Spin Transport across Graphene-Metal Interfaces

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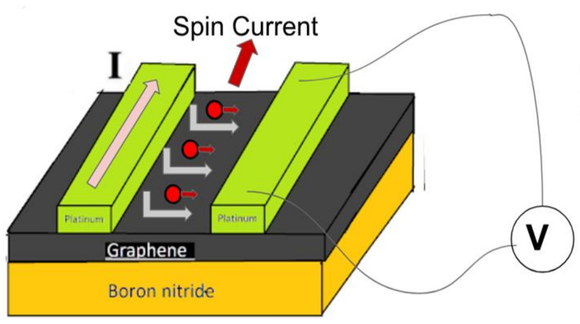
Abstract

This research aims to improve the efficiency and performance of graphene spintronic devices. Graphene spintronic devices use graphene as a channel to transport electron spin that can be used to process information. Theoretically, graphene has a relatively long spin diffusion length and long spin lifetimes at room temperature compared to other conductors; however, the experimental results of the spin relaxation time for graphene do not meet the theoretical predictions. In addition, the poor spin injection efficiency from the contact metal to graphene is also preventing the development of efficient graphene spintronic devices. To overcome these challenges, we employ a dry transfer method to fabricate the contact between the graphene and the metal electrodes. Using this method to transfer the contact metal onto the graphene, instead of physical vapor deposition techniques such as electron beam evaporation, could potentially lead to a defect-free interface as well as improve the spin injection efficiency.

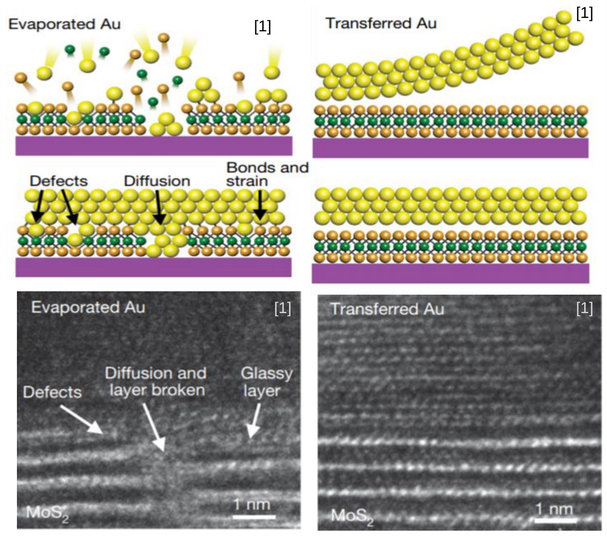
Introduction

- Spintronic devices can process information using spin current
- Graphene has the ability to transport electron spin for long distances
- Spin injection is an important parameter to improve the performance of spintronic devices



Motivation

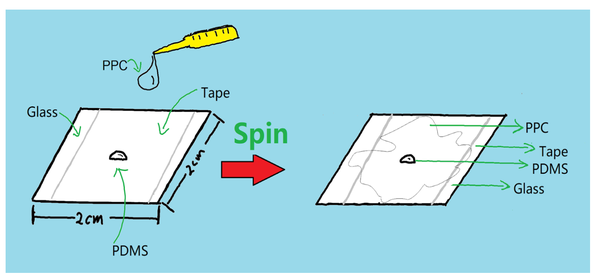
- Chemical evaporated vs. Physical transfer method
- Chemical disorder causes serious sample damage



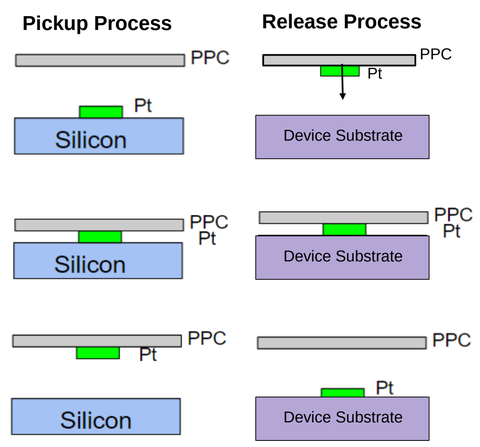
Dry Transfer Process

Template Stamp Prepare

- PPC is the main material to make the sample stick to the template
- PDMS can help to align the precise point for contact



