

STM observation of a box-shaped graphene nanostructure appeared after mechanical cleavage of pyrolytic graphite

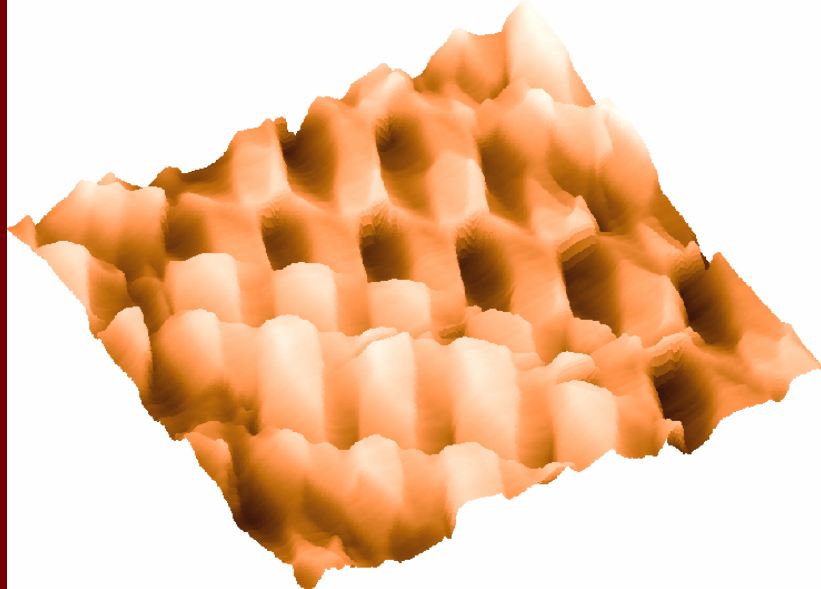
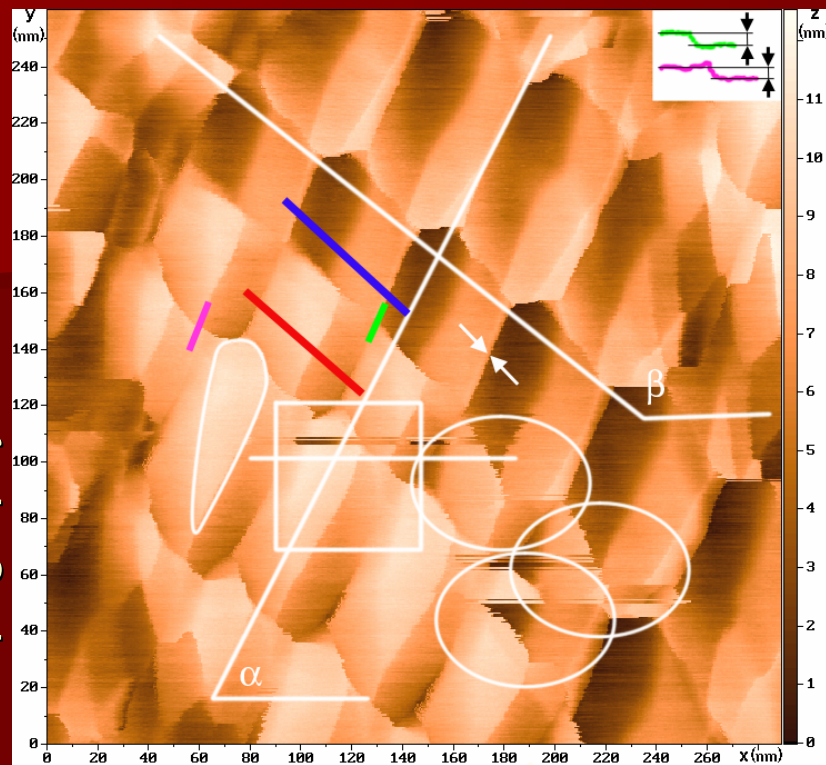
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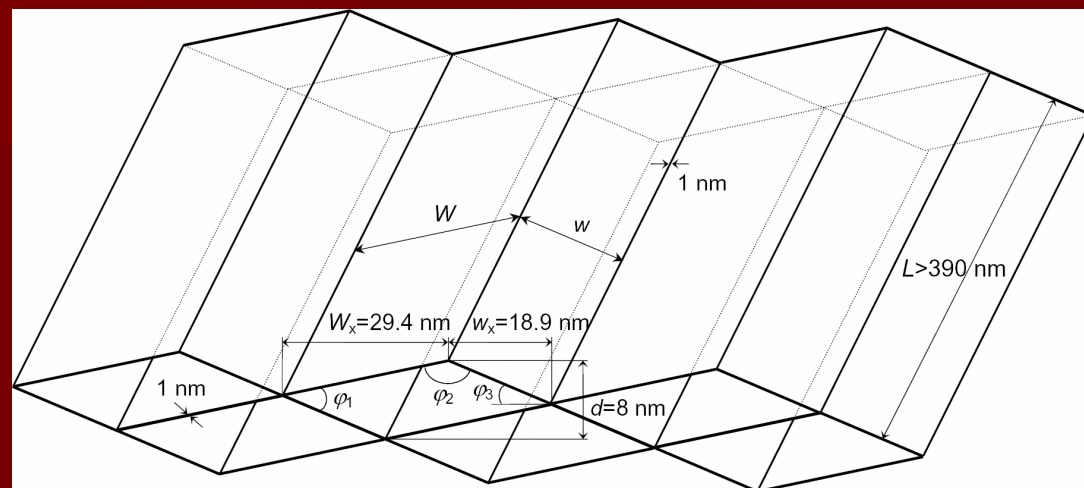
Moscow Institute of Electronic Technology, Zelenograd, Russia

