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Fabrication of graphene based on laser induced shock wave

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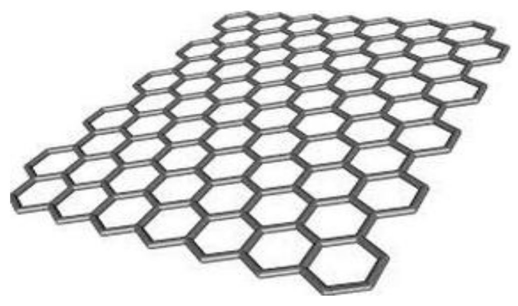
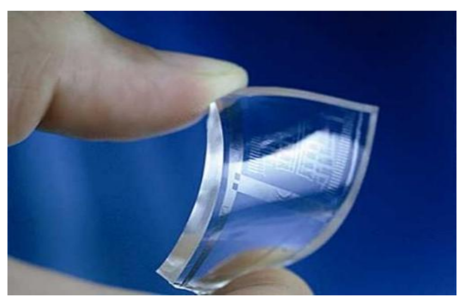
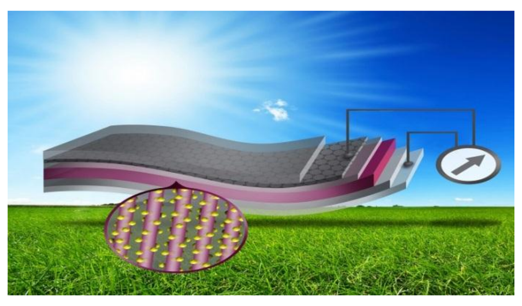
1. Introduction

Graphene, a 2D honeycomb lattice of carbon atoms, has generated many research interests due to its exotic properties in electronic, optical, etc. This project seeks to look at producing an industrially scalable method to produce large quantities of defect-free graphene, currently impossible.



Schematic of Graphene[1]





Graphene potential in Electronic[2] and Solar Cell[3]

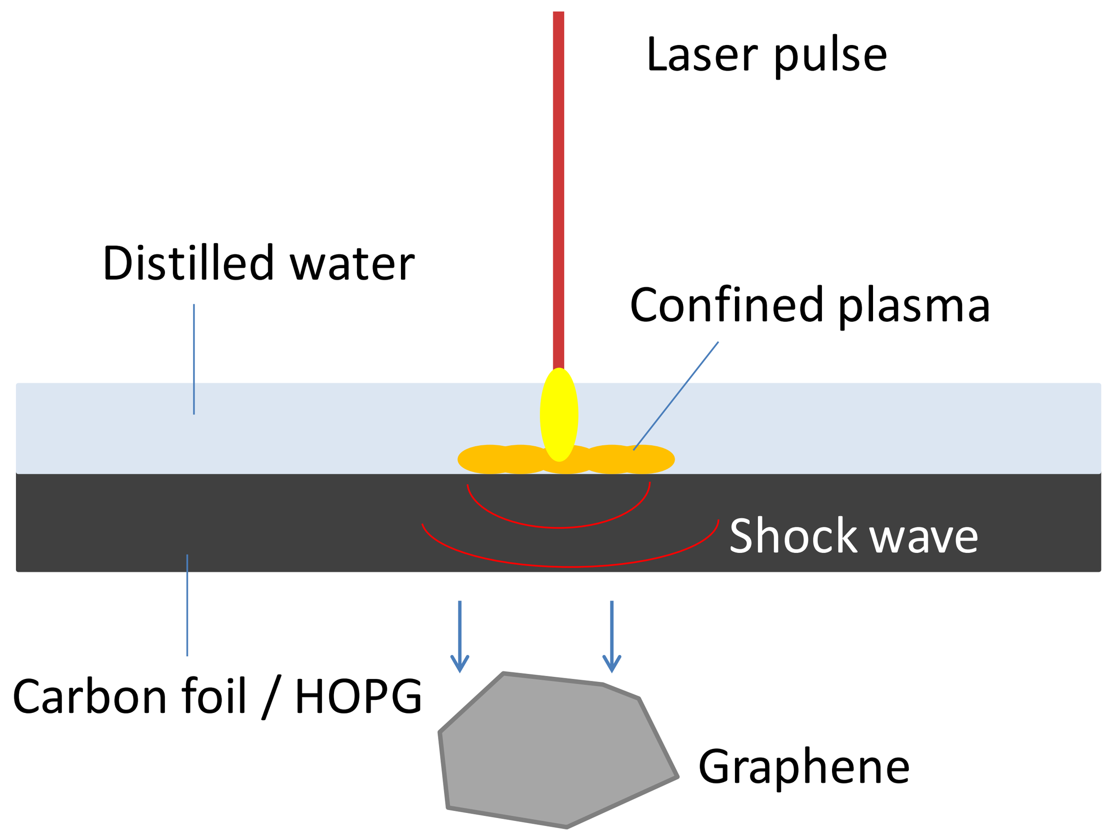
2. Objective

The process mechanism targeted is to fabricate graphene using a shock wave induced by a laser, collecting ejected graphene flakes from the rear. Theoretical model will be built to understand the underlying physics process to position the graphene deposition. Success of this project could also bring a new route to fabricate other 2D materials.

