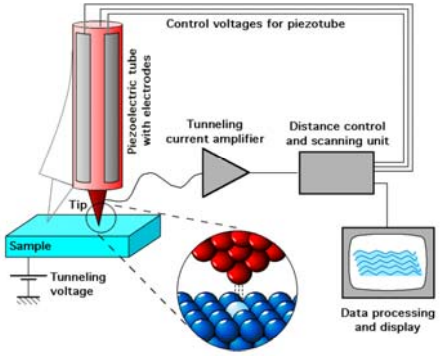
Graphene Visualizes the First Water Adlayers on Mica at Ambient Conditions

Ke Xu, Peigen Cao, James R. Heath

Science 329, 1188 (2010)

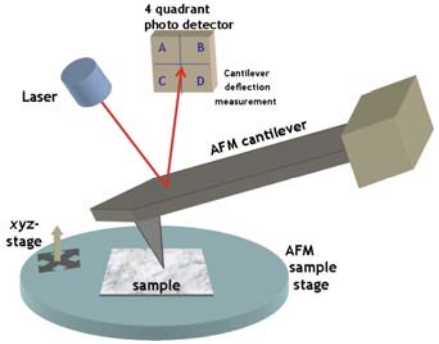
Techniques not suited to study of water in room-temperature

Scanning tunneling microscopy (STM)

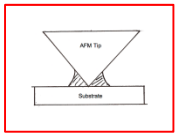


Need ultra high vacuum

atomic force microscopy (AFM)



the capillary menisci formation :



Scanning polarization force microscopy (SPFM) : the lateral resolution of SPFM is relatively low

AFM study of the water adlayer structures on mica under ambient conditions

A difficult water adlayer`s mobility

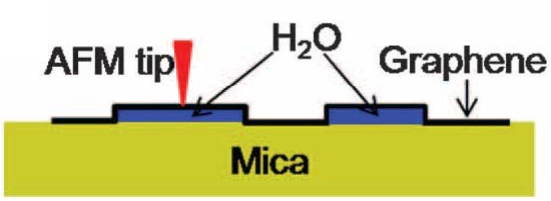
⇩

the use of monolayer graphene sheets (ultrathin coating)

(the standard method of mechanical exfoliation)

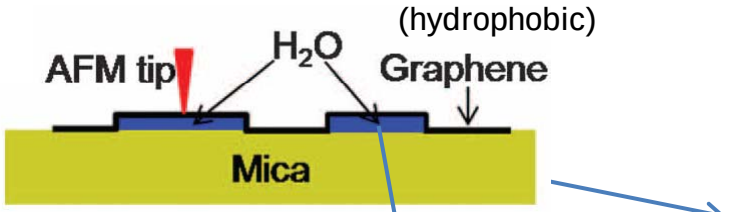
⇩

tightly seal Stably fix



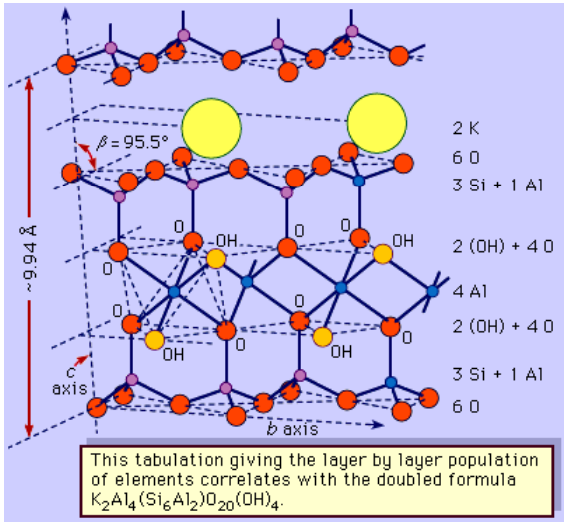
A schematic of graphene

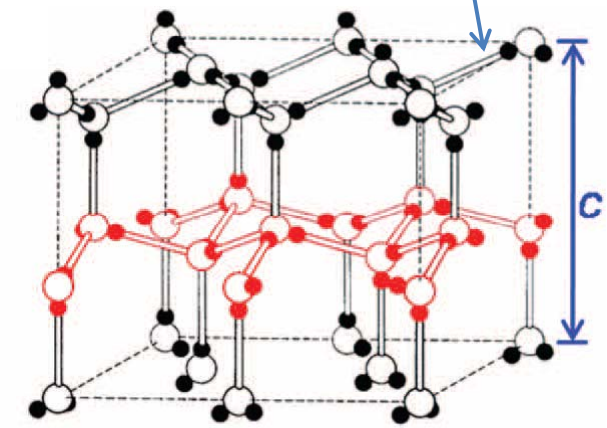
Materials



A schematic of graphene

muscovite: mica structure





A structure of ordinary ice(~0°C)

http://www.britannica.com/EBchecked/topic/398688/muscovite

Humidity-dependent experiments

Ambient humidity experiment (RH=36% to 42%) :

