GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

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10 ANNIVERSARY

Study of the graphene oxide reduction and its impact in biosensing

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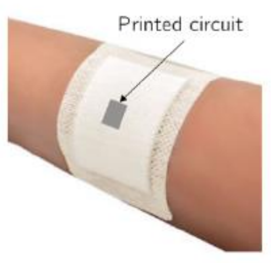
INTRODUCTION

WASP Project aims to develop an electrochemical biosensors for fast detection of biomarkers. Use the 2D ink print technique to prepare flexible electrodes.

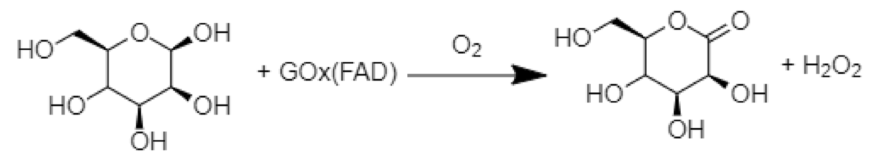


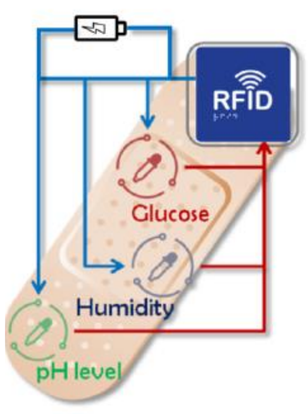
rGO

- Biocompatible
- Low cost
- Good electron transfer kinetics
- Sensitivity to Specific analytes

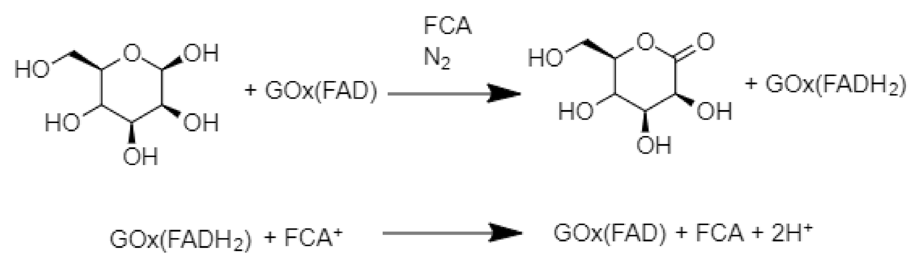
Fast detection of biomarkers

Indirect measurement method of glucose by H_2O_2 detection



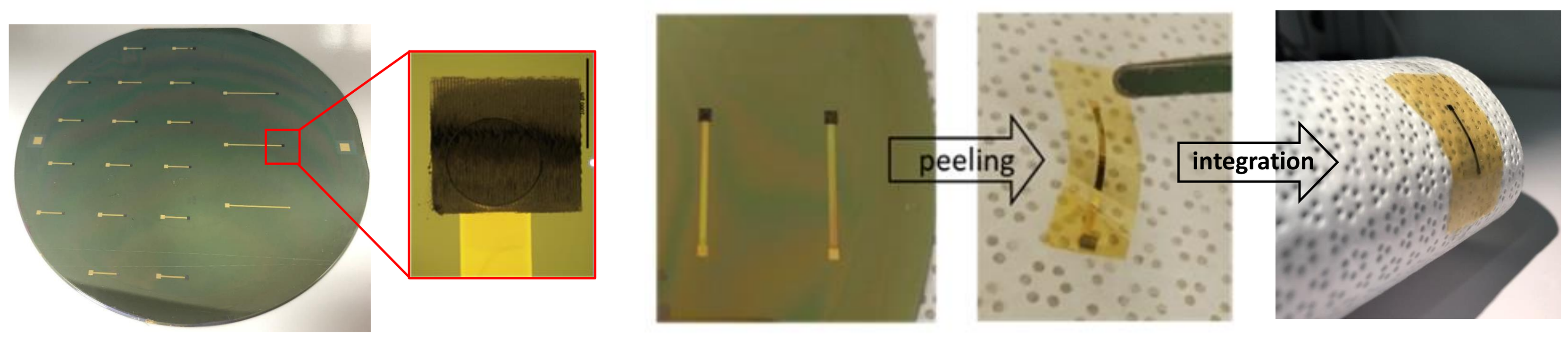


Direct measurement method of glucose using ferrocene as mediator



EXPERIMENTAL

rGO: 2D ink print in flexible substrate (polyimide) developed by University of Manchester



