MAY 27, 2020
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Graphene Industrial Forum &2DM 2020

Graphene Chemiresistors for Gas Sensing

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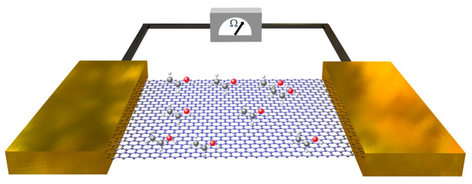
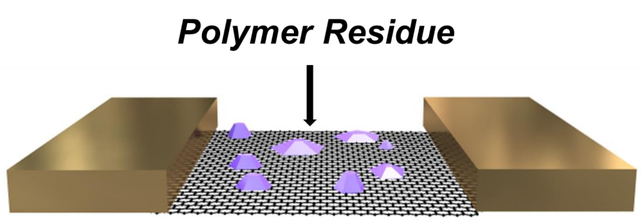
Introduction

Graphene Chemiresistors



- Large surface area
- Chemical stability
- Enormous sensitivity
- Good electrical properties
- Real-time monitoring of the graphene resistance
- Analytes induce an electrical charge transfer into graphene to produce a signal

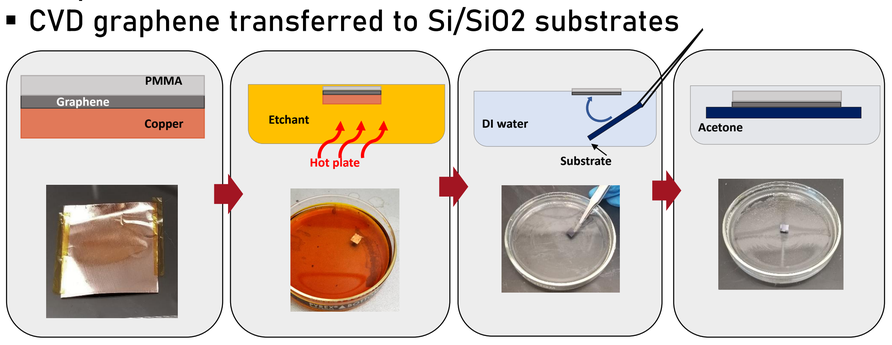
Can microscopic details of the graphene surface affect the sensing performance of devices?

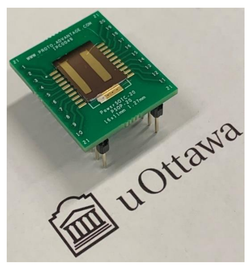


Device fabrication and test setup

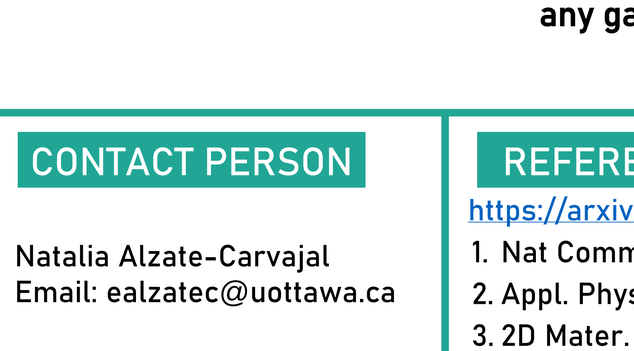
Sensor fabrication

- Graphene surface is coated with PMMA
- CVD graphene transferred to Si/SiO2 substrates





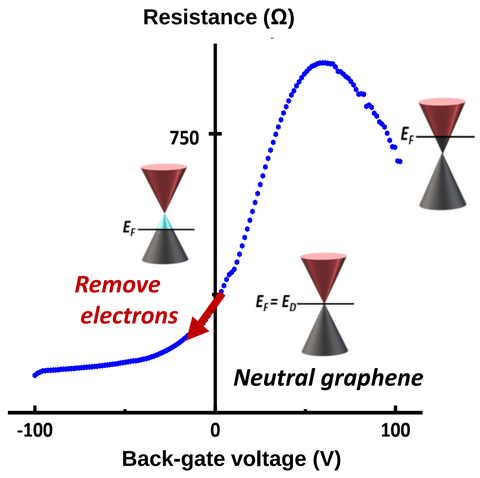
Details of the sensor design and schematic of experimental setup



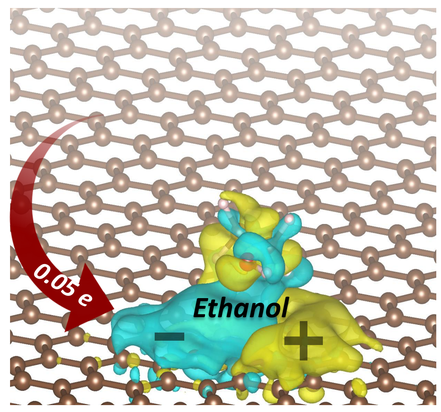
- The response to ethanol was evaluated
- High purity nitrogen gas used as a carrier
- Mass flow controllers: to control the concentration of ethanol reaching the sensor

