Atomic Force Microscopy

Question 1:

The following abstract is taken from a real paper published in a respectable scientific journal. The authors claim that they can grow graphene in triangular shape on any substrate. They base their interpretation on the image (figure 3 in the paper) below.

THE JOURNAL OF PHYSICAL CHEMISTRY C

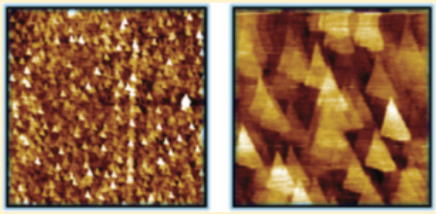
ARTICLE

pubs.acs.org/JPCC

Catalyst-Free Direct Growth of Triangular Nano-Graphene on All Substrates

[redacted]

ABSTRACT: To epitaxially grow graphene, metallic catalysts or carbon containing silicon carbide have been typically utilized. The embedded metallic catalyst between graphene and the substrate as well as the expensive silicon carbide substrate create hurdles in the development of graphene-based devices. However, what is inevitably necessary is not a metallic catalyst but a flat plane able to hold the carbon species and to mediate their interaction on the plane. The plane needs neither to hold a large amount of carbon species nor be a highly efficient catalyst because one monolayer of carbon on the plane may be enough to grow graphene. In this study, graphene was grown directly on various substrates such as transparent substrates, insulators, and semiconductors without any catalyst. The directly grown graphene is triangular nano-graphene with sides of 100−200 nm in length. This study suggests that graphene can be directly grown on all substrates.



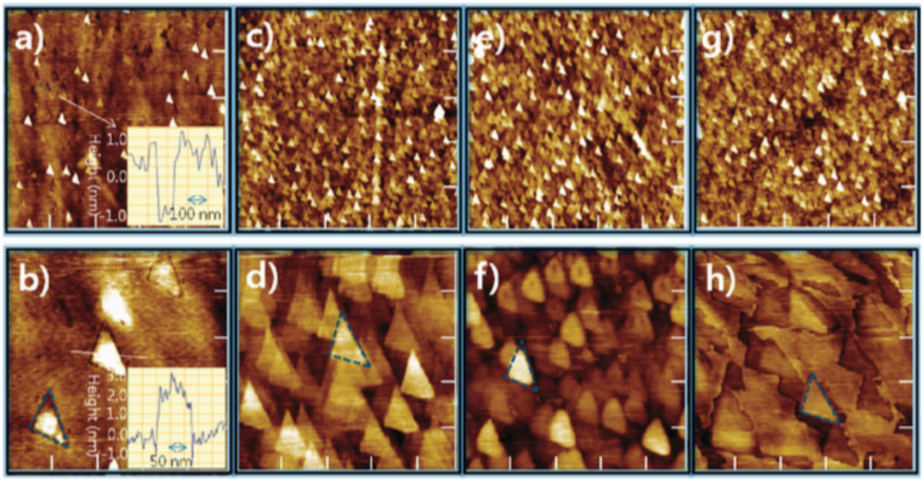


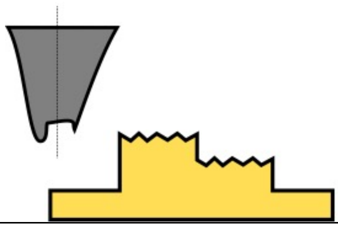
Figure 3. AFM topographical images of nanographene grown on quartz substrates at 900 °C (a and b) at 50 Torr for 5 min, and at 900 °C (c and d), 1000 °C (e and f), and 1100 °C (g and h) at 10 Torr for 1 h. The insets of panels a and b are line profiles. The scan size is 5 $\mu m \times 5\ \mu m$ for (a), (c), (e), and (g) and 1 $\mu m \times 1\ \mu m$ for (b), (d), (f), and (h).

a) The authors clearly misinterpreted their data. Based on the images shown here, what claim is the misinterpretation? What is really going on?

b) What should the authors have done during the measurement to see if their data was correct or not?