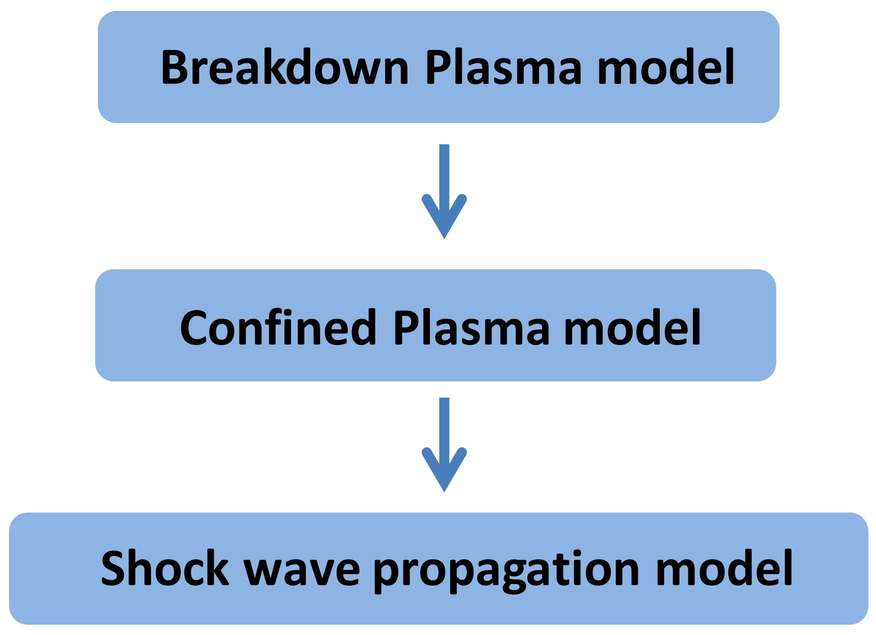
3. Experimental Method

Principle of laser induced shock waves[4]

When a laser beam of sufficient intensity strikes a material surface, thermal diffusion from the surface is limited due to the rapid energy deposition time. The heated material vaporises and achieves high temperature, whereupon electrons are ionized to form a plasma. The plasma absorbs the energy and causes a shock wave by its expansion. A transparent overlay can be used to confine the expansion of the plasma increasing the pressure on the substrate.



Laser generated shock wave with water confinement.



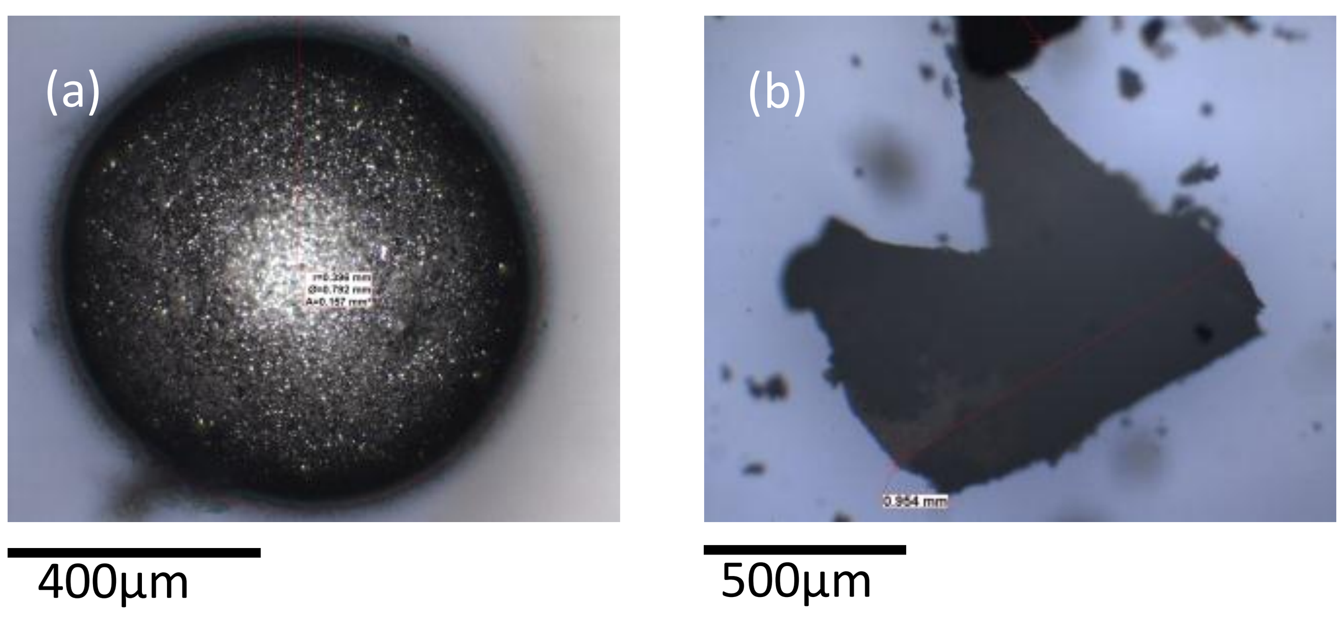
Theoretical model.

