Manual of operation FX200

Introduction to non-contact mode AFM

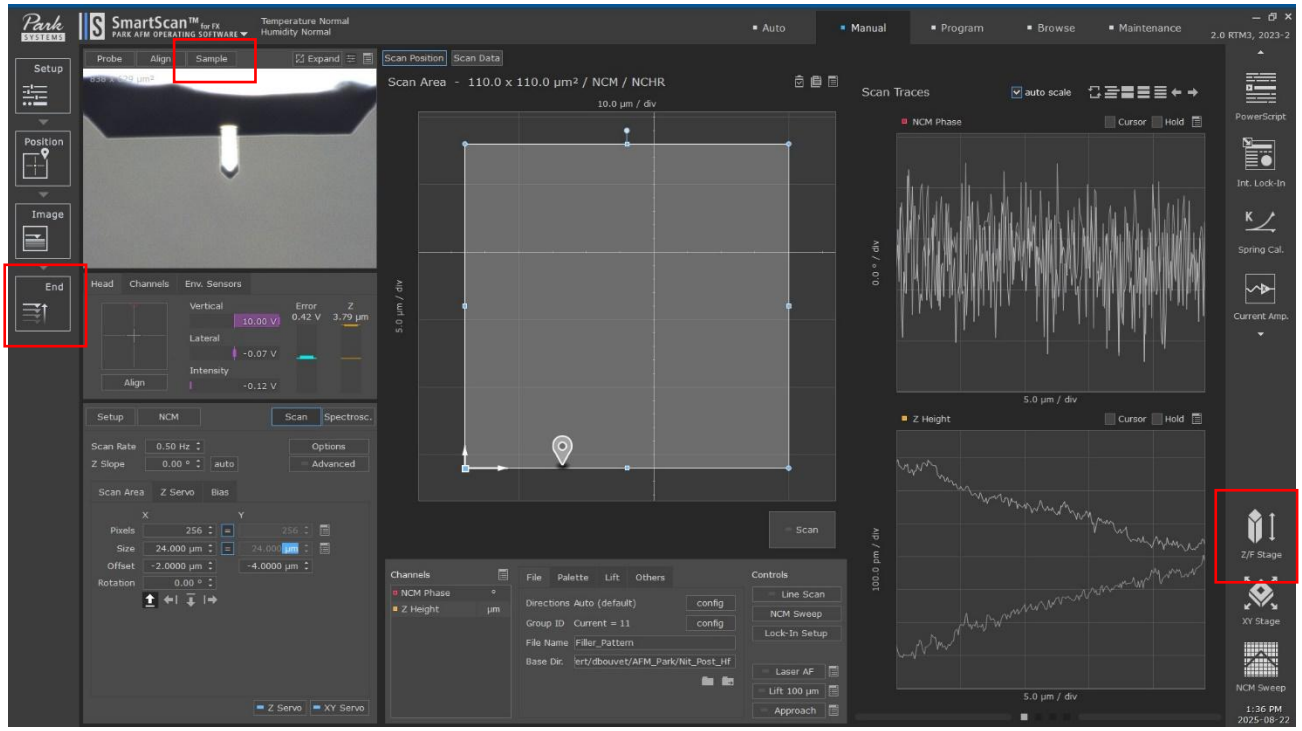
In non-contact mode Atomic Force Microscopy, a sharp tip mounted on a cantilever hovers just above the sample surface without touching it. The tip is kept at a small distance where attractive forces, such as van der Waals forces, dominate. The cantilever is oscillated near its resonance frequency, and interactions with the surface cause slight changes in the oscillation frequency or amplitude. These variations are detected by a laser beam reflected from the cantilever into a photodiode. By scanning the tip across the surface, a high-resolution topographic image of the sample is reconstructed without physically contacting or damaging it.

Start Software

Start SmartScan software, if it is already open, it is good practice to close it and restart it. An "*unhandled exception in script*" error might appear (due to the fact we save data on our remote disk cmi-transfert), just ignore this window and select the software main window.