Question 2:

Draw the image profile that you would get when trying to image the yellow structure with the (broken) AFM cantilever pictured.



Question 3 (Homework):

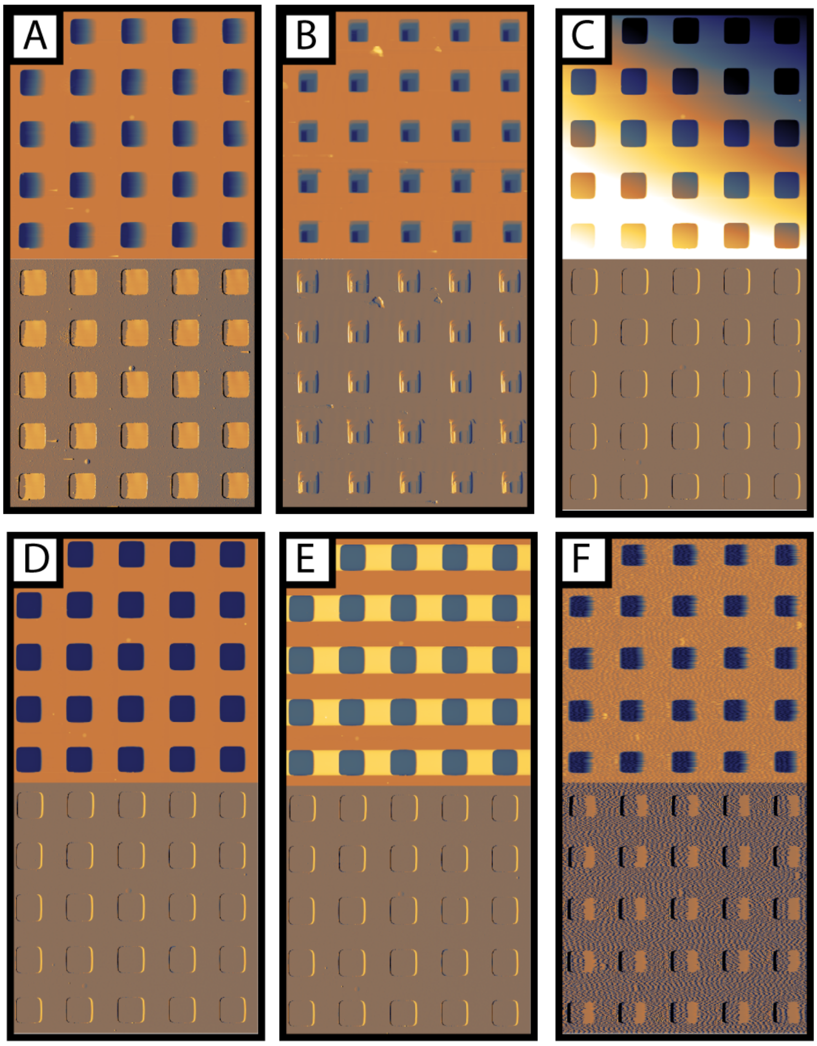
Use for this exercise the additional reading text from the moodle:

Below are 6 AFM images labeled a) through f). The height data is always on top. The error data is always on the bottom. All images have already been processed. Of these six images one, and only one, image is a good image. Each of the other five images has a single problem in either the image capture, or the image processing. No two images share the same problem. You must do the following two things:

1) identify the good AFM image, and
2) for each bad image you must first assign one (and only one) of the possible errors:

1. Wrong flattening
2. Not tracking due to feedback gains too high
3. Not Tracking due to wrong set point
4. Bad tip
5. Bad line-by-line flattened

Describe for each image how you can see what is wrong with the image, and point out in the image where the error is.



Question 4 (voluntary Homework):

You can download the free AFM image processing software Gwyddion from the website: http://gwyddion.net . From the moodle page you can download an example AFM image. Try to process the image using line flattening, plane subtraction, scar removal, 3D representation, or whatever else you like to try out…!