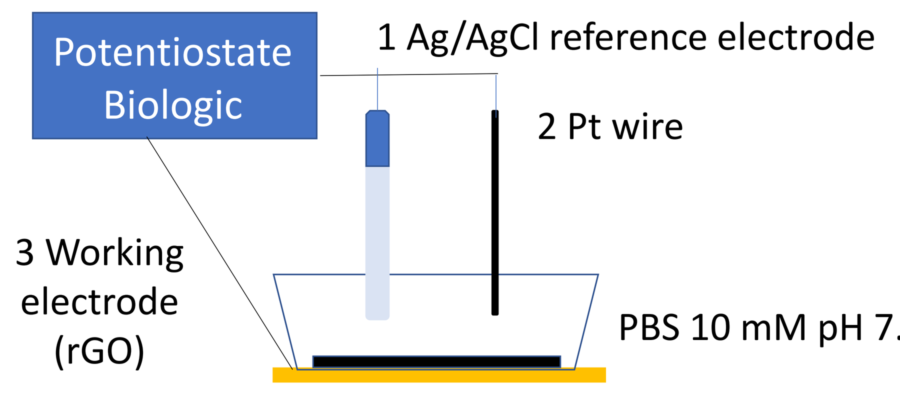
Thermal annealing at 350ºC during 8 h after fabrication

Morphological characterization

RAMAN
Witec, Laser 488 nm
Power 0,2 mW
1800 gr/nm, 50x

AFM
Asylum Origin+
Tapping mode
Cantilever 150 kHz; 9 N/m

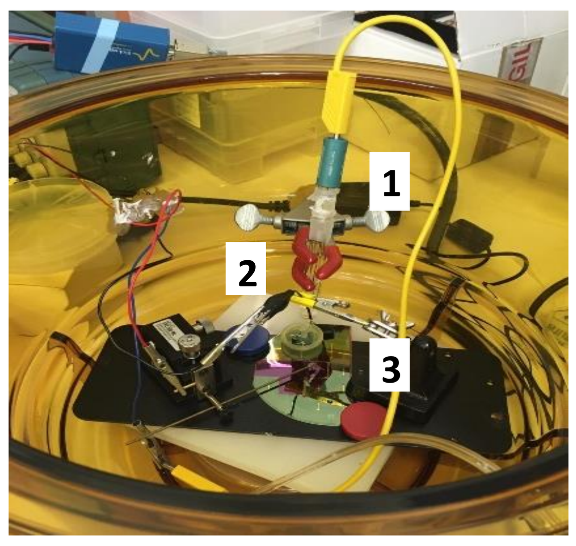
Electrochemical characterization



Electrochemical techniques:

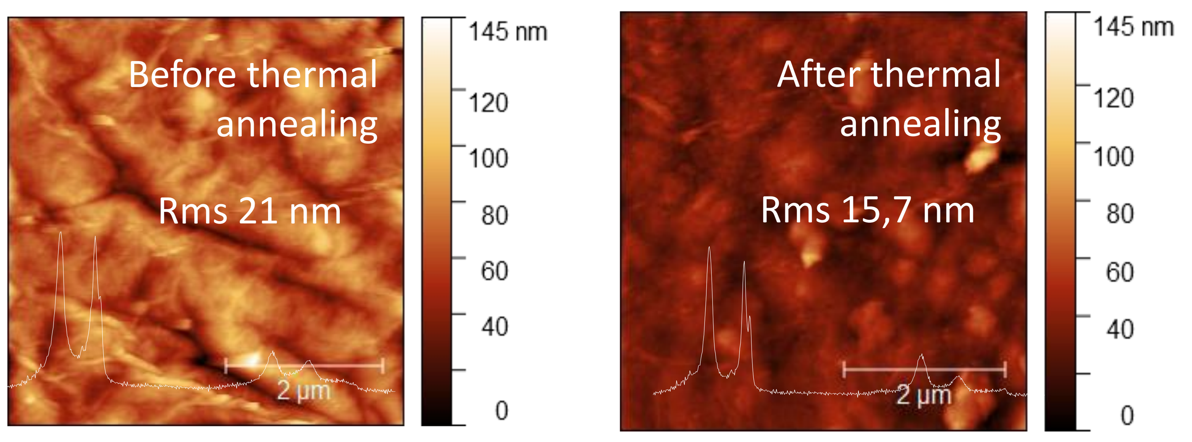
Cyclic voltammetry (CV) 50 mV/s

Potentiostatic electrochemical impedance spectroscopy (PEIS) at 0,2 V vs Ag/Ag/AgCl



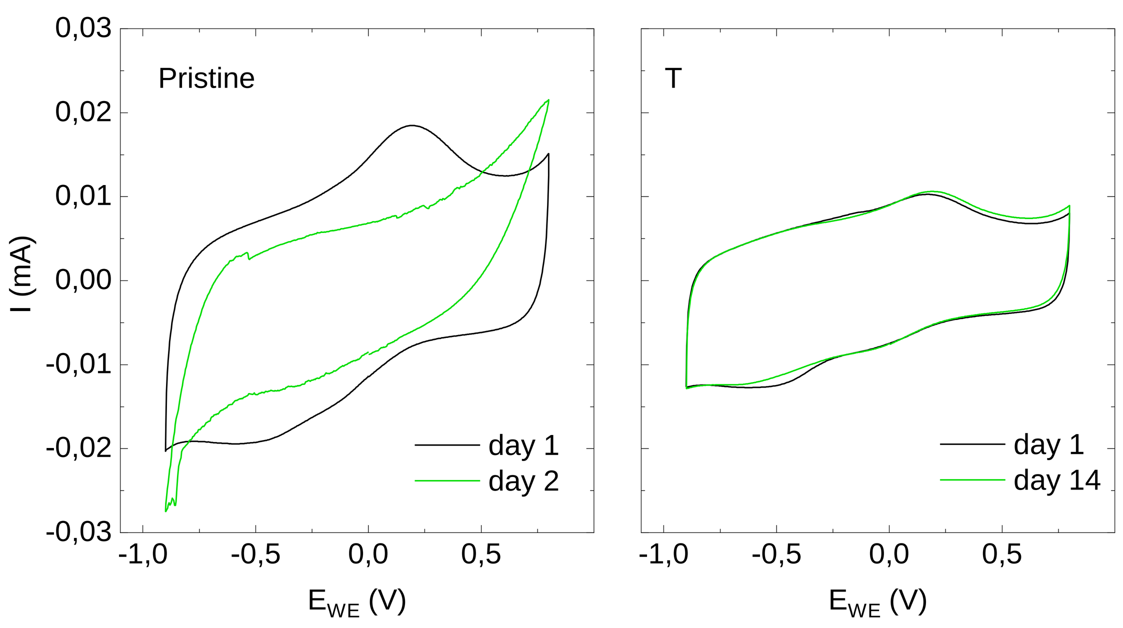
ELECTRODE CHARACTERIZATION

Raman Spectroscopy and AFM



	Height D/G	Area 2D/D	Area D´/D	FWHM D	Area D+G/D
Pristine	1.1	0.38	22	73	0.35
Thermal Annealing	1.1	0.45	8	61	0.30
	less defective material, sp3→vacancies			more reduced material	