- Graphene deposite on mica at ambient conditions

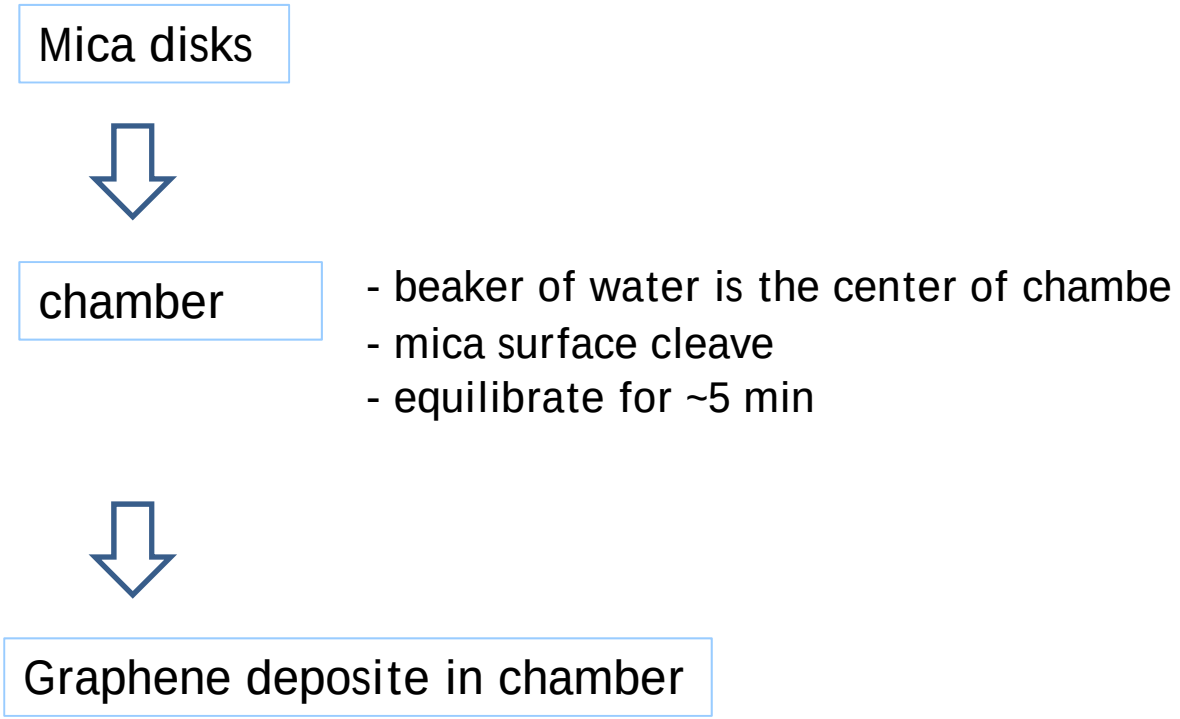
Low humidity experiment(RH = 1.8% to 2.1%):

Mica disks : heat in air at 200 °C for 10 min

- mica surface cleave
- equilibrate for ~5 min
- a continuous flow of ultra-high purity argon

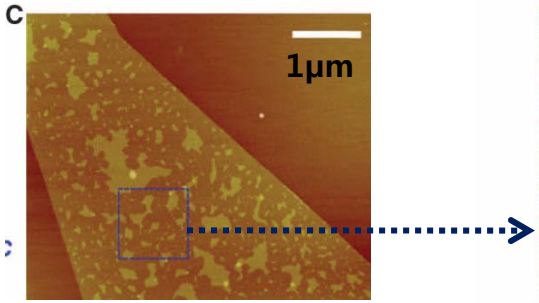
Graphene deposite in glove-bag

high humidity experiment(RH = 89±2%) :