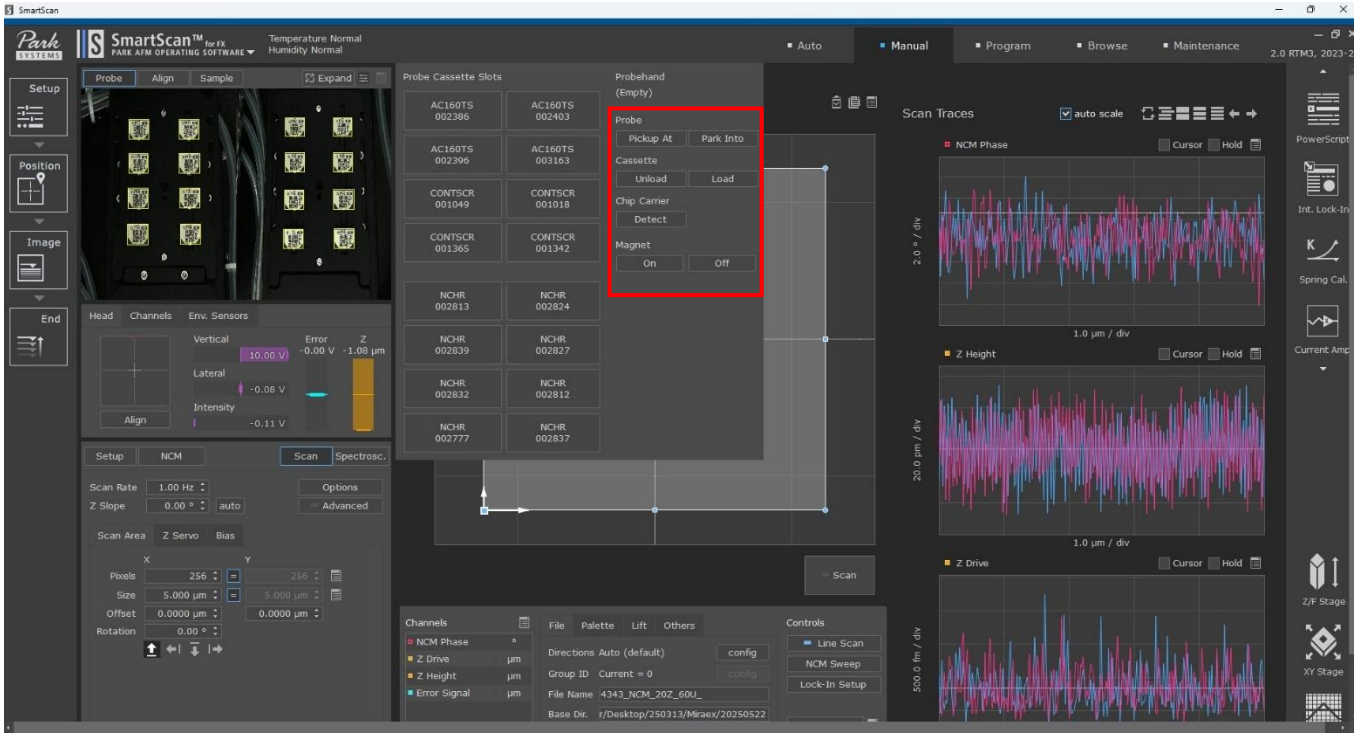
Load Sample

1) Press the **End** function (middle right) to turn off the beam, and then make sure the Z stage is up by selecting Z/F Stage (bottom right) and using the ***Lift Z all*** function.
2) Presse the sample tab and then press unload to move the XY stage towards you. Open the chamber door.
3) Place your sample on the chuck, turn 90° counterclockwise the corresponding valve and activate the pump under the computer screen by using the green switch.
4) Press the load button, this will initiate a sequence of 4 pictures of your sample. Wait until the abort button disappear to further continue.



