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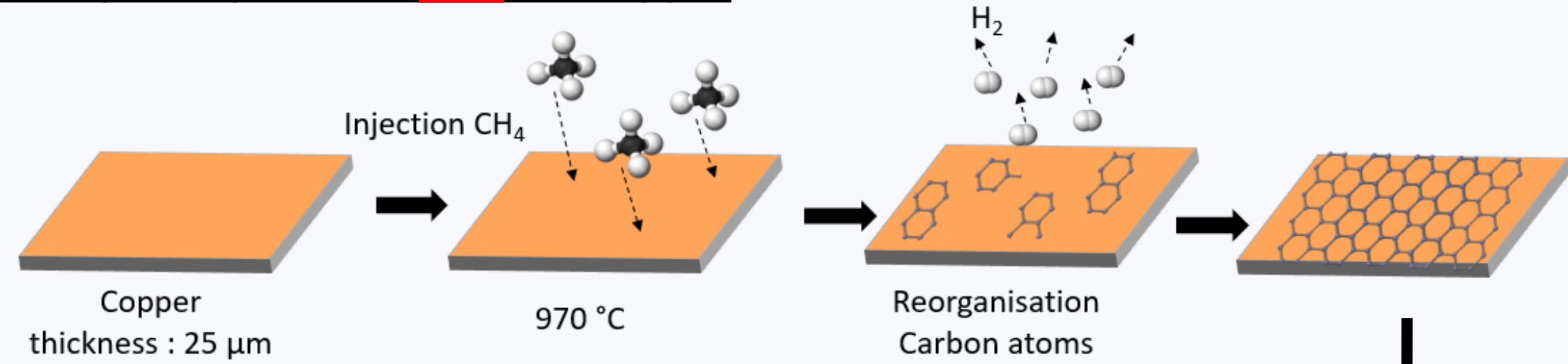
# Development of a graphene microsensor network for the electrochemical detection of micropollutants in water

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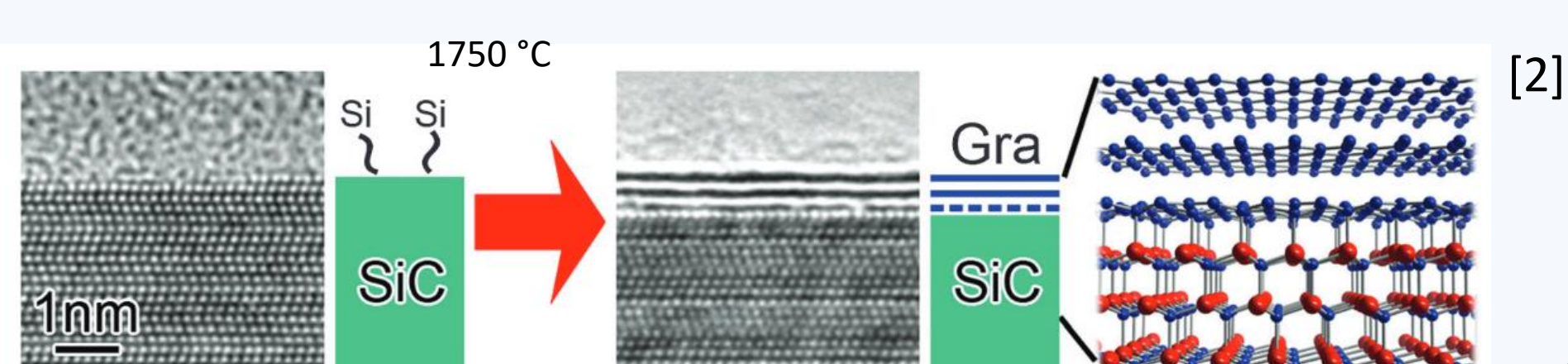
## Graphene synthesis

### Chemical vapor deposition (CVD) on copper



- + Fast and low cost method
- Conductive substrat → Transfer to another substrate

