Graphene Fabrication with a Motorized Linear Stage Based on the "Scotch Tape" Method

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Introduction:

With its amazing electrical and optical properties that grant potential applications of ultrafast transistors, liquid crystal display (LCD) screens, solar and fuel cells, and so forth, an efficient method to fabricate graphene is very important. Based on the principle of the "Scotch tape" method, a mechanical approach using a motorized linear stage is demonstrated to systematically isolate graphene from graphite. Previously graphene was produced by manually splitting graphite flake with adhesive tapes. Since a manual approach is unfavorable for consistent and stable results, a mechanical setup is considered to simulate the process of "folding" and "peeling" in the "Scotch tape" method.

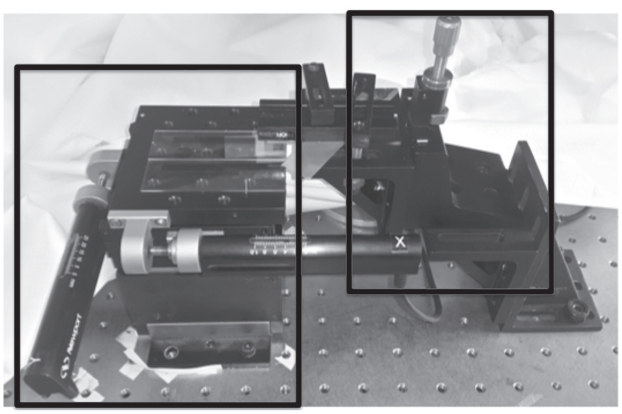

Figure 1: The motorized XYZ linear stage and manual Z-axis translational stage.

The LabVIEW Program:

A LabVIEW program was designed specifically for the motorized linear stage, running in a Virtual Instrument Software Architecture (VISA) supported operation environment. After VISA was initialized and a new session was opened, the motor would be turned on and the desired channel (any of the x, y, z positioners) was selected to receive further commands. Then the stage entered the phase of creating the designated patterns of thin layers of graphite from a single thick flake by moving in x, y, z directions in a chosen sequence. Finally, the motor was turned off and the session was closed.

The Mechanical Setup:

A systematic alternative to the "Scotch tape" method involves the mechanical setup of a motorized XYZ linear stage and a manual Z-axis translational stage, both of which are products of Newport Corporation, Irvine, California.

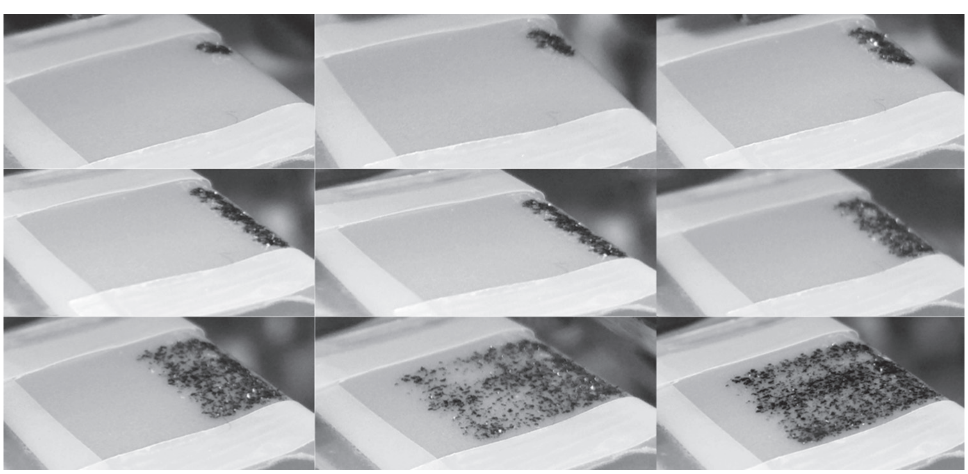

Figure 2: The process of forming a line of flakes from dots and that of forming a block of flakes from lines.

One piece of Scotch tape was attached to a piece of glass slide fixed on the motorized stage; another piece of tape was attached to an aluminum slide, which was mounted on the manual stage. When the basic setup was completed, the system was ready to create the pattern of thin layers of graphite.