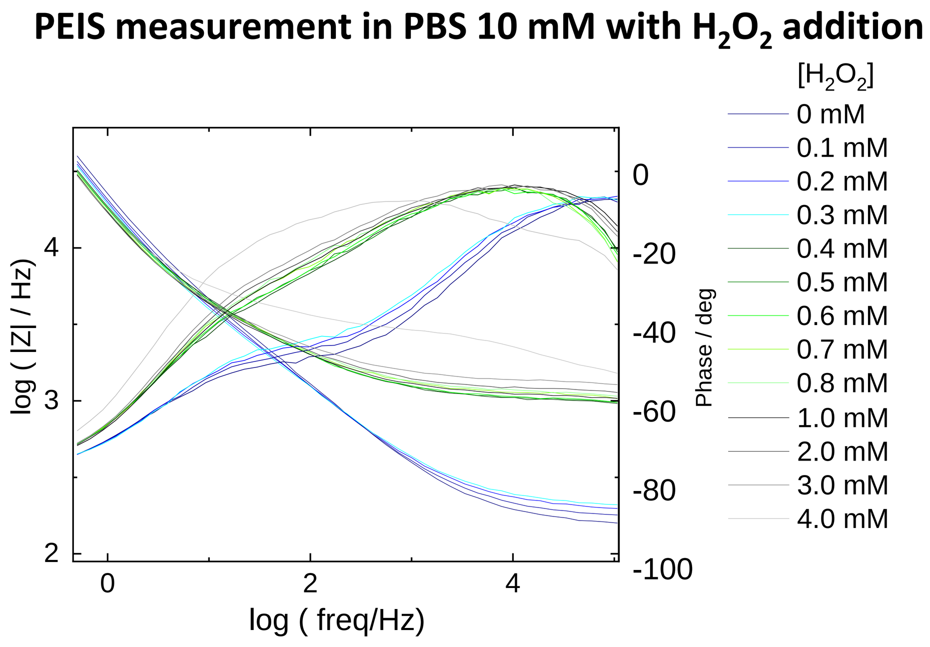
Electrochemical characterization: before and after thermal annealing



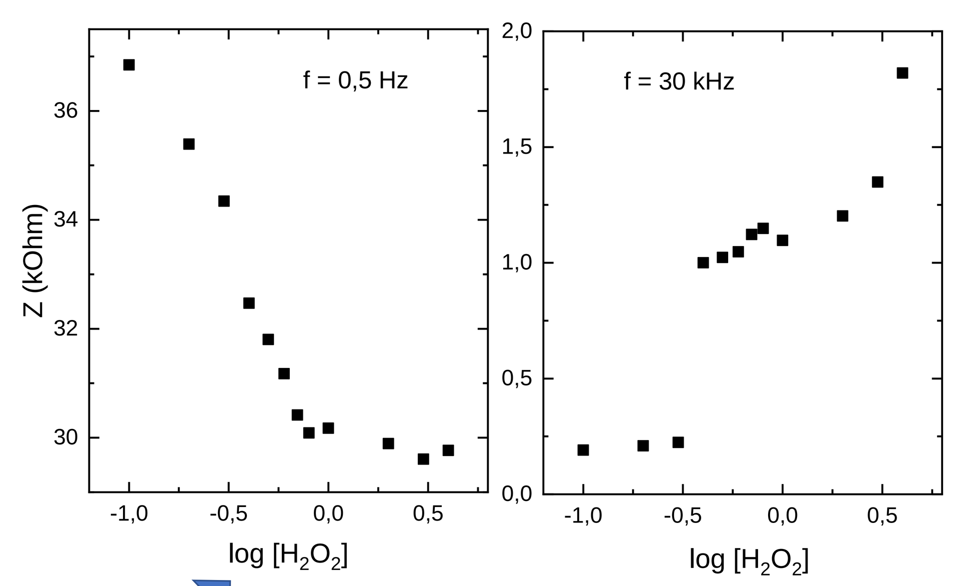
1. Thermal annealing process increases the electrode stability. Before the thermal annealing treatment, electrode needs different cycles to be more stable
2. Capacitance decreases with the material reduction degree