### Epitaxial graphene - Silicon Carbide (SiC) sublimation

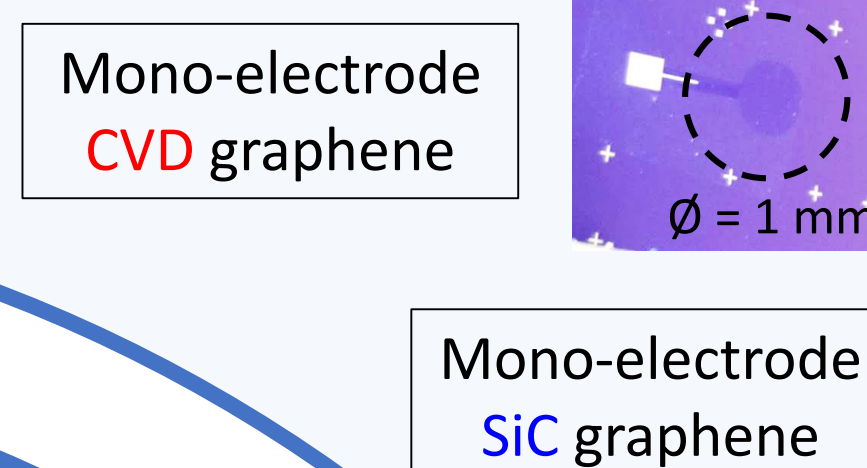
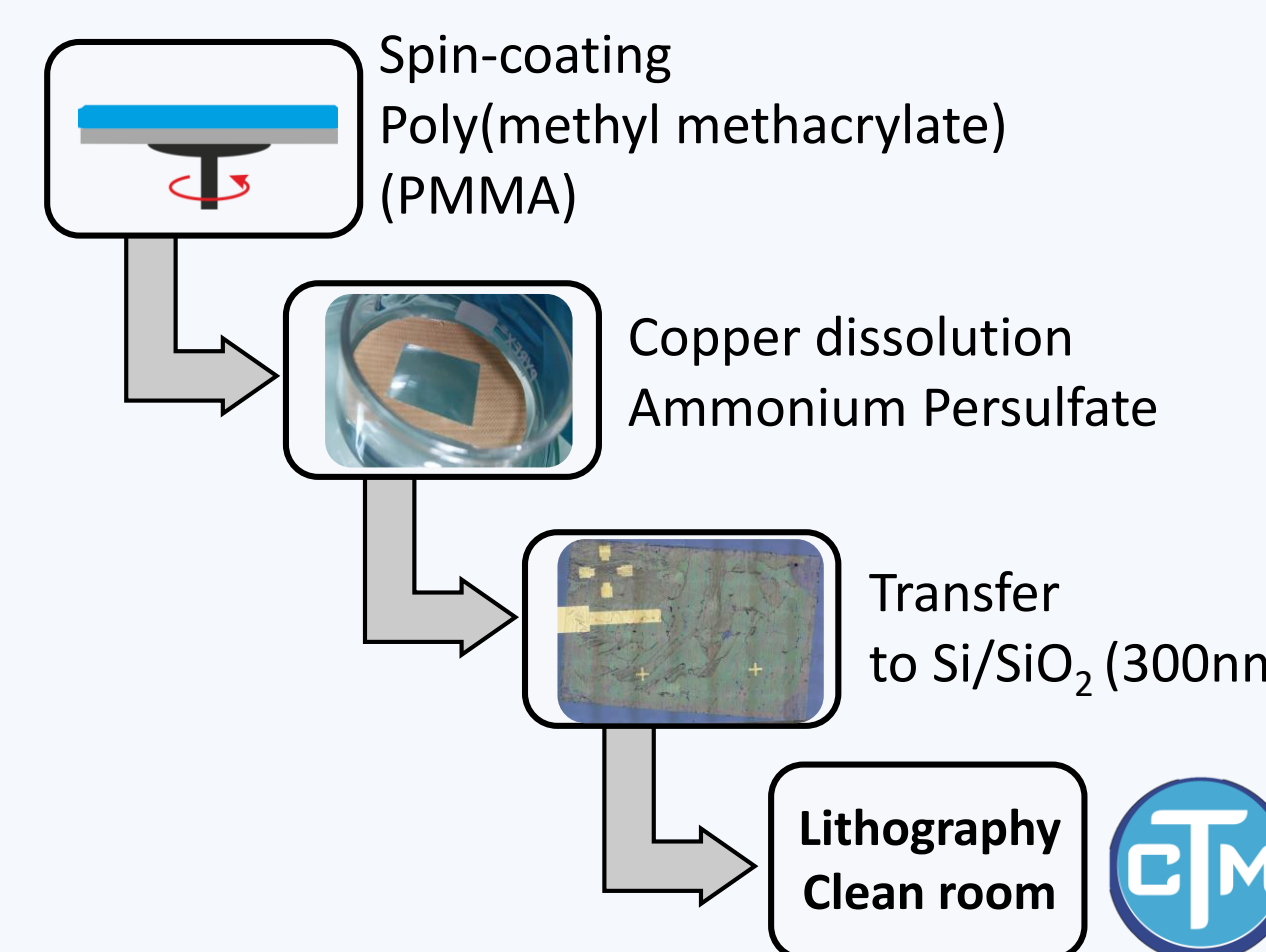