Results and discussion

Sensing mechanism



Gate voltage measurement indicating the effect that carrier concentration has on graphene's resistance

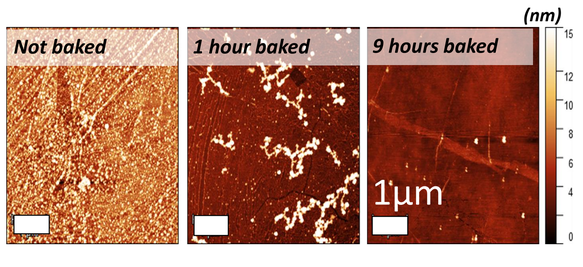


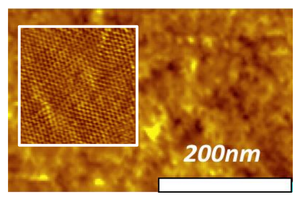
Charge redistribution between ethanol and graphene responsible for sensing – Theoretical calculation

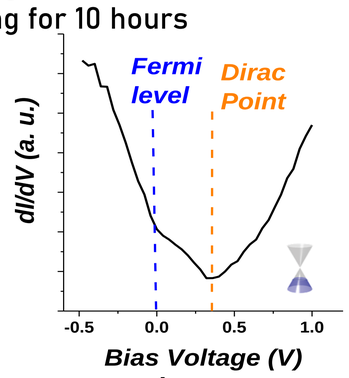
Surface analysis

Surface treatments →

Procedures to remove PMMA residues:
- Acetone rinsing
- Forming gas baking for 1 hour
- Forming gas baking for 10 hours







Atomic force microscopy

sensing surface after different baking time at 400 °C.
→ less residue with longer baking time

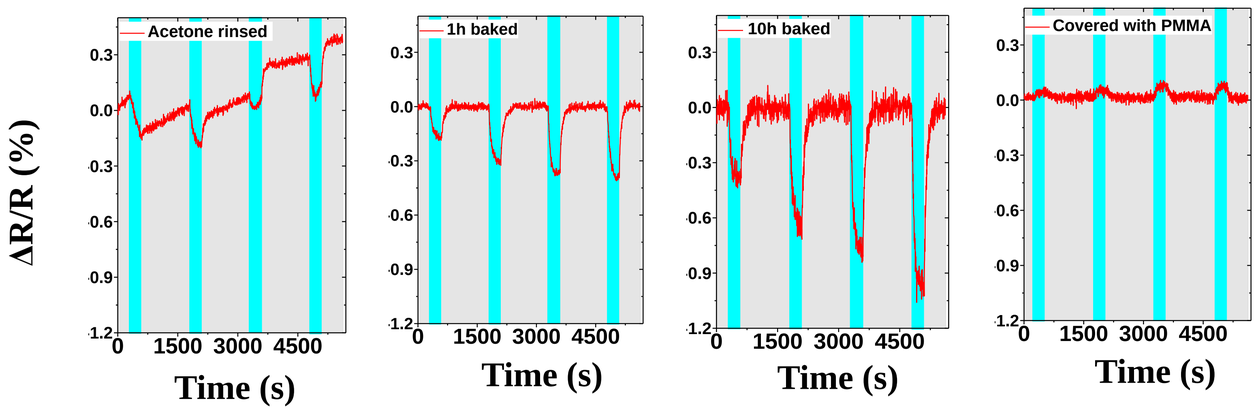
Scanning Tunneling Microscopy and Spectroscopy

STM: After 9 hours, we can image atomically clean surface

STS: The samples are p-doped

Sensing performance after different surface treatments

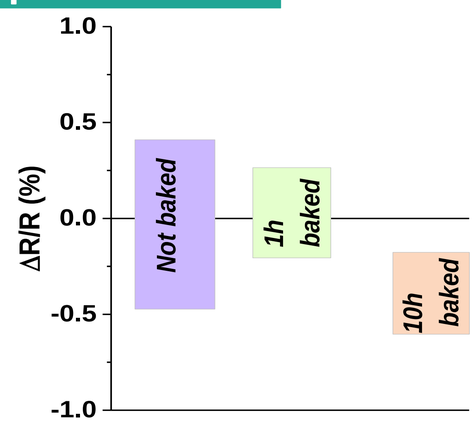
Response to ethanol gas



Conclusions and perspectives

Reliable sensors → **Full control over contamination/response must be achieved**

Our method to control surface quality to improve performances and reliability can be used for the detection of any gas



Sensors without treatment:
- Large variation in response

10h baked best performance:
- Improved sensitivity and reliability
- Further improvement is still needed to narrow the range of the sensor response (device to device variation)

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REFERENCES

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ACKNOWLEDGEMENTS

NSERC CRSNG
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