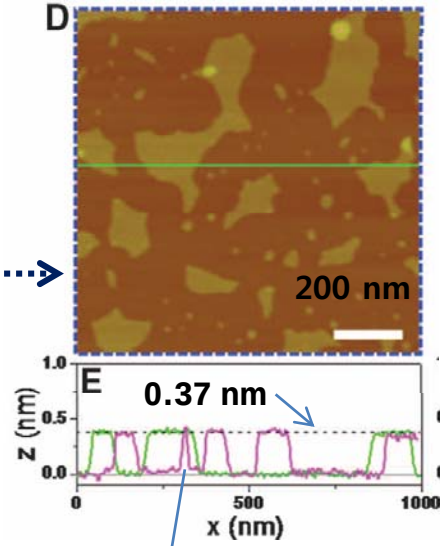


Result & Discussion

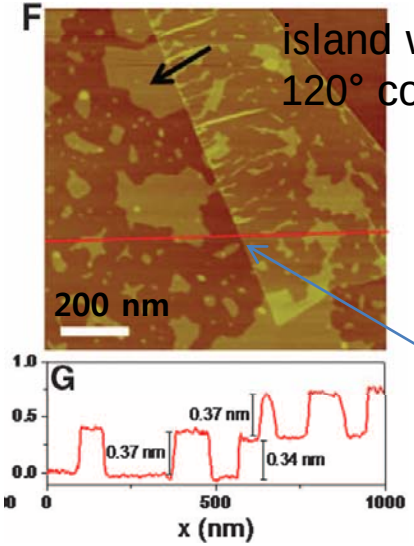
In ambient humidity



(C) AFM image of a monolayer graphene sheet deposited on mica



polygonal shapes



island with multiple 120° corners

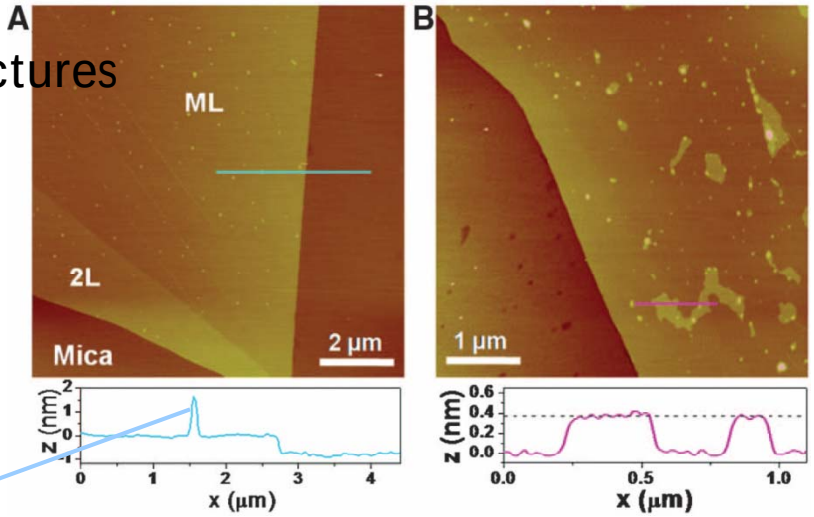
monolayer graphene sheet is folded

- dotlike thicker are surface defects
- surface defects attract water

⇨ the first water adlayer has an icelike structure on the substrate

In low humidity experiment(RH = 1.8% to 2.1%)