Sublimation of silicon atoms in an oven heated to 1750 °C [3,4]

- + Growth on semi-insulating materia → transfer free
- Specific chamber (high temperature)

### Control of two graphene sources

## CVD graphene transfer



## Electrodes production

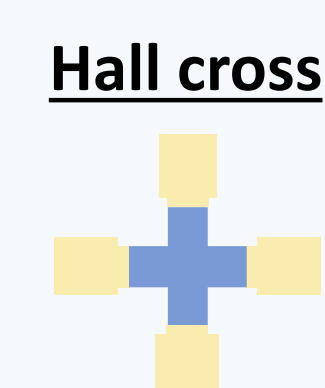
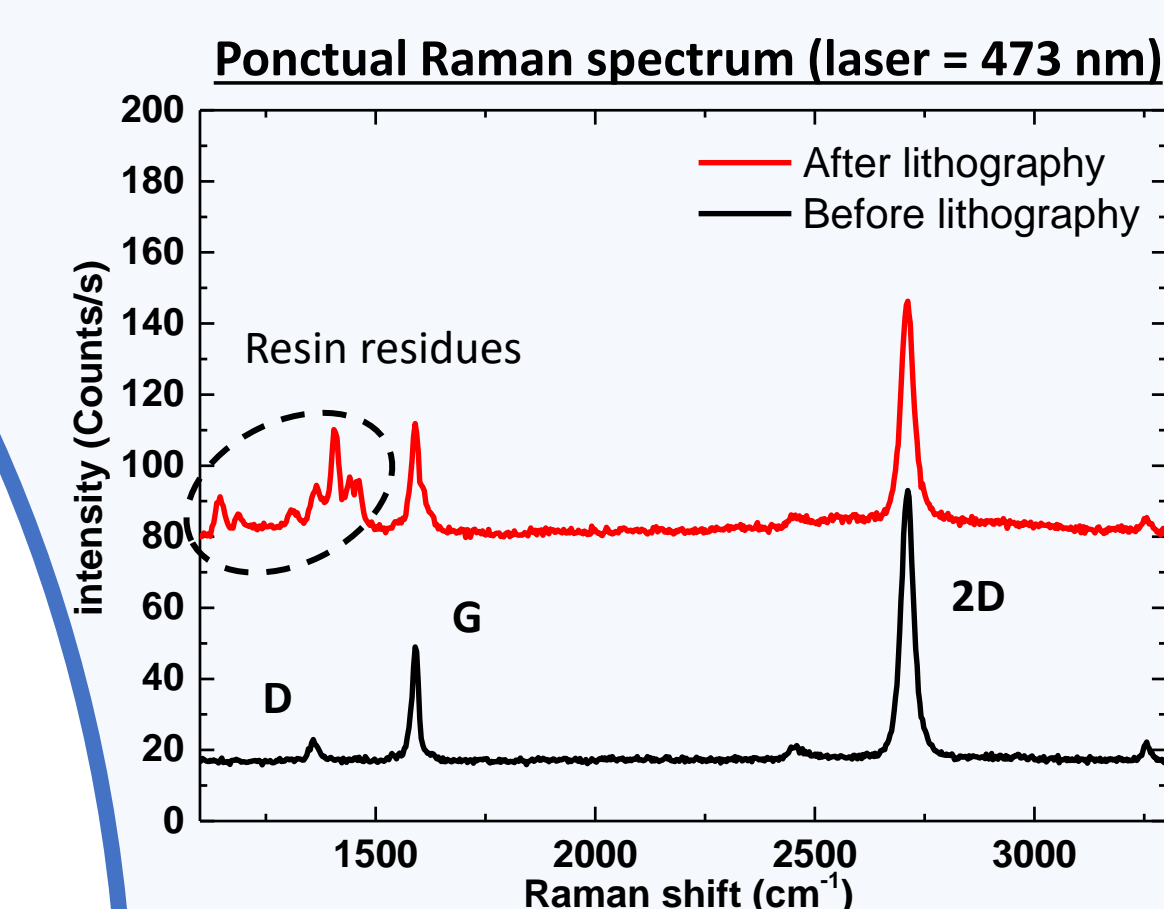
### Proof of concept: 3-electrodes system

