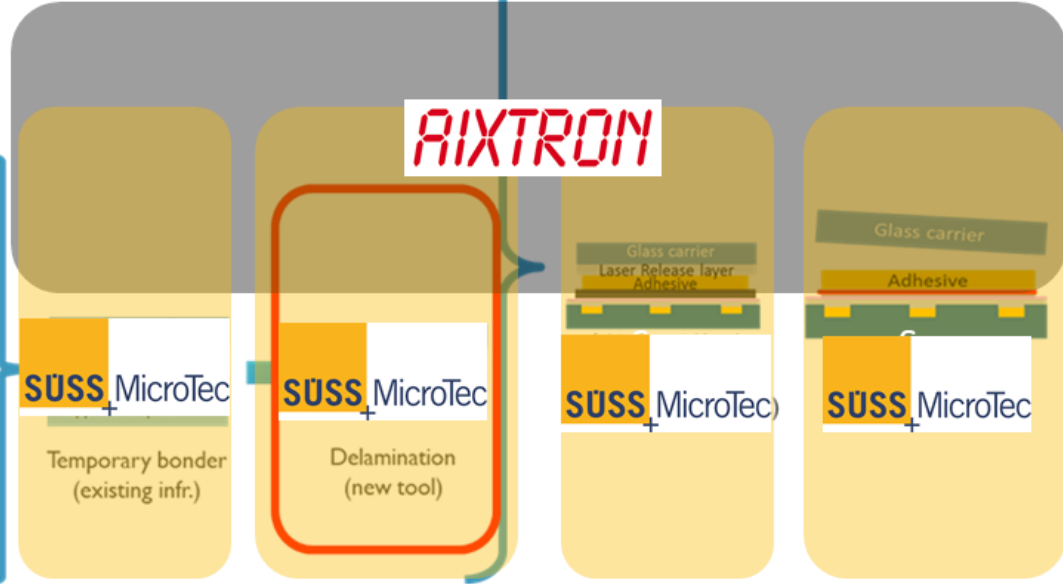
Sealing and cladding of 2D active patches to avoid delamination (existing infr.)



planarization (existing infr.)



contact (existing infr.)



# Towards product & tool ecosystem – Access to 2D-EPL technologies

## Graphene device manufacturing in 2D-EPL

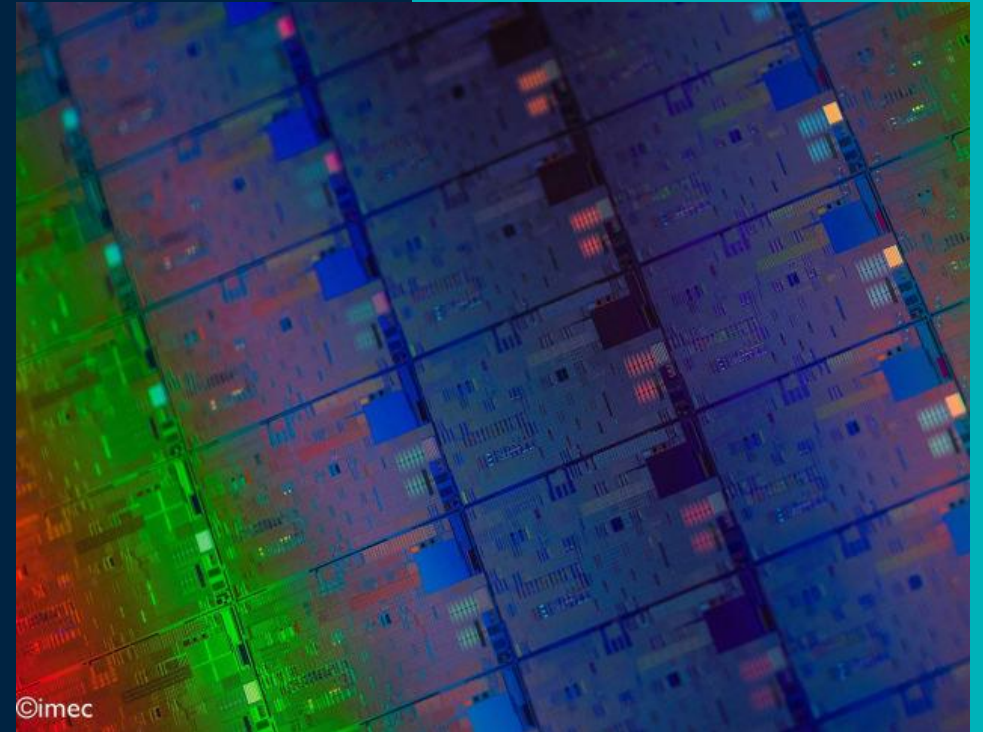
- Multi project wafer (MPW) runs by AMO, VTT, imec
- Cost based pricing, with up to 20% discounts
- Single entry-point at 2D-EPL web-site (TBC)
- Transfer to EURORACTICE after 2024