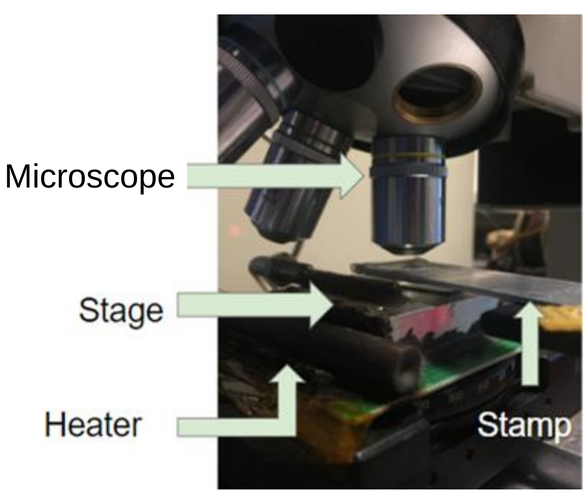
Dry Transfer Process



Experimental Setup

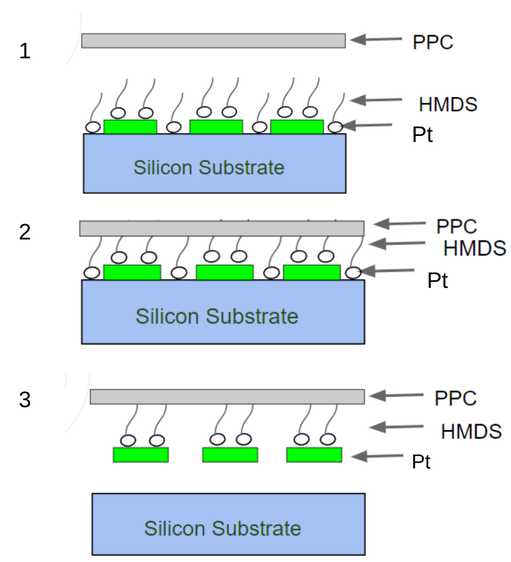
Dry Transfer Tool

1. Heat up the sample
2. Align the stage with the stamp
3. Lower the stamp down
4. Let the stamp contact with the sample
5. Lift up the stamp
6. Switch the substrate and repeat all the steps



Unique Process for Platinum Dry Transfer

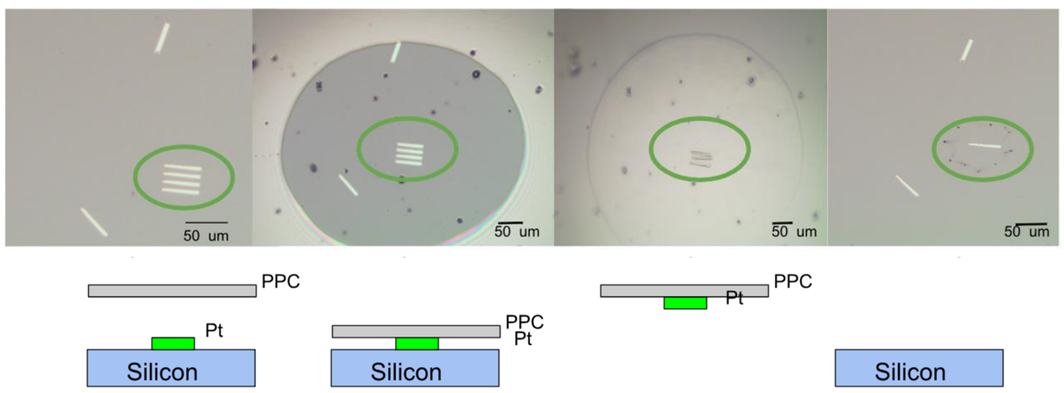
Hexamethyldisilazane (HMDS) is a self-assembled monolayer that helps adhesion between Pt and PPC



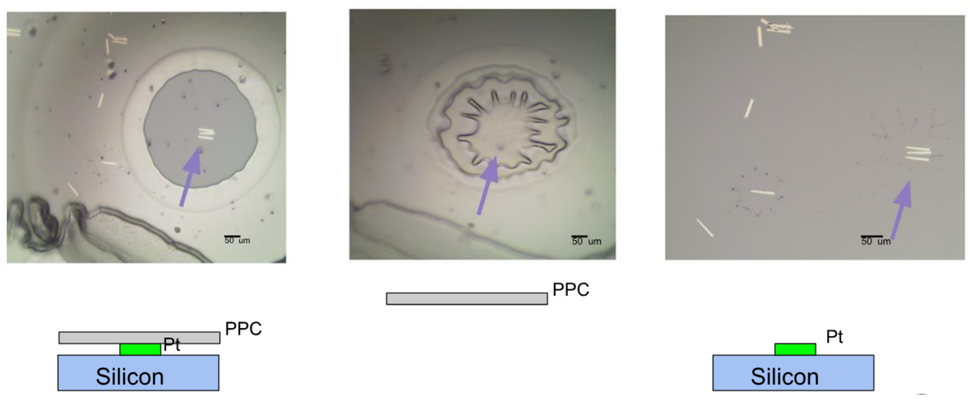
Results

- **By coating the HMDS layer, the recipe for dry transfer of platinum thin films was developed**

Pickup Process:



Release Process:



- **Successfully replicated previous experiments of dry transferring BN; therefore, we are able to dry transfer all the material (BN, graphene, and Pt) for graphene spintronic device fabrication**

Material	Pick-up Temperature	Pick-up Contact Time	Release Temperature	Release Contact time
Boron Nitride	40°C[2]	Light Contact*	110°C[2]	Light Contact*
Graphene	40°C[2]	Light Contact[2]*	110°C[2]	Light Contact[2]*
Platinum	75°C	5 minutes	125°C	Light Contact*

*Light Contact: the PPC template lightly touching the substrate for approximately 10 seconds

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References

[1] Liu, Yuan, et al. "Approaching the Schottky–Mott limit in van der Waals metal-semiconductor junctions." *Nature* (2018): 1.

[2] Pizzocchero, Filippo, et al. "The hot pick-up technique for batch assembly of van der Waals heterostructures." *Nature communications* 7 (2016): 11894.

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Support Information
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