INDIRECT DETECTION METHOD: ELECTROCHEMICAL SENSING OF H_2O_2

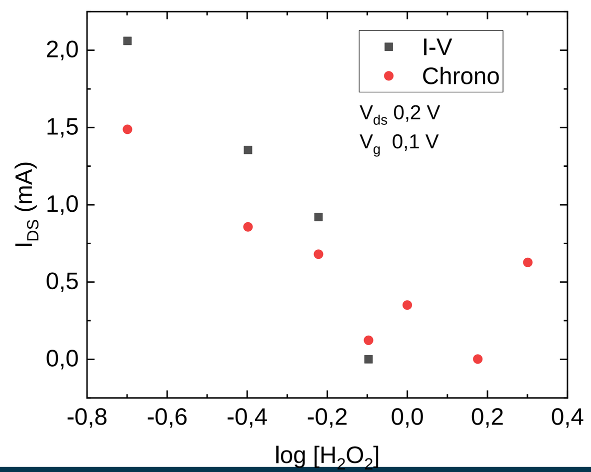
PEIS measurement in PBS 10 mM with H_2O_2 addition



PEIS at 0,5 Hz and 30 kHz



Transistor configuration measurement in PBS 10 mM with H_2O_2 addition



Resistance increases with the H_2O_2 additions in both measurements

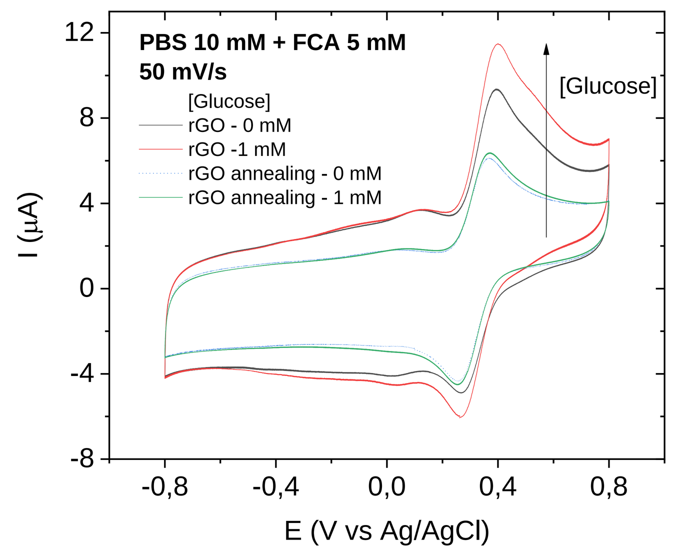
Oxidation degree of rGO increases with H_2O_2 additions

rGO sensible to the H_2O_2 changes

DIRECT DETECTION METHOD: ELECTROCHEMICAL GLUCOSE SENSING BY MEDIATOR

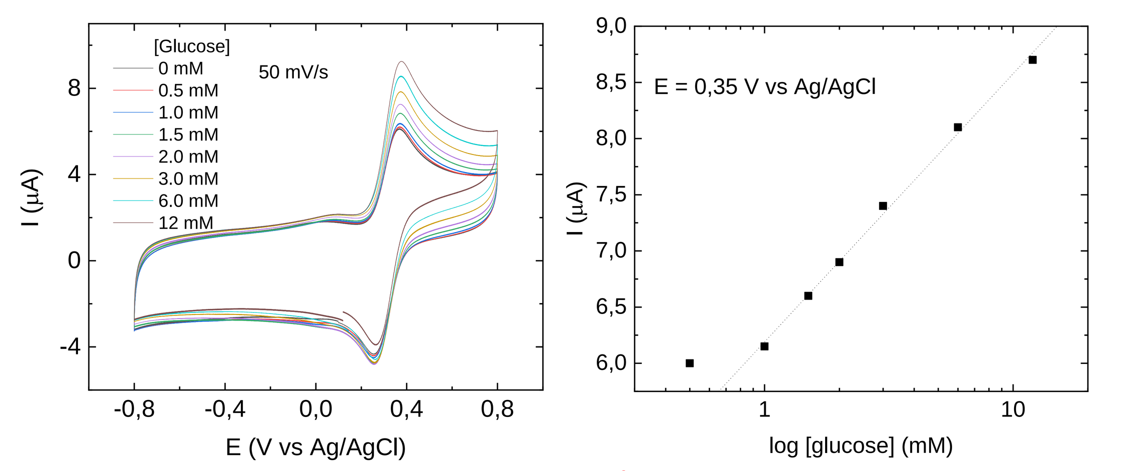
Cyclic voltammetry measurement with glucose addition

