In-situ TEM patterning and electrical characterisation of graphene

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In-situ TEM patterning and electrical characterisation of graphene

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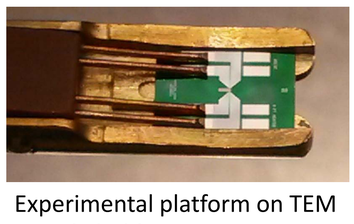
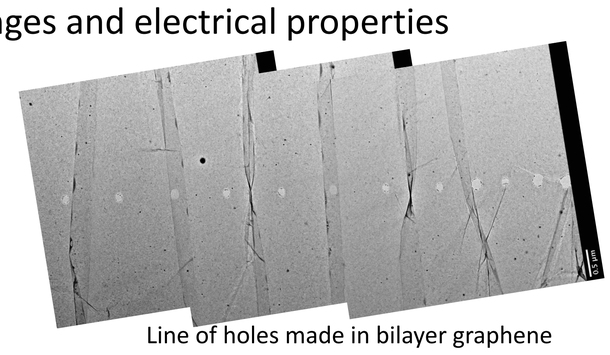
Introduction

- Transmission electron microscopy is an excellent characterisation tool for obtaining information about the graphene structure on an atomic scale
- It can be used to shape the graphene as well as other 2D materials (hBN, MoS_2, etc) through (1) knock-on damage from the beam[1, 2], (2) etching via oxygen or water (in an environmental TEM), (3) nanoparticle induced etching[3].
- We have fabricated silicon microchips that fit into a standard TEM holder, with electrodes to measure the electrical properties of graphene as well as for heating the samples.
- Here we present our preliminary work with graphene in-situ TEM, correlating structural changes and electrical properties



Experimental platform on TEM sample holder

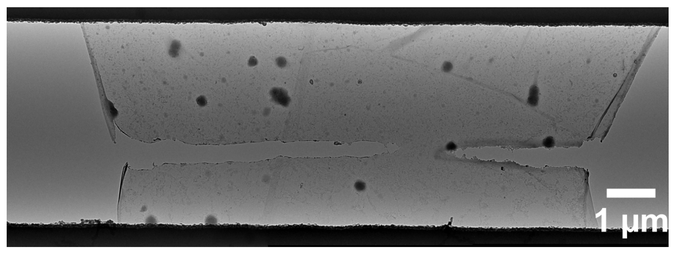


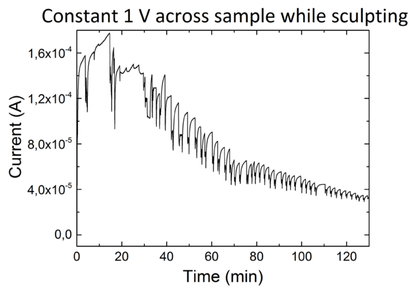
Line of holes made in bilayer graphene

1. "Correlating Atomic Structure and Transport in Suspended Graphene Nanoribbons", Z. J. Qi et al, Nano Lett. 11 (2014), 5184-5188
2. "Atomic-Scale Electron-Beam Sculpting of Near-Defect-Free Graphene Nanostructures", B. Song et al, Nano Lett. 11 (2011), 2247-2250
3. Discrete Dynamics of Nanoparticle Channelling in Suspended Graphene. T. J. Booth et al, Nano Lett. 11 (2011), 2689-2692

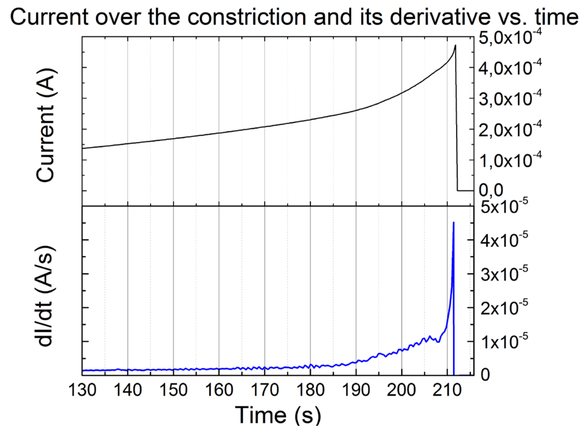
Graphene Constrictions

1. Using knock-on damage we can structure the graphene by focusing the beam to a small area, in this case forming a constriction.