## Product & process development services, small scale production during 2D-EPL

- Custom orders from AMO, imec and VTT

## New tools for growth & transfer, process chemicals

- Future products from Suss, Aixtron, Oxford, MRT



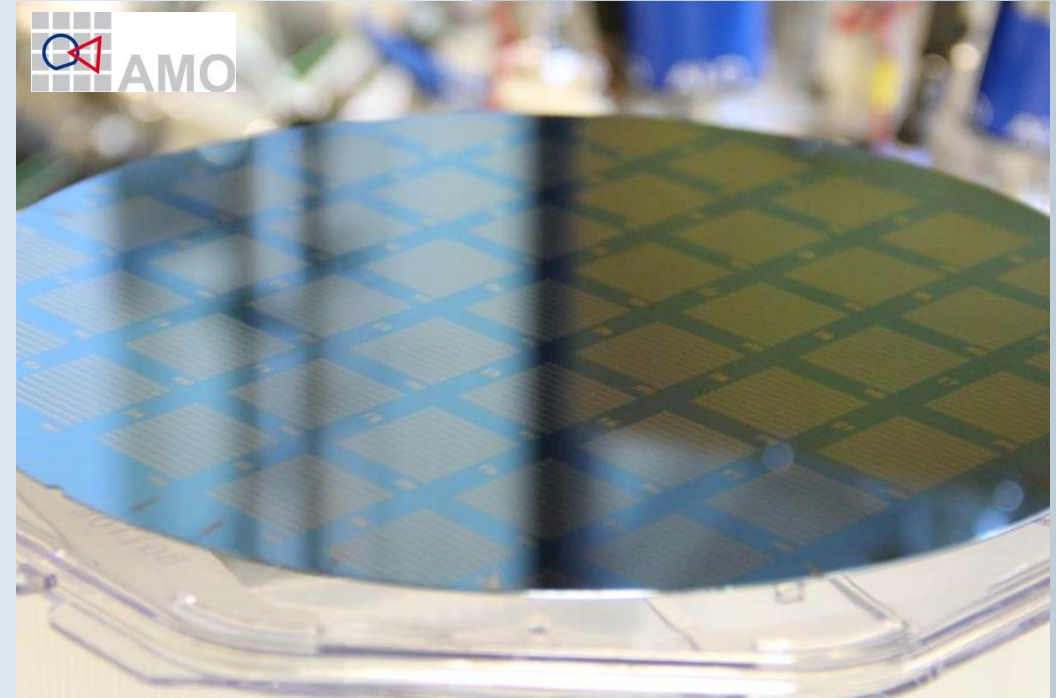
# MPW runs

## #1 by AMO – Bottom gated graphene sensors on silicon substrate

- Call opens October 2021 for Expression of Interest
- First draft PDK & instructions November 2021
- **Call closes June 2022**
- Wafers ready October 2022

## #2 by VTT – Bottom & liquid gated graphene sensors with passivation and opening

- Call opens March 2022 for Expression of Interest
- First draft PDK & instructions May 2022
- **Call closes December 2022**
- Wafers ready March 2023