4. Results and discussion

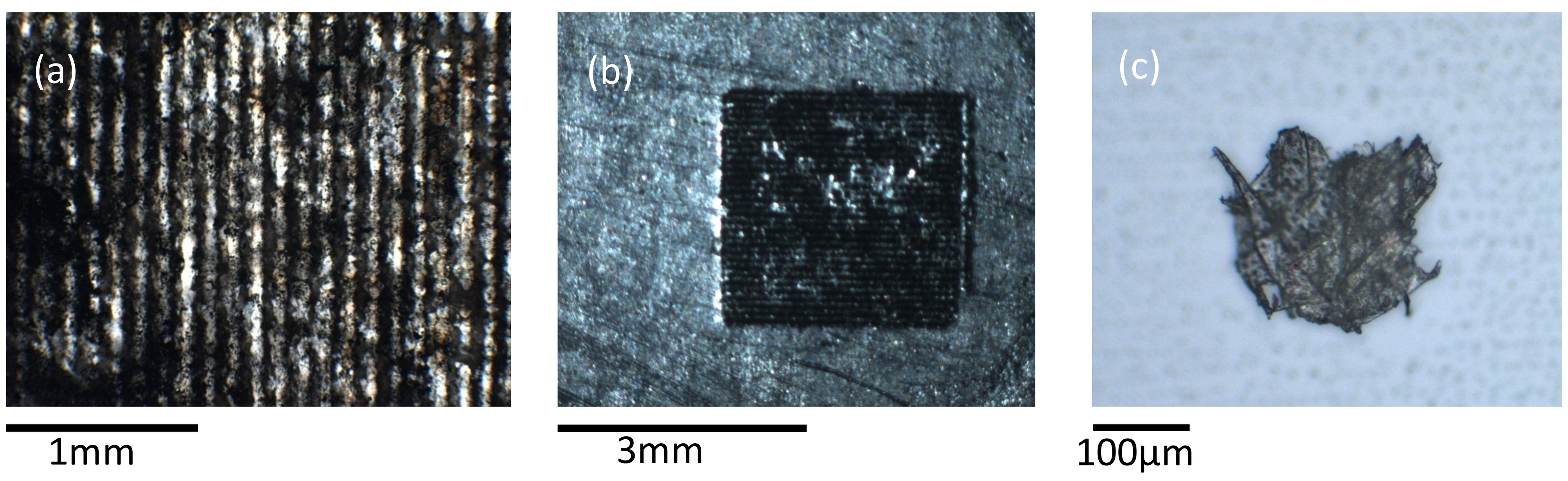
Substrate used for these experiments: carbon foil - 10 mm x 10 mm x 0.5 mm

Satsuma laser: 500 kHz, 280 fs, 2.32 W, water assisted. Flakes were observed on the interaction surface but no evidence from the rear.

SPI G3 laser: 25 kHz, 200 ns, 20 W, not water assisted. Flakes from the rear surface were firstly observed on a glass slide and then collected by a water filled cuvette.



Flakes that peeled off from the interaction surface during (a)spot processing. (b)area scanning.



Images of (a)glass slide against the rear surface (b) the rear surface of carbon foil and (c) typical flake collected from the rear surface.

5. Conclusions and future work

Conclusions

- Micro size (~400µm) flakes can be produced on the interaction surface (500 kHz, 280 fs, 2.32 W).
- Smaller (~200µm) flakes can be fabricated from the rear surface(25 kHz, 200 ns, 20 W).
- The structure / composition of the eject has yet to be assessed.

Future work

- Further shock processing using a range of high peak power lasers and additional materials, both with and without water coatings.
- Structural and chemical assessment of the generated flakes using techniques like Raman Spectroscopy and TEM.
- Theoretical modelling on shock processing and analysis of results.

References: 1. http://www.nanochemistry.it/download/download.html 2. http://www.ft.com/cms/s/0/d902e60e-b07d-11e1-8b36-00144feabdc0.html#axzz312gpeNIY 3. http://www.laboratoryequipment.com/news/2012/12/graphene-nanowires-team-make-flexible-light-solar-cells visit time: 07.05.2014 4. H. Niehoff, F. Vollertsen, Laser induced shock waves in deformation processing, - Journal of Metallurgy,11, 184 (2005)

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