No islandlike structures



high density of surface defects

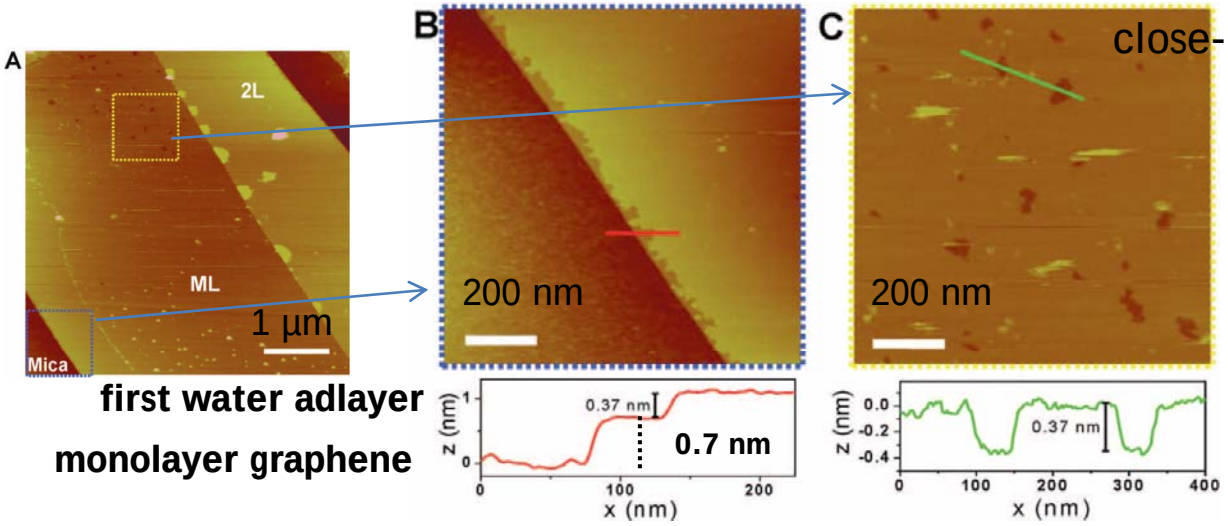
~0.37 nm

- dotlike structures
- surface defects
- no reliably detectable water adsorption on mica surfaces

height of ~0.37 nm indicat single adlayer of water

⇨ - most islands connect nearby defects
- the importance of defects for water adlayer nucleation

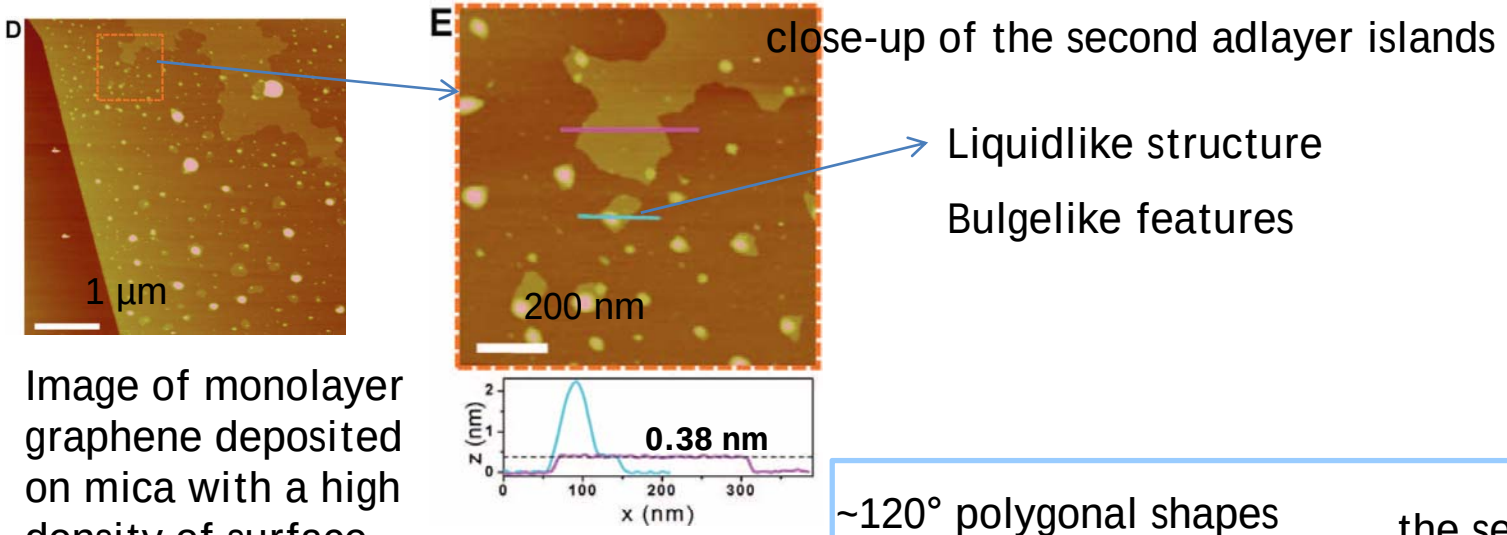
In highhumidity experiment(RH = 89±2%)



close-up of the pinholes

first water adlayer

monolayer graphene



close-up of the second adlayer islands

Liquidlike structure

Bulgelike features

Image of monolayer graphene deposited on mica with a high density of surface defects.

~120° polygonal shapes

SPFM results

⇨ the second water adlayer icelike structure

Conclusion

- Water adlayers grew epitaxially on mica in a layer-by-layer fashion.

- Submonolayers form atomically flat, faceted islands of height 0.37±0.02 nm, in agreement with the height of a monolayer of ice.

- In higher relative humidity, the second adlayers also appear icelike, and thicker layers appear liquidlike.

- Surface defects serve as nucleation centers for the formation of both the first and the second adlayers.