# MPW runs

## #3 by AMO – Bottom and top gated graphene devices for electronics & sensors

- Oct 2022 – March 2023; by September 2023

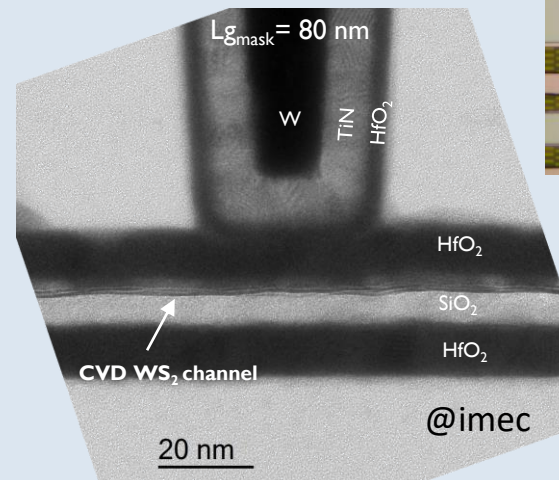
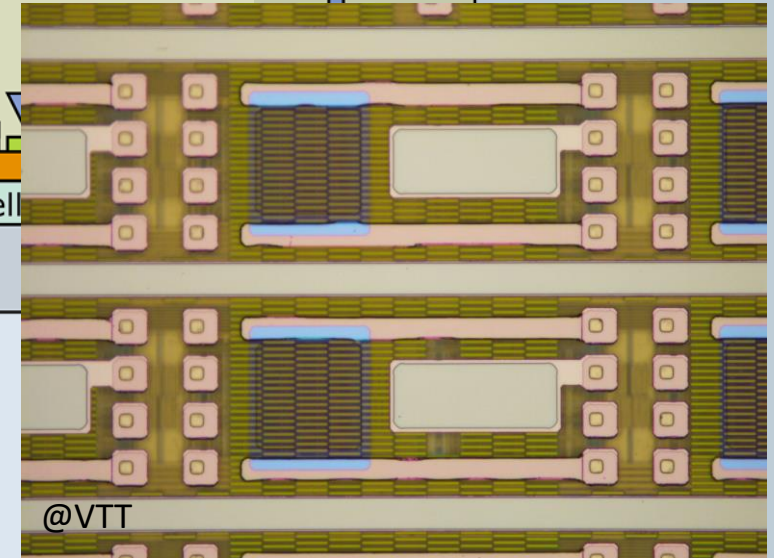
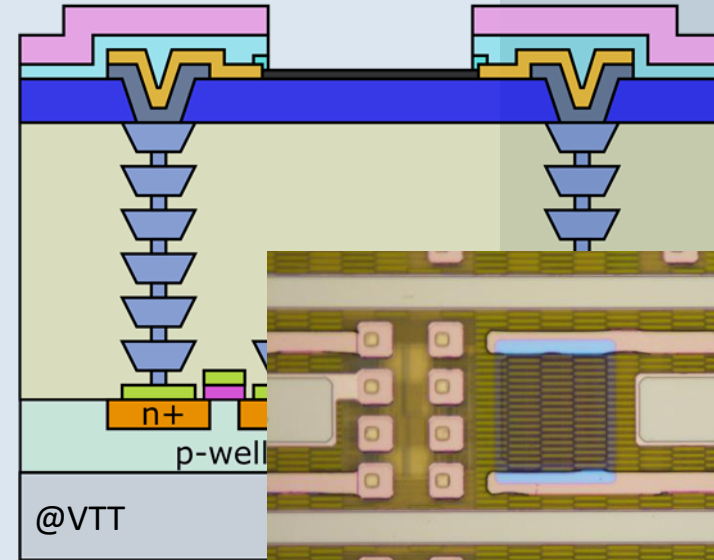
## #4 by VTT – Graphene devices on silicon CMOS for sensors & imagers

