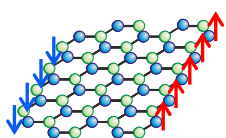


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Background & Motivation

Zigzag (zz) Edge State of Graphene [1]



- Zz edge of graphene possesses localized electronic state at Fermi energy.
- The zz edge state in zz graphene nanoribbon (zGNR) can be spin polarized.

Hydrogen Plasma Etching (HPE)

Hexagonal (hex) nanopits with zz edges are created.



The zz edges are :

- atomically precise
... confirmed by STM/S [2,3]
- terminated by one H atom
... confirmed by HREELS [4]

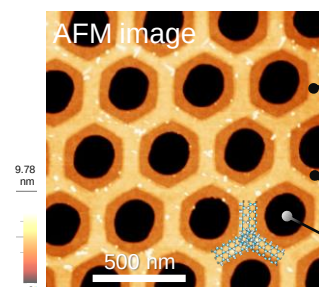
Nanopits are created in two steps (although the detail mechanism is not cleared yet) :

1. Make defects
2. Enlarge the defect into hexagonal shape

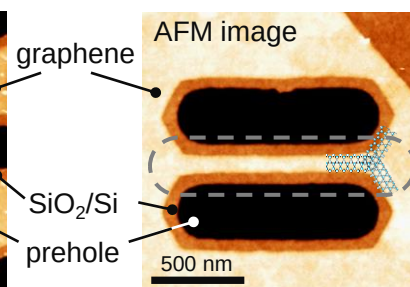
One can align the hex.-nanopits and
fabricate graphene devices with zz edges.If position and the size of the hex.
nanopits is controlled.

Results & Discussion

zGNR network

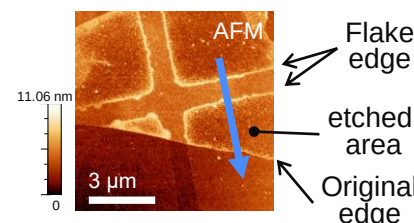
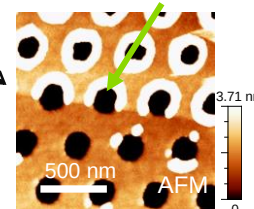


zGNR

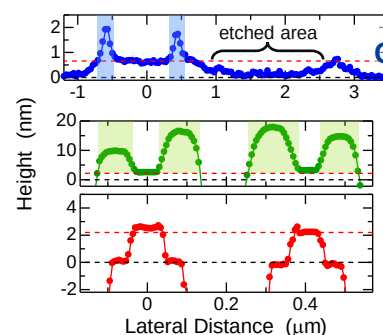


Edge evaluation

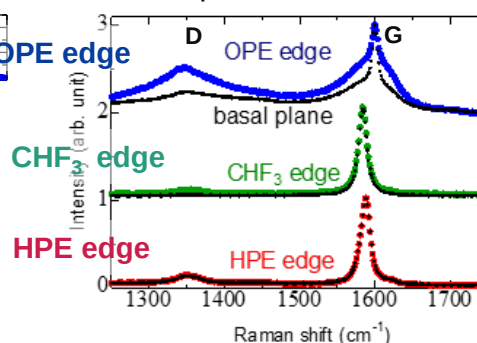
O-plasma etching (OPE)

CHF₃-plasma etching

AFM line profile

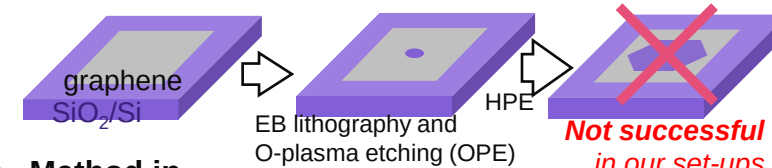


Raman spectrum

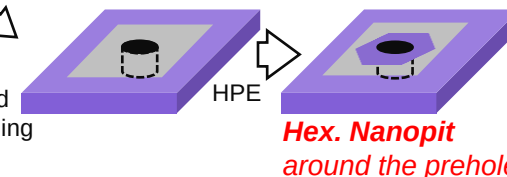


Method

Previously reported method [5]



Method in this work

EB lithography and
CHF₃ plasma etching

Summary

- Successfully established a way to fabricate graphene nano-devices with zz edges by HPE.
 - Defects created by OPE does not work as nucleuses of hex. nanopits in our set-ups.
 - This method is applicable even to thicker graphene.
- HPE edges are sharp unlike OPE and CHF₃ edges.
 - ← AFM line profile
- Graphene is homogeneous to the edge.
 - ← Raman spectroscopy

[1] M. Fujita *et al.*, *J. Phys. Soc. Jpn.* **65**, 1920 (1996).[2] TM *et al.*, *J. Phys. Chem. C* **123**, 22665 (2019).[3] A.E.B. Amend, TM *et al.*, *e-J. Surf. Sci. Nanotech.* **16**, 72 (2018).[4] TO *et al.* in preparation.[5] Z. Shi *et al.*, *Adv. Mater.*, **23**, 3061 (2011).