Different reduction degrees of rGO



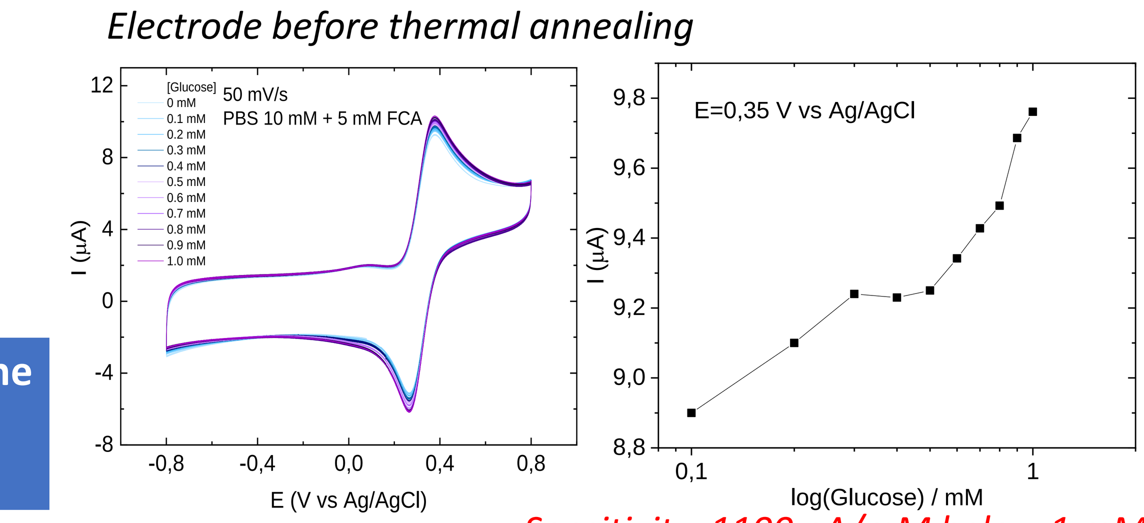
Biosensing capacity of reduced Graphene oxide is dependent of the material reduction degree

Electrode after thermal annealing



Sensitivity 270 nA/mM No response below 1mM

Electrode before thermal annealing



Sensitivity 1100 nA/mM below 1 mM

CONCLUSION

- rGO reduction degree increases with the thermal annealing process
- Electrode stability of rGO is dependent of the reduction degree
- rGO is sensible to the H_2O_2 variation. Electrode resistance decreases due to the material oxidation by the H_2O_2
- rGO is sensible to the glucose changes. The reduction degree of carbon material affects to the sensitivity
- rGO is able to sense below 1mM of glucose with a 1100 nA/mM glucose of sensitivity whitout thermal annealing

ACKNOWLEDGEMENT

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REFERENCES

[1] Mutyala, S.; Mathiyarasu, J. A Reagentless Non-Enzymatic Hydrogen Peroxide Sensor Presented Using Electrochemically Reduced Graphene Oxide Modified Glassy Carbon Electrode. *Mater. Sci. Eng. C* **2016**, 69, 398–406.

[2] Díez-Betriu, X.; Álvarez-García, S.; Botas, C.; Álvarez, P.; Sánchez-Marcos, J.; Prieto, C.; Menéndez, R.; De Andrés, A. Raman Spectroscopy for the Study of Reduction Mechanisms and Optimization of Conductivity in Graphene Oxide Thin Films. *J. Mater. Chem. C* **2013**, *1* (41), 6905–6912

[3] Gnana Kumar, G.; Justice Babu, K.; Nahm, K. S.; Hwang, Y. J. A Facile One-Pot Green Synthesis of Reduced Graphene Oxide and Its Composites for Non-Enzymatic Hydrogen Peroxide Sensor Applications. *RSC Adv.* **2014**, *4* (16), 7944–795

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