Box-shaped graphene (BSG) nanostructure

STM topography

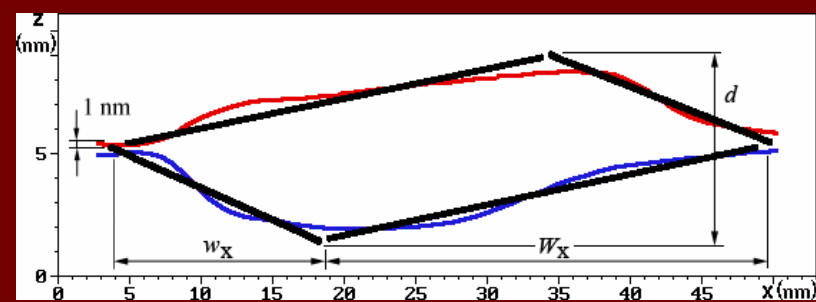


Model representation



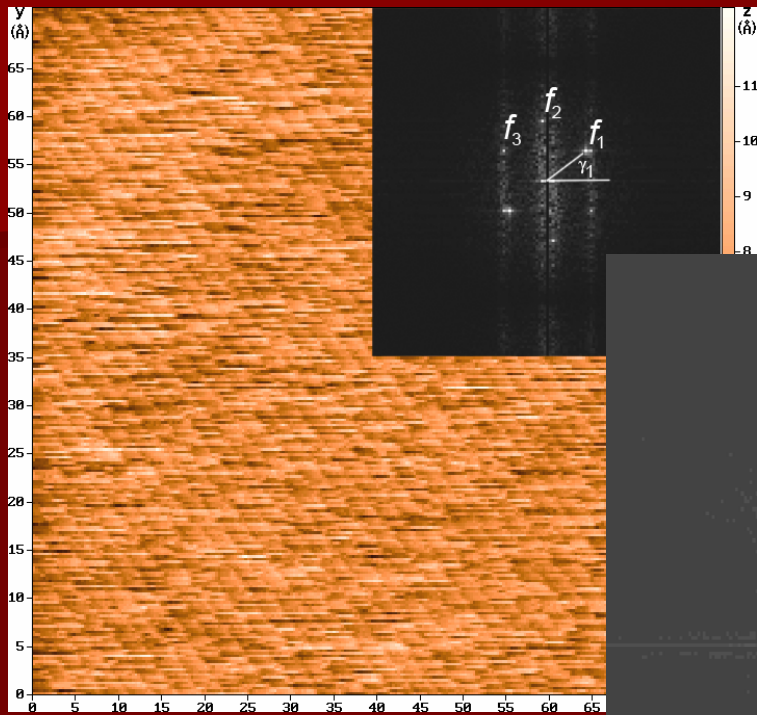
Thickness of the channel facets/walls makes about 1 nm. Width of small facet $w=19.3$ nm, width of large facet $W=29.7$ nm