As the program was running, the motorized stage would move up and down so that the first flake was halved. Then the controller would command the y-positioner to move a unit distance and repeat the z-axis movement to make the second flake "dot." On either of the two pieces of tapes, there would appear 1 dot, 2 dots, 4 dots, and 8 dots in sequence (Figure 2). Similarly, as the first line had been made, the controller would direct the x-positioner to move a unit distance and then had the z-positioner perform the z-axis movement, which would ultimately lead to the formation of a whole block of thin layers of graphite. When the setup was set to make the whole block of thin layers of graphite automatically, after the two pieces of tape were fixed in the desired positions, the entire process took approximately 20 to 30 minutes.

Peeling Angle:

In the further investigation of the capacity of the mechanical method to fabricate graphene, the angle between the two pieces of tapes was taken into consideration. In the application of the basic method of producing a block of thin layers of graphite described in the last section, the angle between tapes was 0 degree. It was found that samples made in this way contained much more thick flakes of graphite than those produced with the manual "Scotch tape" method, which has 180 degrees of angle between two pieces of tapes. A sample environment that has more thick flakes usually has a lower possibility of containing graphene. Also, the "Scotch tape" had already been tested to be successfully in producing graphene. Therefore, it was presumed that a larger peeling angle would be more capable to create thinner layers of graphite.

Two types of mechanical setup, which involved the usage of springs, were proposed (Figure 3).

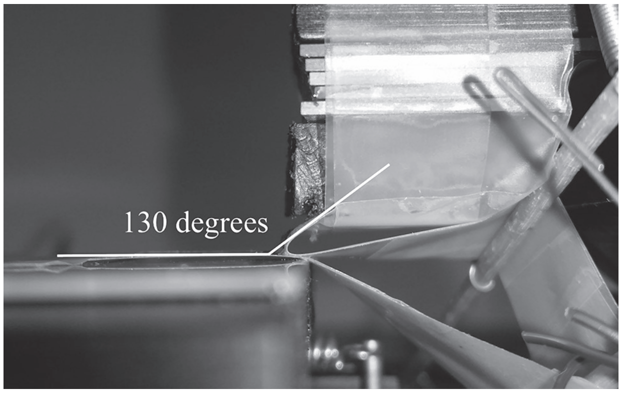

Figure 3: A proposed setup that includes four springs and has a 130° peeling angle.

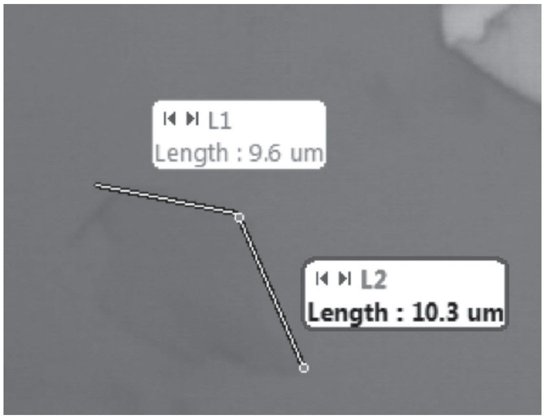

Figure 4: The graphene flake produced with 0 degree peeling angle and manual z direction movement.

Results and Future Work:

From the resulting block of thin layers of graphite as well as the sample under optical microscope, it was found that the zero peeling angle method was more capable of producing consistent samples even though it might not necessarily have higher possibility in fabricating graphene. Also, with a larger peeling angle, the sample appeared to have a lot of long glue on it, which was from the tape and could unfavorably cover graphene if there was any.

Currently, with no less amount of thick flakes, even more glue on the sample, and higher possibility of contamination due to more steps in the procedures, the methods with larger peeling angles do not seem to help produce samples of higher quality. However, if these problems can be resolved, the setup that can achieve 130 degrees peeling angles can still be promising since it is closest to the "Scotch tape" method, which has 180 degrees peeling angle and has been proved to be capable of providing productive results.

So far one flake of graphene with acceptable size (8 µm × 8 µm) has been produced with 0 degree peeling angle and manual z direction movement (Figure 4). We will still need to enhance both methods to see which one has higher potential to produce as many and large area of graphene as possible.

Acknowledgements:

I wish to thank Harvard University, CNS, and the NNIN REU Program, my mentor, Dr. Sagar Bhandari, and my PI, Dr. Robert Westervelt, my site coordinator, Dr. Kathryn Hollar, and the National Science Foundation for funding via Grant No. ECCS-0335765.

References:

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