Graphene Growth Mechanisms and the Application of Graphene in Strain Gauges

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Abstract

Goal: Fabricate a highly sensitive graphene-based strain gauge

Project duration so far: 4 weeks

Not only sensitivity, but also consistency in piezo resistive response

Most consistent gauge factor so far has been around 3.8

Graphene

Graphene: tape-like, 2-D honeycomb lattice of carbon atoms

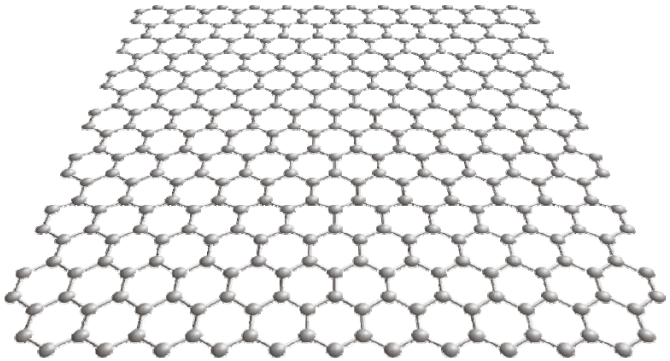
Sp2 (three bonds) hybridized carbon atoms

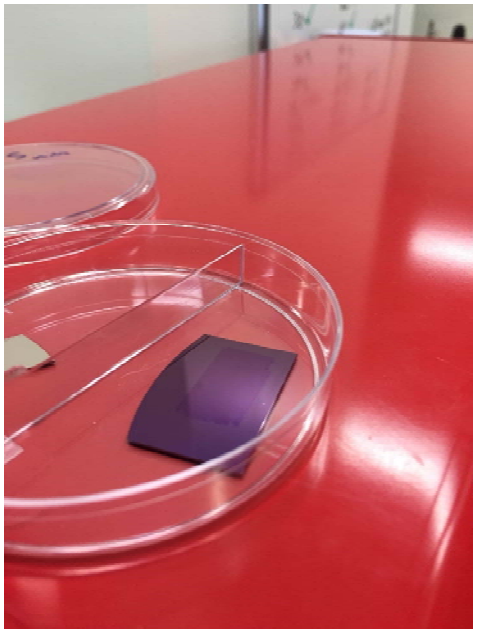
Isolated/characterized 2004

Impressive electrical and physical properties

Several applications:

1. Energy Storage
2. Ultrafiltration
3. Touchscreens
4. Strain Gauges





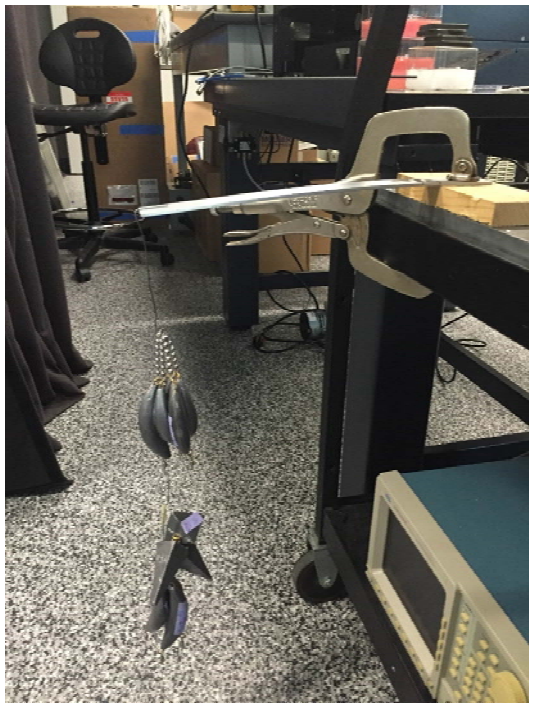
Piezo Resistivity/Gauge Factor

Piezo resistivity: As the material is strained, its resistance changes.

Gauge Factor: Ratio of change in resistance to strain

High Sensitivity:

1. Small strain put on graphene
2. Large increase in resistance
3. High gauge factor



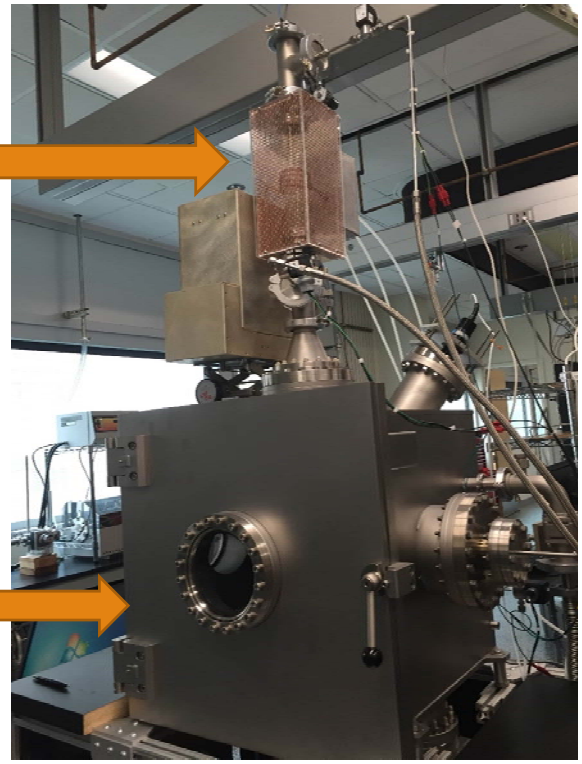
ICP CVD

Inductively Coupled Plasma Chemical Vapor Deposition

Top Column: Generate plasma

Bottom Chamber: Grow graphene

1. Gasses flow into column
2. Electrons pulled away by power in inductor
3. Gasses enter chamber as ions
4. Carbon bonds with ready-made catalyst coating on substrate



ICP CVD: Roles of Gasses

C2H2 or CH4: Carbon Precursor; Supplies carbon for graphene growth

Ar2: Inert; non-reactive; controls back pressure of system

H2: Dehydrogenation; pulls hydrogen from carbon precursor.