Cross-sectional view of a nanochannel

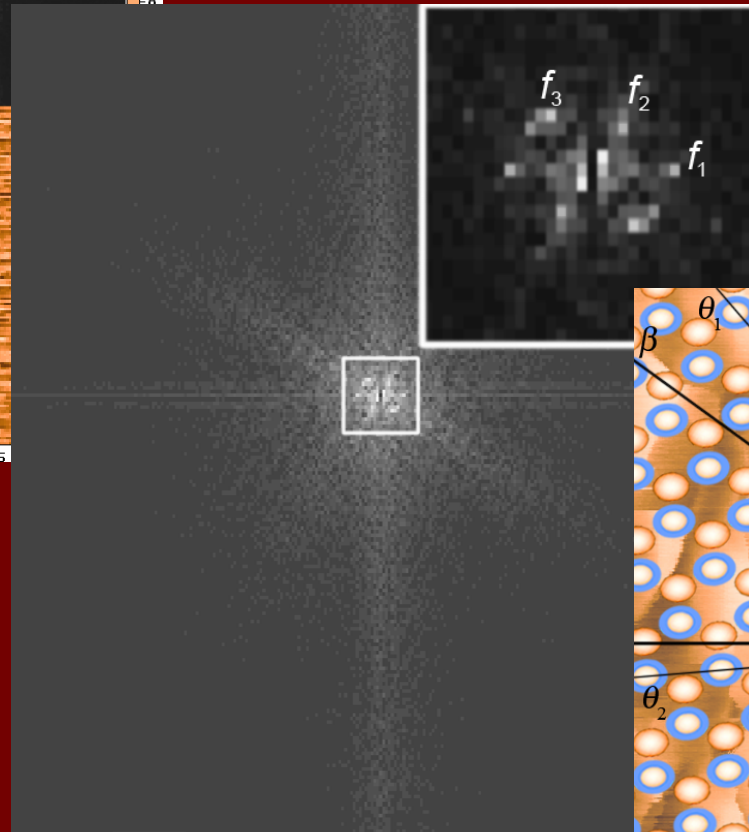


STM image 512×512 pixels obtained in air in constant current mode, $U_{\text{tun}}=50$ mV, $I_{\text{tun}}=890$ pA