- Transition from a 3D electrochemical system to a 2D system
- Simplification of the design in order to work on the main area of interest: the working electrode

### Working electrodes

Control of the working surface: Study of the charge transfer kinetics

- Measurement of electrical properties:
- Tracking the electrical performance fabrication steps
  - Correlation of electrical and electrochemical properties



## Context

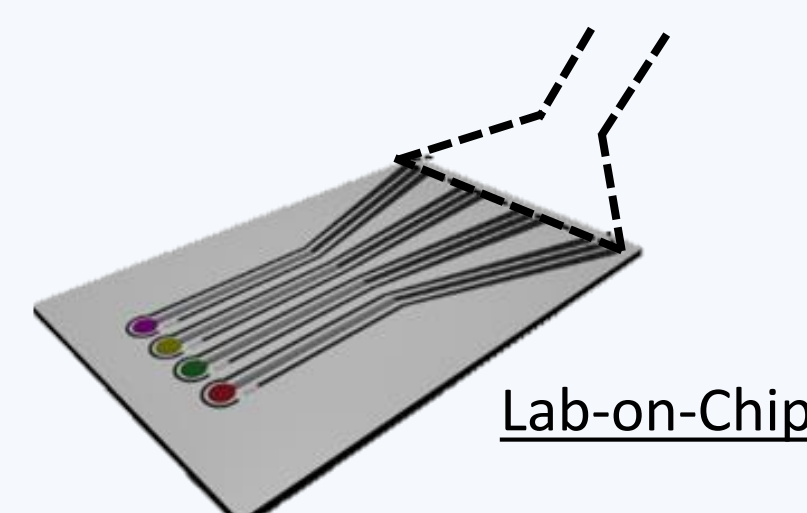
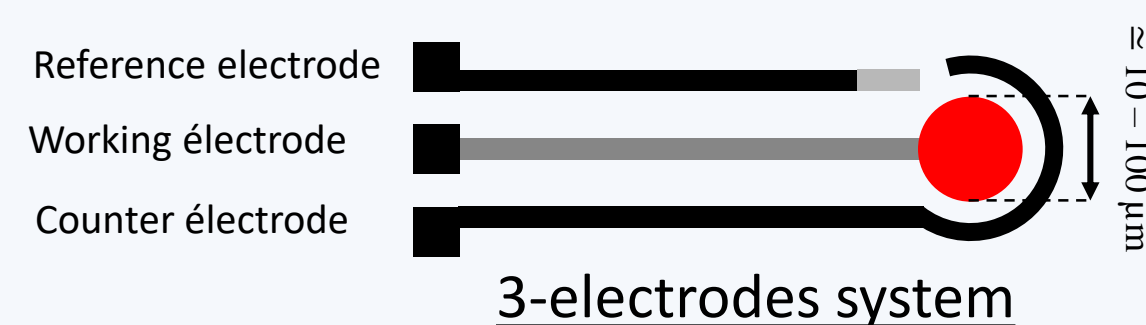
Pesticides and herbicides have a strong impact on health and biodiversity

Need for monitoring of river water quality. October 2000 → Implementation of the Water Framework Directive (WFD) [1].

Detection limits of the pollutants must be 10x lower than the environmental quality standards (~ 1 μg.L<sup>-1</sup>).

Development of new detection methods for real-time remote monitoring.

### Graphene μsensor network coupling graphene and molecularly imprinted polymers



- Shaping of a graphene platform with each working electrode functionalized for a WFD's list pollutant

### Why graphene ?

- Electrical conductor
- Possibility of miniaturisation
- Electrochemical properties: Charge transfer kinetics and wide range of electroactivity

