# Biosensing With Graphene

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## Introduction

- I'm working primarily on a substance called Graphene.
  - Graphene is the single-layer version of graphite, made out of carbon atoms in a hexagonal lattice.
- One of the properties of graphene is conductivity, and this particular property facilitates our experiment of sensing HIV RNA/DNA in our samples.

Image 1: Graphene

- Using graphene for biosensing allows us to diagnose HIV effectively and efficiently.
- For our detection, we used Silicone Oxide wafers with Gold etching to flow current through them.
  - Chips have gaps in the channels to be filled with Graphene to detect samples

## Process Description

- **GFETs** (Graphene Field Effect Transistors) are used to detect HIV RNA/DNA through changes in current

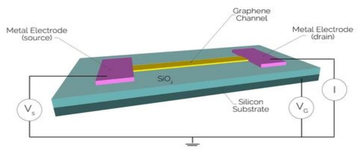


Image 2: GFET Model

- We use **Chemical Vapor Deposition** to grow our single-layer graphene.
  - Step 1) We put a quartz block with copper foil into a 1000 degree celsius furnace.
  - Step 2) Furnace is constantly flowing Methane and Hydrogen gas so that the carbon atoms get deposited onto Cu foil
- We transfer the graphene onto our GFETs with the **Bubble Transfer Method**
- **Exposure and Incubation**
  - Exposure allows for graphene covering electric channels
  - Incubation allows for samples to bind to graphene for detection

## Graphene Growth and GFET Wafer


Image 3: Graphene 4" Furnace at 1000 degrees C

Image 4: Silicone Oxide Wafer with Au patterned GFET chips

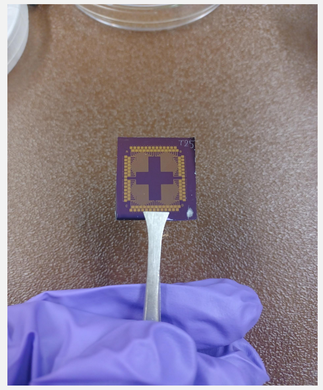

Image 5: Single GFET chip with 52 (?) device channels

## Cu foil with Graphene onto Chip

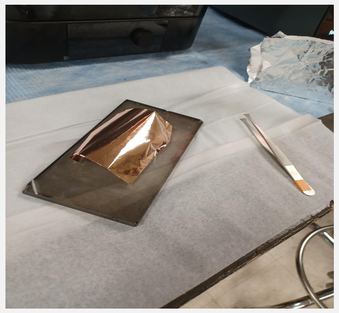

Image 6: Cu foil on Quartz Block covered with Graphene from Furnace

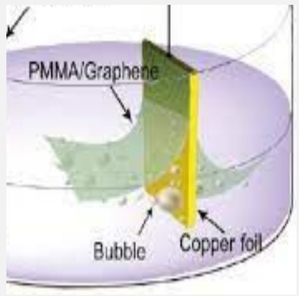


Image 7: Bubble transfer Method
(In our research, PMMA is on one side)

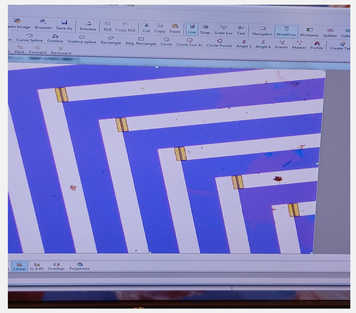

Image 8: Graphene-covered channels on GFET chip after exposure to UV ⇒ closing circuit.

## Dirac Voltage (DV) Curve: Unfunctionalized vs. Functionalized

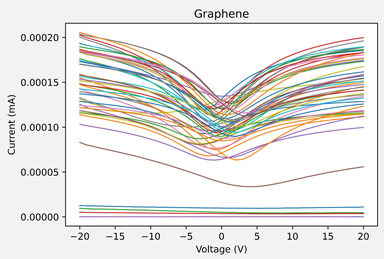


Image 9: DV Curve Unfunctionalized

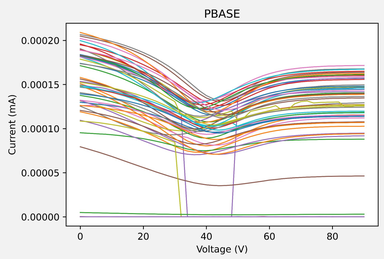


Image 10: DV Curve after PBASE

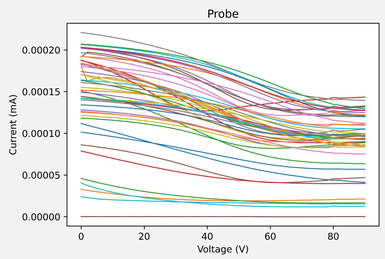


Image 11: Curve after Probe

# Key Learnings

## Graphene Growth

- The most efficient way to produce graphene is through **Chemical Vapor Deposition**
  - Graphene was first made with pencil shavings and tape, CVD is used for large scale production
- **Graphene is used in multiple forms**
  - 2D Graphene/ Single sheet
  - 1D Fullerene
  - Carbon Nanotubes

## Graphene Transfer and Development

- Bubble Transferring is the main method to put graphene onto our chips
  - We use NaOH acid to act as a medium for our current.
  - Put source 20 V into the NaOH and the drain connected to the graphene Cu foil to close the circuit
- After graphene is on GFET, we selectively expose the chip to UV rays to only cover our gaps

## Chemical Bonds, Incubation, Data Collection

- **Linker Molecule**- Pyrene (PBASE)
- **Probe/Aptamer Molecule**
- **Target Molecule**- RNA
- These molecules, in conjunction, help our RNA/DNA bind to the system
- We incubate for about 3-6 hrs depending on the length of RNA/DNA
  - 22-mer or 80-mer
- After each molecule binding, we take run current through the chip to see how the voltages shift
  - Indicates efficacy of binding

## References

- Image 1: https://www.buchi.com/en
- Image 2: Graphene News
- Image 7: Bulgarian Journal of Physics