- Mar 2023 – September 2023; by March 2024

## #5 by imec – TMDC devices for electronics

- Call to be defined; ready by September 2024

Continuation – EUROPRACTICE



# Towards industrial adaptation – The Industrial Advisory Board (IAB)

## Key technology representatives from Europe

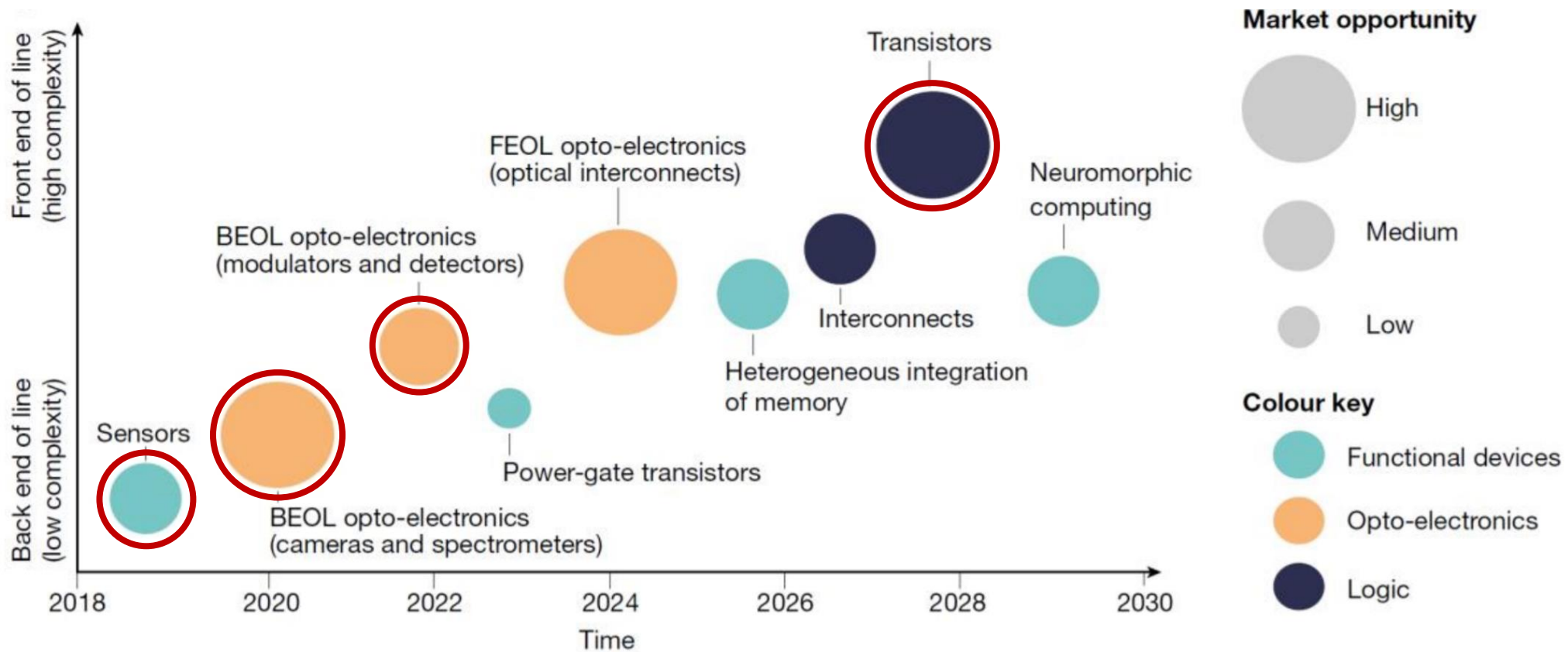
- Integrated device manufacturers
- Semiconductor foundries
- SME's in graphene industry
- Industrial initiatives (spearheads) in Graphene Flagship

## IAB will have a **steering** and **advisory** function

- Define technological direction towards the relevant applications
- Advise on the way to integrate GRM technology in semiconductor manufacturers
- Advise on pathways towards technology transfer to semiconductor industry



**Industrial Advisory Board**



Potential applications of 2DMs and modern transistor devices

## Graphene and two-dimensional materials for silicon technology

Deji Akinwande<sup>1\*</sup>, Cedric Huyghebaert<sup>2</sup>, Ching-Hua Wang<sup>3</sup>, Martha I. Serna<sup>1</sup>, Stijn Goossens<sup>4</sup>, Lain-Jong Li<sup>5</sup>, H.-S. Philip Wong<sup>3,5</sup> & Frank H. L. Koppens<sup>4,6</sup>

<https://doi.org/10.1038/s41586-019-1573-9>

Thanks for listening!

Find us on the Graphene Flagship Website:

[graphene-flagship.eu/innovation/pilot-line](https://graphene-flagship.eu/innovation/pilot-line)

     /GrapheneEU



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