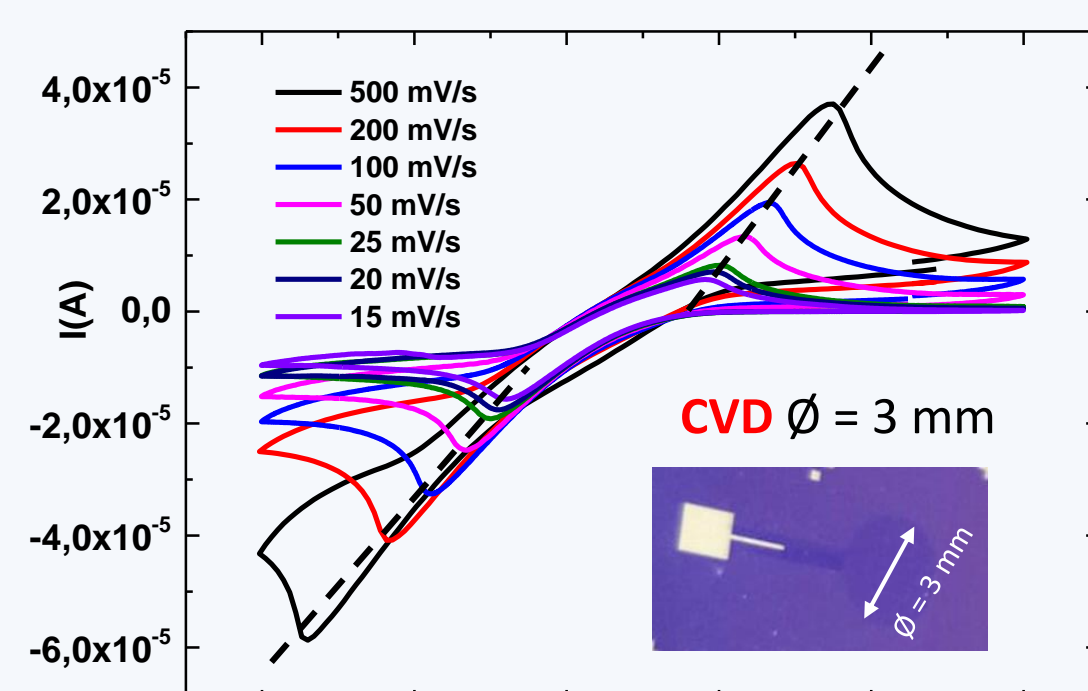
## Results

### Electrical characterisation

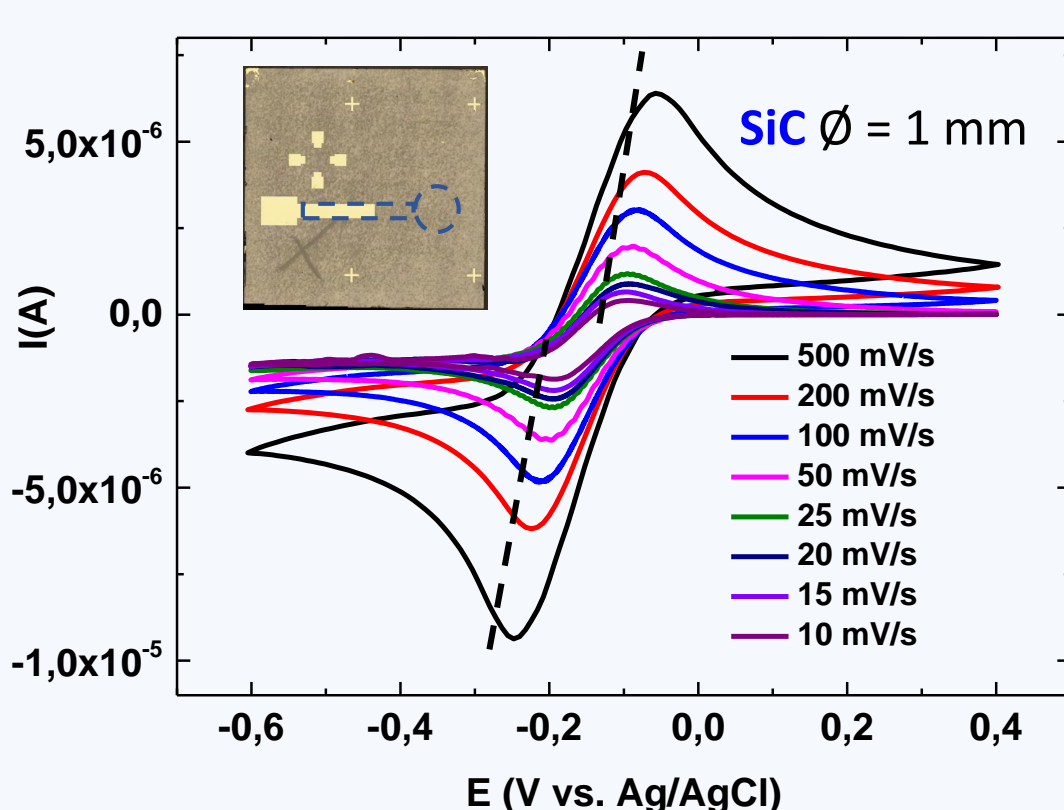
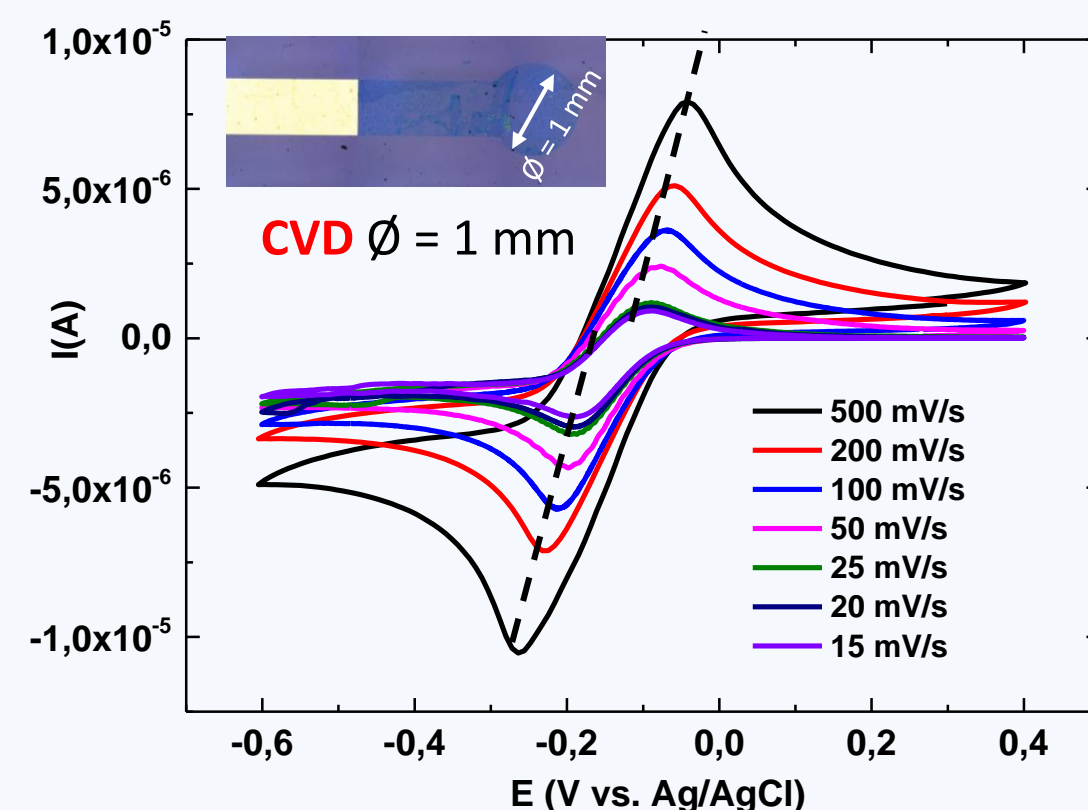
	Resistivity	Charge carrier concentration	Mobility
CVD Graphene	≈ 1 kΩ/□	≈ 5 × 10 <sup>12</sup> cm <sup>-2</sup>	≈ 1500 cm <sup>2</sup> V <sup>-1</sup> s <sup>-1</sup>
SiC Graphene	≈ 4 kΩ/□	≈ 1 × 10 <sup>12</sup> cm <sup>-2</sup>	≈ 1000 cm <sup>2</sup> V <sup>-1</sup> s <sup>-1</sup>

- The two graphene sources have slightly different electrical characteristics
- Does it have an impact on the charge transfer kinetics of the electrodes ?

