Fortgeschrittenen-Praktikum

Experiment Nr. 42 – Atomic Force Microscopy

Group 176

1 Hard Sample

The images shown in Figure 6.1 of the manual were to be reproduced. Here are our measurements.

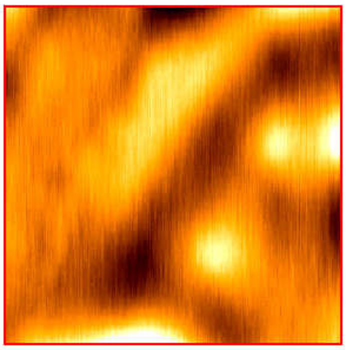
1. The rms-surface roughness in the image of the 5 µm scan size was 0,4125 nm.
2. The height and width of the structures in 15, 30, 40 µm scan size was measured using the AutoProbe Image software. Original screenshots are in the appendix of this report.
In the calculation of the width of the structure, the contortion of the sample was taken into account by multiplication with a factor of cos 12,5° = 0,97.

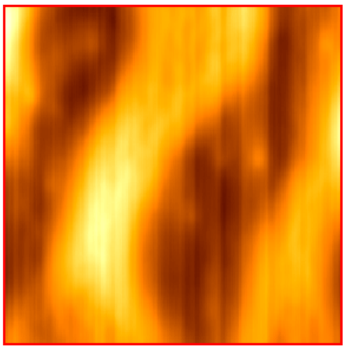
Scan size [µm]	Height [nm]	Width of gap [µm]	Width of structures [µm]
15	253	1,01	
30	244	1,35	11,8
40	229	1,46	11,9
RMS			

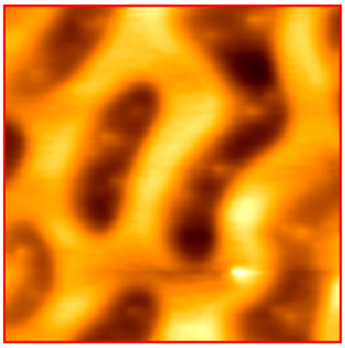
2 Soft Sample

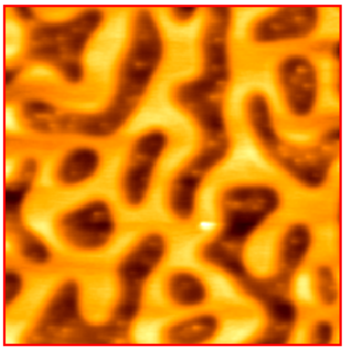
We now examined a polymer film deposited on a flat substrate.

6 Images and RMS roughness


2µm scan size, 1,127 nm RMS roughness


4 µm scan size, 8.810 nm RMS roughness

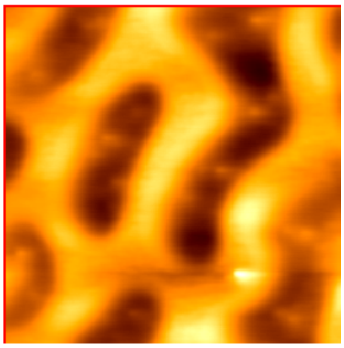

8 µm scan size, 7,864 nm RMS roughness


16 µm scan size, 8,030 nm RMS roughness

7 Physical origin of the surface structures

We observed both covered and uncovered regions of the surface. This corresponds to the state of dewetting, as described in figure 3.5 d in the manual. The structure results from the surface energy of the whole system, which is at minimum. Two effects are important for the building of holes, or free areas as we observe them: nucleation and amplification of thermal fluctuation at the surface.

8 Length scale of observed structures


8 µm square size

We can distinguish at least two different types of structures: the polymer itself and the holes. The polymer-covered areas have a width of approximately 1 µm, while typical widths for polymer molecules are ~ 10 nm. Thus the structures that we observe cannot be single molecules, but are assemblies **of many polymer molecules**.
A self-assembly process is a process, which starts to run automatically, if the environment conditions are proper. Self-assembly processes cannot only observed with polymers, for example also lipids show such effects, for instance building of membranes or vesicles.

9 Defects

The driving Energy of the defects is Entropy, which cannot get too small during pattern formation, and the surface energy, which must be at minimum in equilibrium. Defects on the surface will appear to fulfil the condition of minimized surface energy.

10 Discussion

The structures are distributed isotropically over the surface. Probably we would get a very similar image, if we looked some 10 µm away from the surface area, that we looked at. However, because we see structures at all, one could say that the polymer is not distributed isotropically on the surface on a small length scale.
Images of stationary patterns in reaction/diffusion systems can look very similar as our images, and also the length scales can be possible for reaction/diffusion systems. The molecules involved in a diffusion system on a length scale of µm should be rather small, for instance no polymers or proteins, because diffusion for larger distances gets very slow for larger molecules.