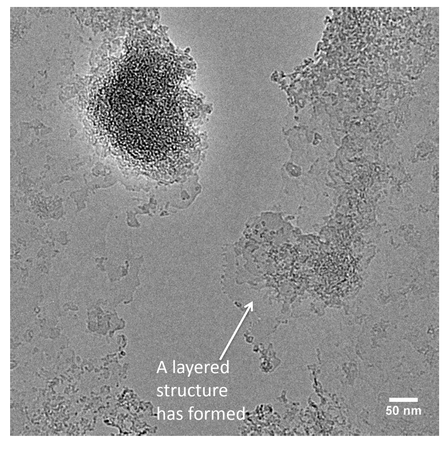




2. After sculpting, the voltage across the constriction was increased until breakage



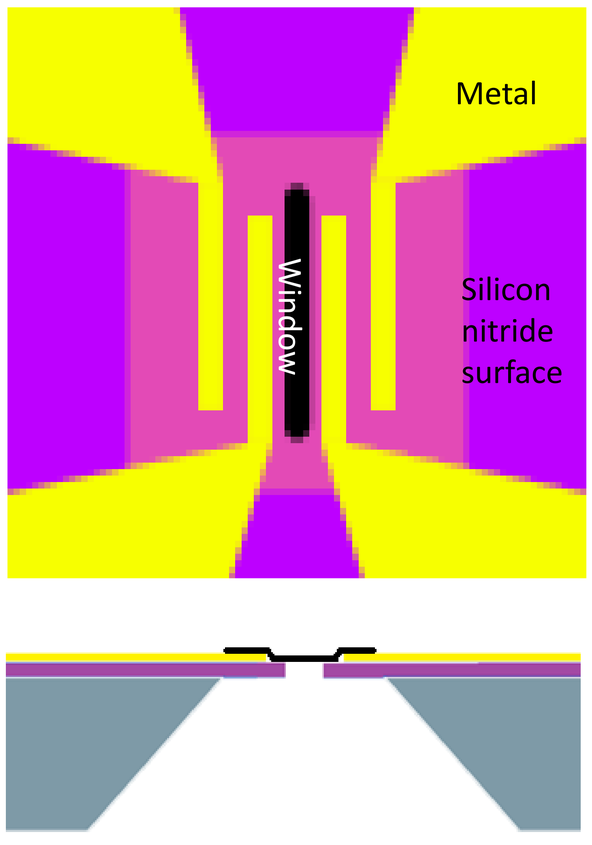
3. High resolution images of the broken area shows some indications of heating



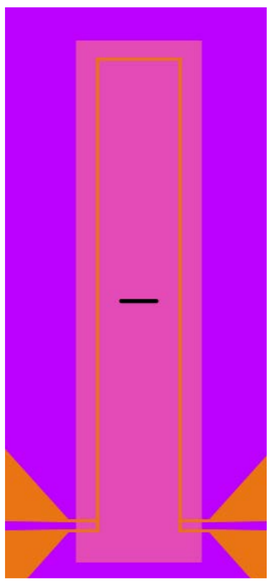
TEM Platforms

TEM chips: Silicon nitride membrane with embedded Pt heaters and surface electrode structures for electrical measurements.

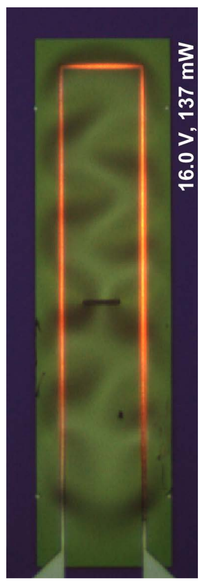
Schematic of the 4 terminal contact chip.



4-point heater structure

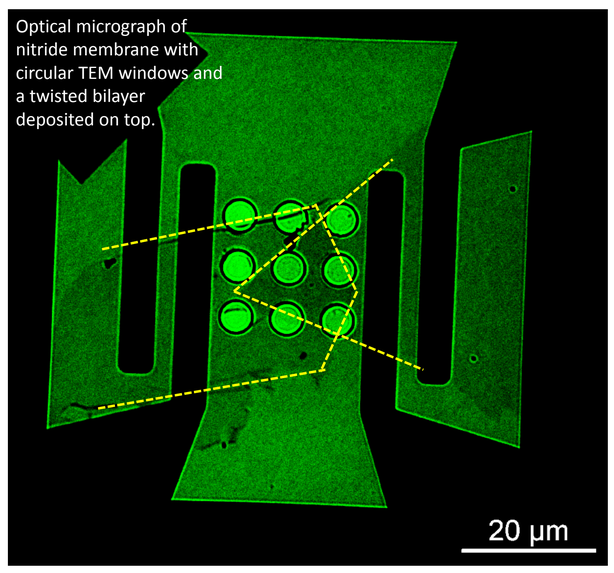


Chip glowing hot in normal atmosphere

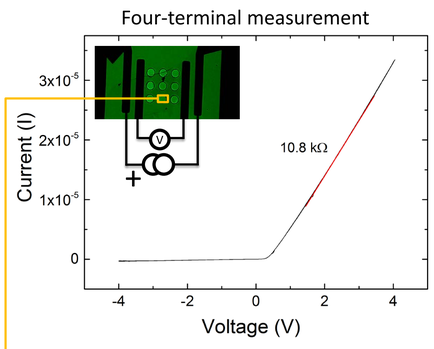


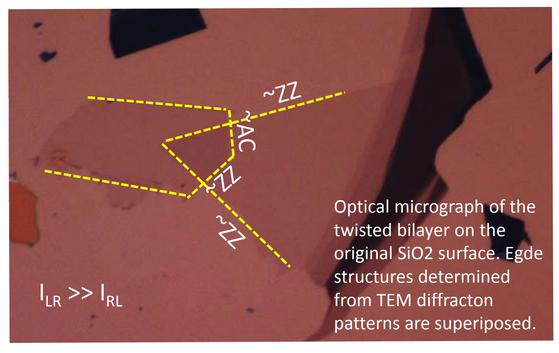
Twisted Bilayers

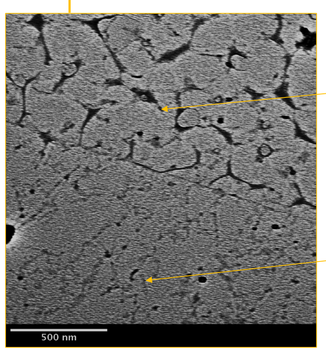
Twisted bilayers - stacked incommensurate monolayers – were made using wedging transfer. The stack is then transferred to the TEM platform.

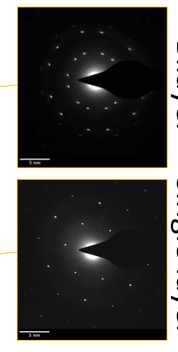


10 twisted bilayer devices were characterised. While most samples showed linear IV characteristics, this sample showed a diode-like behavior









Center for Nanostructured Graphene

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