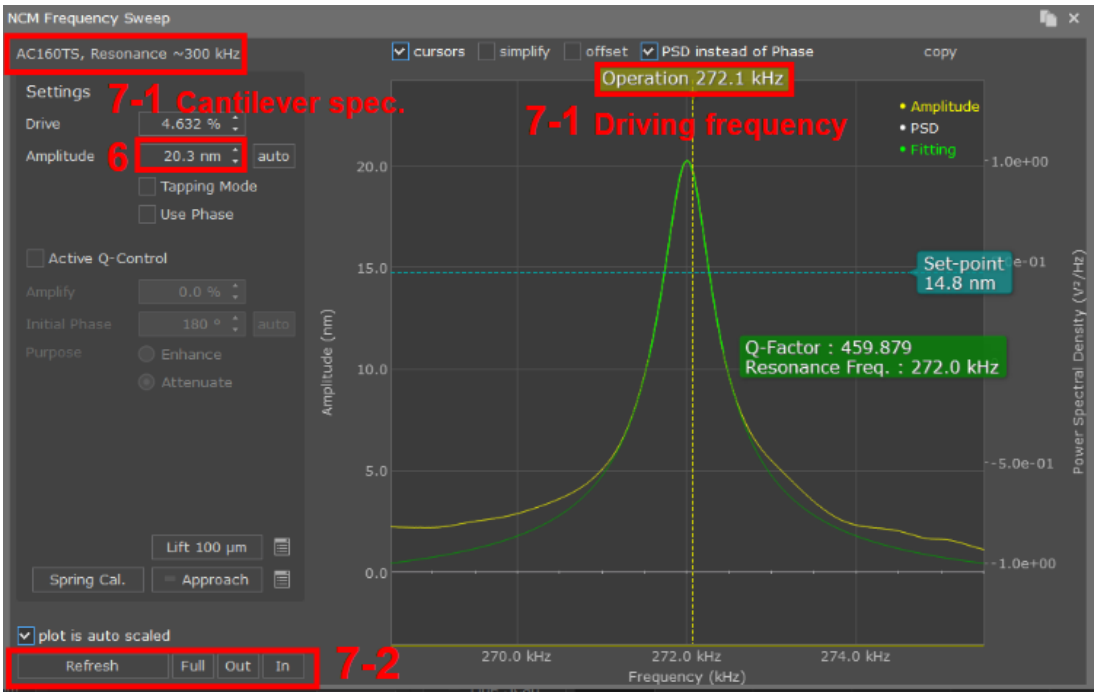
Load probe

1) Press the **Probe** tab and then load cassette it will move the available probe inside above the camera. Press the chip carrier detect function, this will update the available probe inside the cassette. If the previous user forgot to park its tip, select an available tip slot and use the “park into” function.
2) Choose the tip corresponding to your Lab/company. If your lab does not have a specified tip, choose one of the free-to-use tip according to the list. Use the **Pickup At** function to automatically mount the tip on the head.
3) SmartScan software will perform an automatic alignment of the focus and the beam on the cantilever. If the alignment is not good, (the focus on the cantilever is not sharp or the beam is not localized on the center of the cantilever) you can manually tweak the parameter focus by using on the Z/F Stage menu.

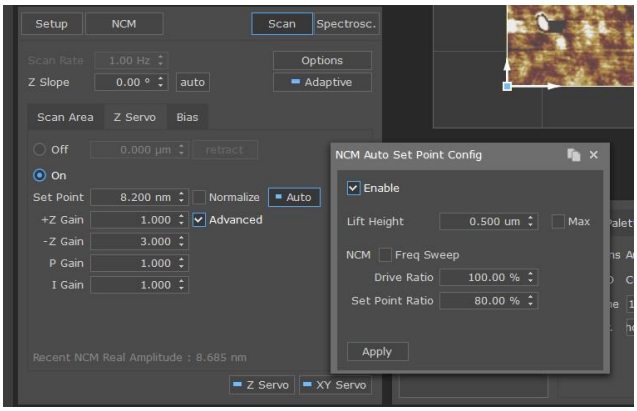


Imaging

1) Click “**Sample**” button at the top of the left camera view. Your sample will be displayer and you will be able to move the marker. Click “**Go to**” to move the head above the tip the area you want to measure.
2) Perform a frequency sweep using the “**NCM Sweep**” menu and the “**Auto**” function, you should have narrow frequency around 330 kHz if you are using the standard NCHR tip.
3) The amplitude of vibration of the Z scanner can be manually setup. A good starting point is between 10 to 20 nm. The more rough your surface the higher the amplitude should be.



4) Now that you have setup your cantilever and make sure that the NCM set point is set to auto. To do so, go on the **Z servo** tab, press Auto and make sure the *Enable box* is ticked. Set the scan size to zero and click on the option button right next to approach to make sure the approach is set to quick and safe. You can now do your approach.



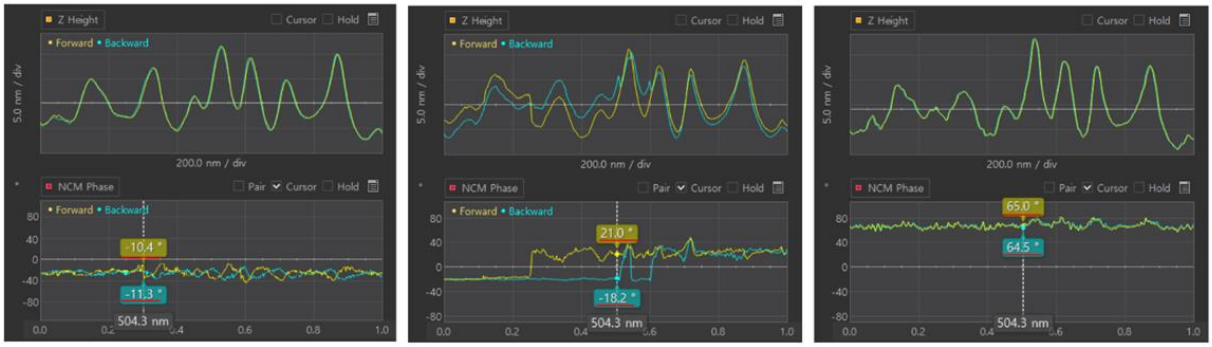
5) Once the tip is close to the surface the orange rectangle depicting the piezo-motor range should be half empty. This means that the piezo motor is at the right position and move freely to follow the substrate profile.

