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Major in physic
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Developing new stamping techniques for ultra-large atomically thin 2D crystals

The motivation to explore 2D material

Two-dimensional (2D) materials, sometimes referred to as single-layer materials, are crystalline materials consisting of a single layer of atoms. These materials have found use in applications such as photovoltaics, semiconductors, electrodes and water purification.
The first 2D material, graphene, a single layer of graphite, was isolated in 2004. Thereafter many other 2D materials were identified.
Many great discoveries have been made since then and Nobel Prize have been awarded to the scientists in this area.

The exfoliation of graphene

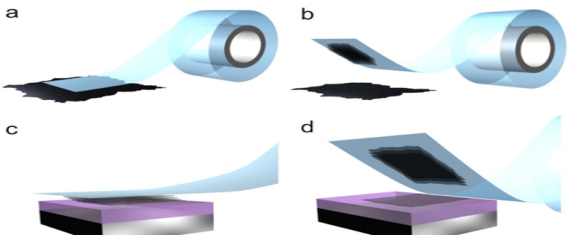

Figure1: the scotch tape method

The scotch tape method.

1) Use the scotch tape to exfoliate some layers from the graphite, as shown in (a) and (b). and cleave several times until the graphite on the tape thin enough.
2) Clean the surface of the silicon wafer with acetone and isopropanol, and finally oxygen plasma.
3) Stick the tape to the silicon wafer and heat the entity at the temperature of about 120 ℃.
4) Peel off the tape and observe the few layers or even the monolayers on the microscope

Figure2 Figure3

(Figure2 and Figure3 are pictures captured during my experiment and they are few layers and monolayers of graphene)

Metal assisted manipulation

There are also a number of 2D materials in the world, and their properties are similar to the graphene. And we can use the similar method to exfoliate them.

Figure4 Figure5

(Figure4 is the pictures of MoS_2 on the scotch tape. Figure5 is the pictures of MoS_2 on the silicon wafer, and the image is captured under the microscope. The blue parts are the few layers or monolayers)

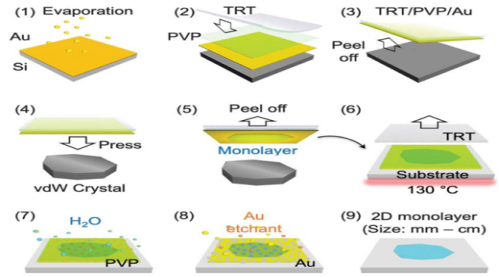

Figure6 : metal assisted exfoliation.[1]

1) Deposit about 3nm gold on the silicon wafer.
2) Peel off the gold film with the PC film.
3) Use the gold-PC entity to peel off the top-layer of the crystal.
4) Drop down the monolayer on another silicon wafer.

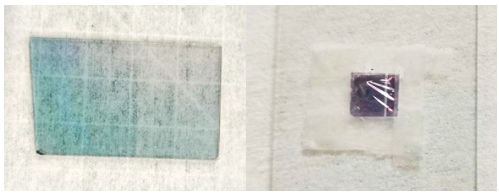

Figure7 Figure8

(Figure7 is the image of gold film on PC/glass, Figure8 is the image of gold/PC film on the PDMS/glass)
The previous method is the way to exfoliate the few layers or monolayer for TMDCs, we also find a way to move the few layers.

Figure9 Figure10

(Figure9 and Figure10 are the image of PDMS micro dome)
We can make PDMS micro domes to control the micrometer sized flakes on the substrate. And with the help of transfer stage, we can actually have fully control of the flakes.

Figure11 Figure12

(Figure11 is the position before movement, and Figure12 is the position after movement. By detecting the surroundings, we will notice that the flake did moved)

Future directions and applications

Many of the 2D materials are under close consideration for a number of industries, in areas including electronics and optoelectronics, sensors, biological engineering, filtration, lightweight/strong composite materials, photovoltaics, medicine, quantum dots, thermal management, ethanol distillation, electromagnetic shielding and energy storage, cryptography and have enormous potential.

Reference

1. (Figure 6) F. Liu, W. Wu, Y. Bai, S.H. Chae, Q. Li, J. Wang, J. Hone, X.-Y. Zhu, *Science* **367** (6480), 903-906 (2020).