### Electrochemical characterisation - Redox probe



- φ = 3 mm electrode → probes indicate a quasi-reversible system. This means that the charge transfer kinetics are not fast enough
- After decreasing the surface area → oxidation and reduction potentials are less impacted by the change in scanning rate → Improvement of the charge transfer kinetics

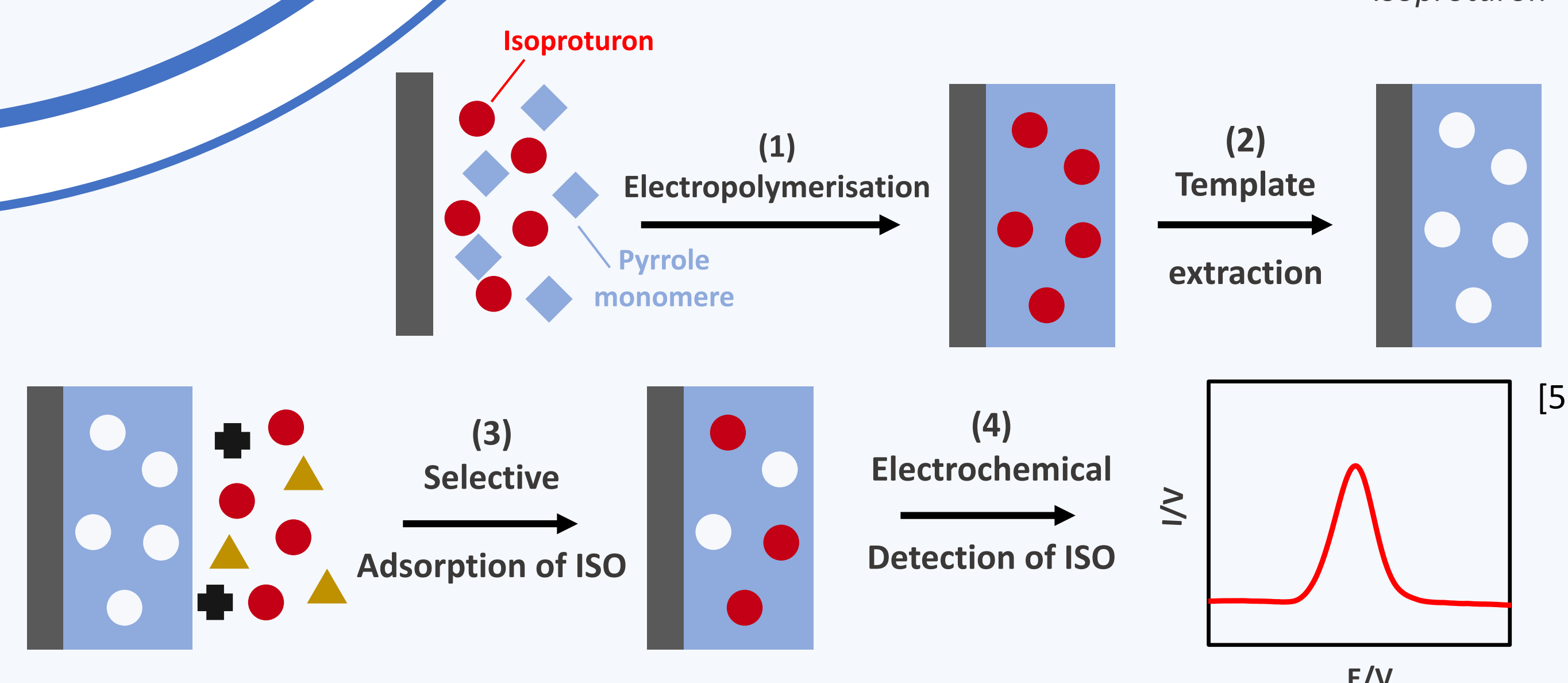


Similar results for CVD and SiC graphene

Cyclic voltammetry at different scan rates in hexaamineruthenium (III) chloride solution

## Electrodes functionalisation

Surface functionalisation by a thin layer of molecularly imprinted conductive polymer (MIP)



- Pyrrole electropolymerisation, trapping of isoproturon molecules
- Isoproturon extraction by oxidation in solution
- Incubation of the electrode in the presence of isoproturon
- Pollutant detection by pattern recognition and chemical interactions

Selective sensor at very low concentrations, μg/L range

## Conclusion and perspectives

- Shaping of single-layer graphene electrodes
- Control of two graphene sources with similar electrochemical performance

Electrodes miniaturisation  
From millimetres to hundreds of micrometres

Adaptability to functionalisation

Study of the impact of graphene crystal defects on electrochemical performance

## Thanks

This work was supported by a grant overseen by the French National Research Agency (ANR) as part of the "Investments d'Avenir" Programm. We also acknowledge the Société Chimique de France for financial support.



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