Cleavage front orientation

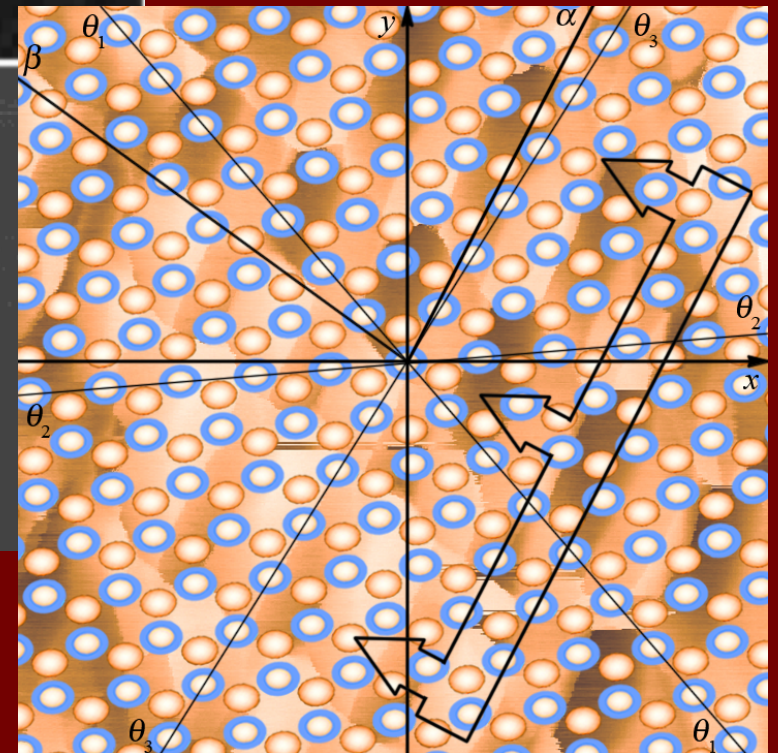


Atomic structure of a facet & its Fourier spectrum

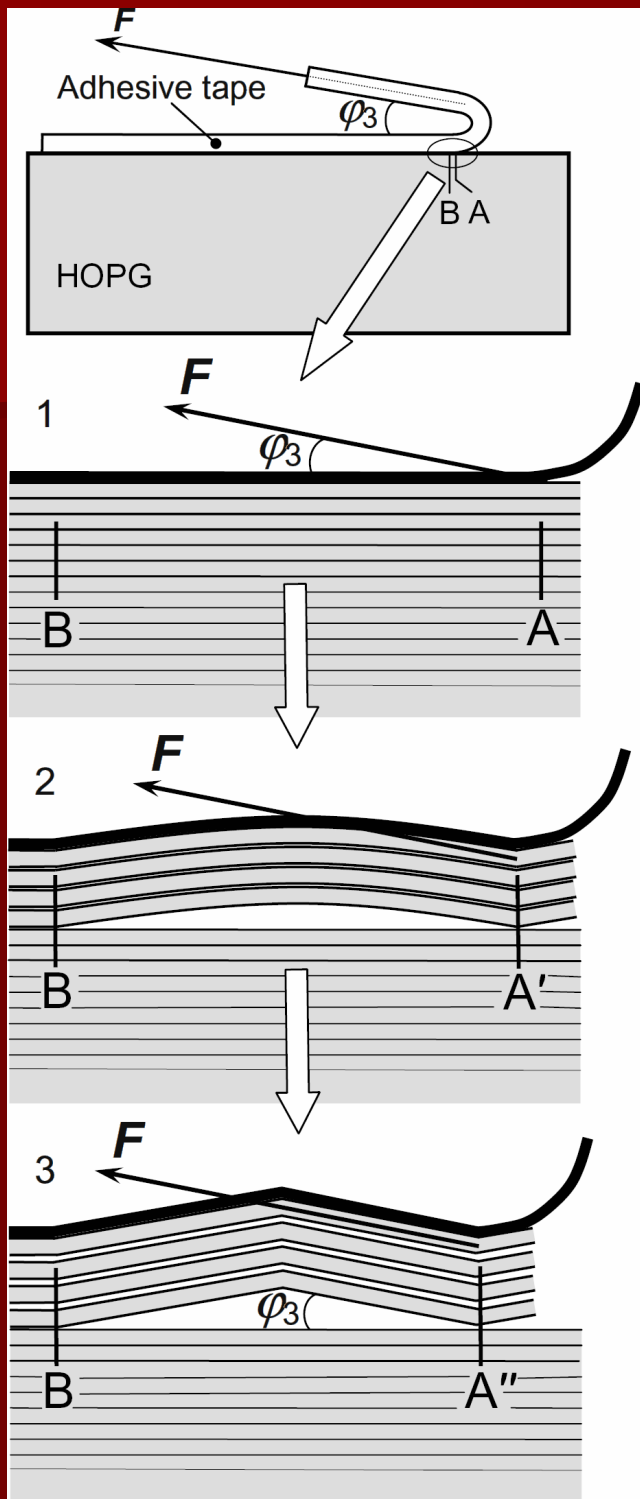


Fourier spectrum of the BSG nanostructure

Overlapping of atomic structure of the graphene facet upon the BSG nanostructure



Mechanism of nanofold formation



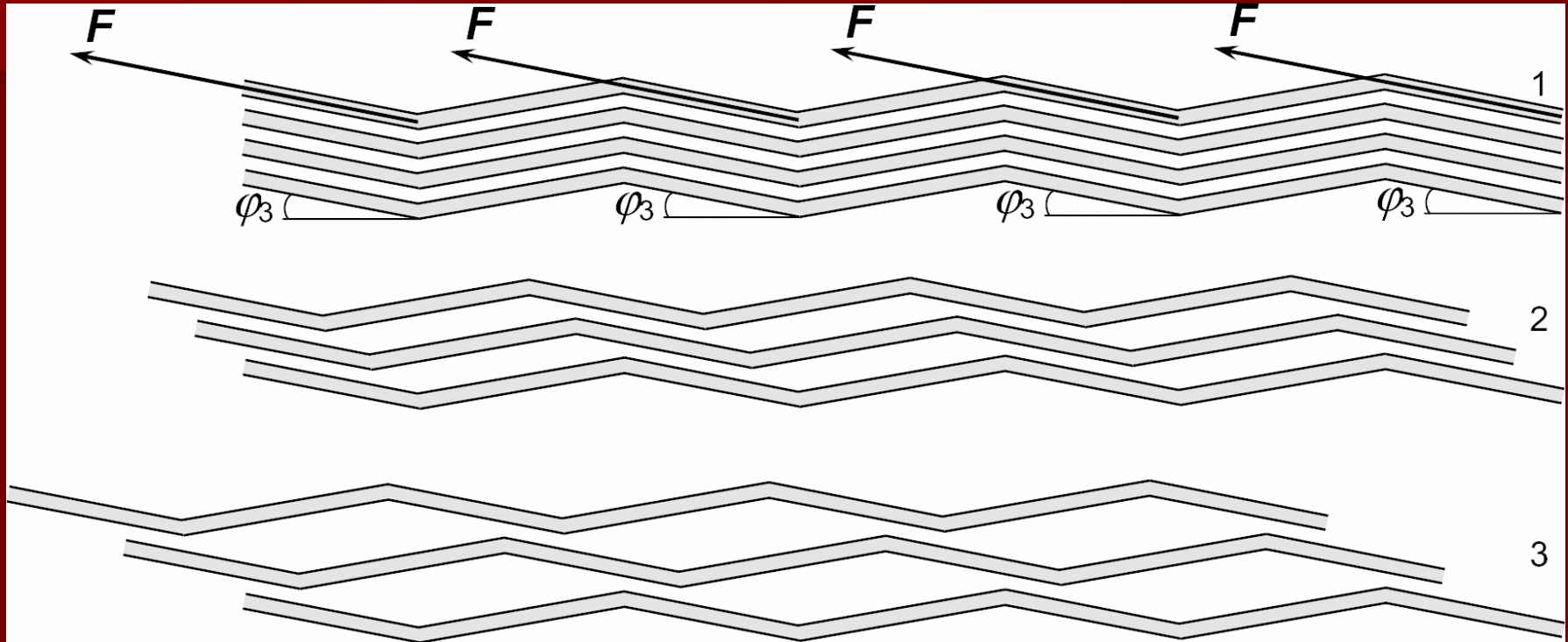
pos. 1 – elastic compression of a thin surface layer

pos. 2 – elastic bending of the thin surface layer and its detaching from the crystal

pos. 3 – plastic bending of the thin surface layer and its splitting into graphene sublayers

F stands for a cleaving force applied to the basal plane at the angle φ_3 ,
 $AB = w + W$, $A''B = w_x + W_x$

Simplified formation mechanism of the nanochannel layers



Two channel layers (cross-sectional view) appear from three split-in-folds graphene layers during relative shifting (sliding) of these layers along the plane of the small facet under the action of a cleaving force F . φ_3 is the angle of force application, i. e., the tilt of the small facet plane to the graphite basal plane.

Possible applications

- Sensitive elements of detectors
- Catalytic cells
- Nanochannels for microfluidic devices (molecular sieves, DNA sequencing and manipulation)
- Heat sinking surfaces
- Rechargeable batteries
- Nanomechanical resonators
- Multiplication channels in electron emission nanoelectronics
- Sorbents for hydrogen storage

Conclusions

1. A previously unknown 3D box-shaped graphene nanostructure has been detected on highly oriented pyrolytic graphite after mechanical cleavage
2. The discovered nanostructure is a multilayer system of parallel hollow nanochannels having quadrangular cross-section with typical width of a nanochannel facet 25 nm, typical wall/facet thickness 1 nm and length 390 nm and more
3. An original mechanism has been proposed that qualitatively explains the formation of the nanostructure detected. To elaborate a more detailed mechanism, a more detailed investigation of the nanostructure is required including theoretical analysis, computer modeling, and attempts of intentional fabrication
4. Applications are revealed where the use of the box-shaped graphene nanostructure may lead to new scientific results or improve performance of existing devices

Thank you

Collage "Organ pipes"



Organ pipes
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I am grateful to Oleg E. Lyapin for his assistance in the preparation of these audio slides