6) As tip approaches the sample, the resonance frequency is shifted to lower values due to tip-sample attractive interaction. You have to make sur that the NPM phase is negative and that the signal looks like noise. If the phase is positive or that the forward and backward signal are on top of each other, it means that you tip is to close and you are taping your sample. You should adjust the parameters to have a good signal. Start by adjusting the set point in the Z servo tab. Your setpoint should be lower than the Recent NCM Real Amplitude value. A good start is to try 90% of this value.

① Non-contact
- Negative degree of phase
- A flip-vertical shaped F/B*

② Bi-stable
- Positive & negative mixed degree of phase
- Mismatched line & signal jumps in F/B

③ Tapping
- Positive degree of phase
- Matched F/B

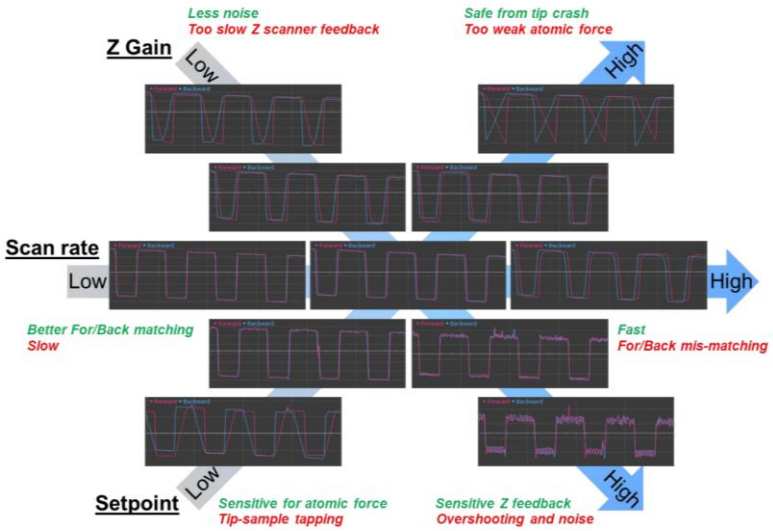


- Phase shows a flip-vertical shape of the forward and backward line as like error
- No tip-sample contact with high setpoint

- Tip-sample interaction in bi-stable area by setting the setpoint between Non-contact and Tapping
- Unstable phase and height

- Phase represents mechanical property changes of surface
- High amplitude and low setpoint for tip-sample Tapping

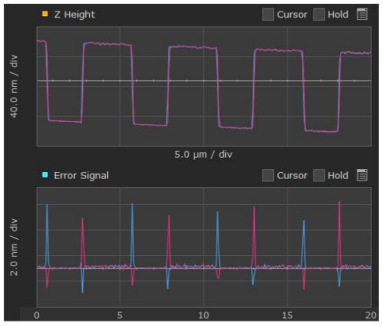
7) If the tracking is not good, you can also adjust Z gain in Z servo tab and scan rate. Refer to the following slide to understand the effects of adjusting each parameter.
Z Gain: Feedback sensitivity by controlling P and I gain
Scan rate: Scan speed (Hz) Keep in mind that the speed of the tip will be (2*Scan Size *Scan Rate), and that too high speed will result in tip and sample damage.



The error signal can be used to check how well the feedback control works on well defined topography. Refer to the following slide example to verify your scan parameter.

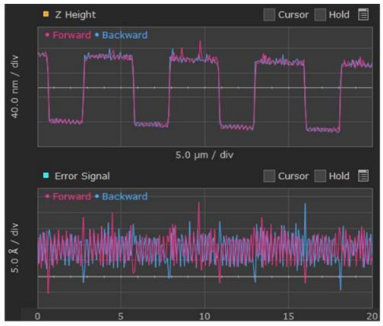
- Error signal indicates how well the feedback control works.
- Error signal can be monitored to verify the scan parameters are suitable.

Good example :
Good topography



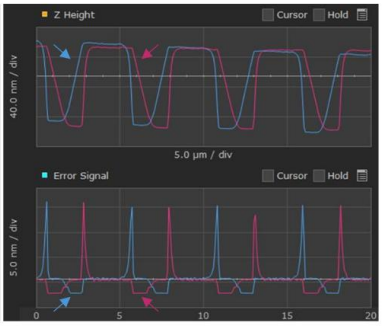
- Error signal shows a flip-vertical shape of the forward and backward line near features

Bad example 1:
Noise on topography



- Noisy error signal is caused by
  - too low Set Point
  - too high Z gain
  - contaminated tip/sample

Bad example 2:
Mismatched F/B*



- Flat area of error signal is caused by
  - too weak tip-sample interaction
  - too high Set Point
  - too low Z gain

* F/B : Forward/Backward lines

Data analysis

The data can be distorted by wrong line flattening. For the line flattening without data distortion, recommend to flatten on fast scan direction only. And select an area with the same height level of surface that occupies the widest area as reference region for undistorted flattening.