ICP CVD: Parameters

Plasma Power

Plasma Duration

Gas Species

Gas Partial Pressures

Back Pressure

Growth Temperature

Anneal Time

Catalyst Type/Thickness

Cleanliness of Quartz Tube

Materials

SiO2 substrate

Cu/Ni Catalyst coating

PMMA/Spin coater/pipette

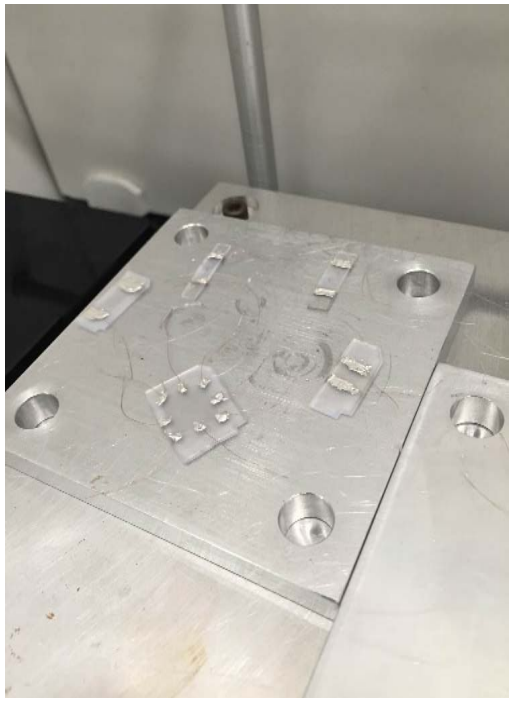
PET Thermoplastic

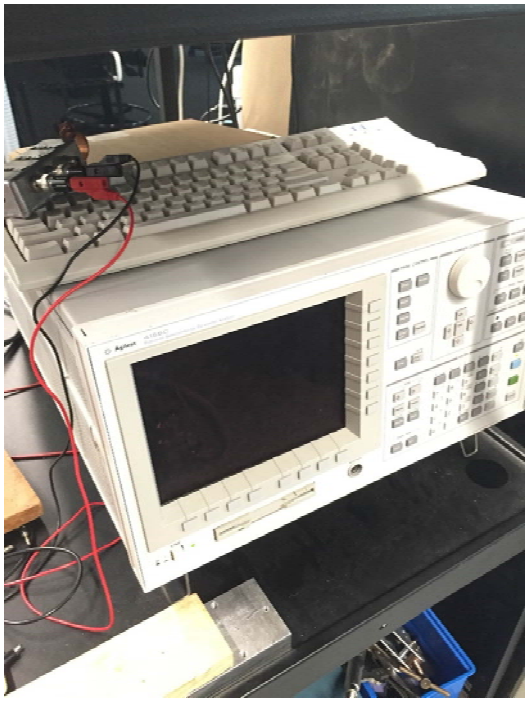
FeCl3 etchant

Heating surface

Ag epoxy/Cu wire

SPA

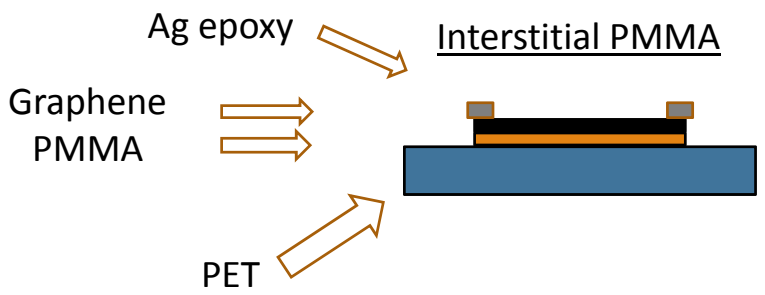


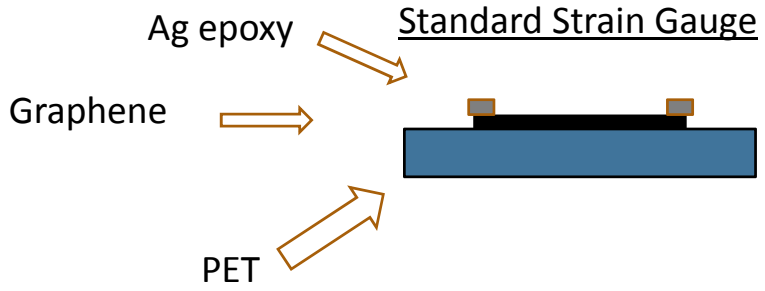


Methods

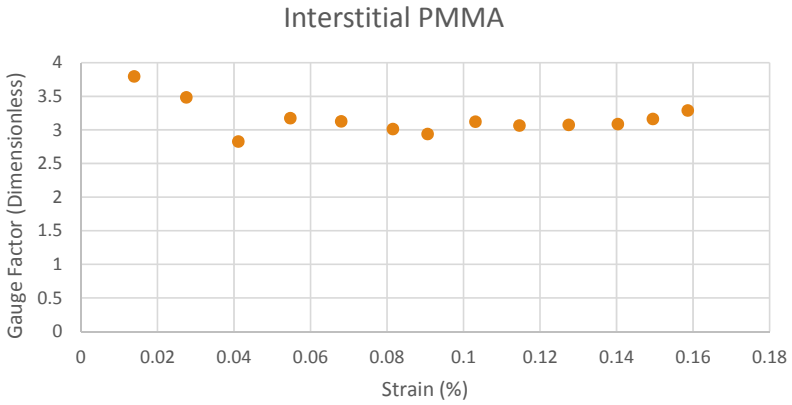
Most Successful Sample Procedure:

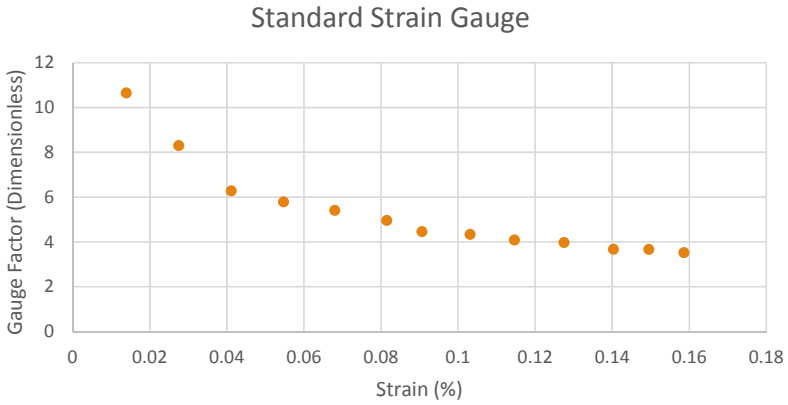
I. 135 µL PMMA spin-coated
II. Heated 135 °C, 3 mins
III. 20 µL PMMA dripped
IV. Three PET strips laid
V. Heated 135 °C, 20 mins
VI. Scratches made between strips
VII. Etched in $FeCl_3$ for 24 hours
VIII. Dried naturally/heating
IX. Fabricated and tested gauges





Results


Interstitial PMMA
Gauge Factor (Dimensionless)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Strain (%)


Standard Strain Gauge
Gauge Factor (Dimensionless)
12
10
8
6
4
2
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Strain (%)

Discussion

Initial sensitivity:

1. Initial Compression
2. Initial Tension

Almost all gauges non-flat prior to testing

Small G.F: Change in Resistance doesn’t compensate for increase in strain

Conclusion

Interstitial PMMA: Most consistent with highest G.F of 3.8

Small gauge factors consistent with industry foil-based gauges

Source of error: Fabrication Technique

Future Research:

1. Effect of Graphene quality + Number of layers
2. Enhance fabrication method

Questions?

References

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Jing, Zhao, Zhang Guang-Yu, and Shi Dong-Xia. “Review of Graphene-based Strain Sensors.” (2013): n.pag. Web.

Acknowledgements

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