Veeco Innova Operation Notes

General

- Start the SPMLab software and load the DSP code then turn on the HV.
- Select SETUP → MICROSCOPE, or click the Microscope tool button to select appropriate operation mode (Contact, Tapping, etc.) Note that the microscope is "Innova" and the Scanner is the "284 Linearized Large Area Scanner for Innova".
- Mount the cantilever on the carrier carefully. The cantilever will be easily destroyed by touching. Use only the mounting fixture (black brick) to open the chip clip. Do not use excessive force or tune the screw – the carrier and/or the pushing pin on the fixture can be damaged!!
- Mount the chip carrier to the appropriate cartridge if Tapping mode is desired. Use only the spring tool to clip the carrier. Do not use excessive forces or the clip may break. Never drop the cartridge or the piezo crystal under the clip may break.
- Use double sided tape to fix the sample on the sample holder. Do not use glue on public holder. Remove sample and put the public holder back after done.
- Lock the isolation platform before move the instrument or insert the cartridge and sample.
- Mount the specimen holder carefully. Mechanical shock can damage the piezo scanner on the stage.
- Make sure the scanner head is far enough from the sample so that the cantilever will not crash on the sample during cartridge insertion.
- Tune the laser so that the spot is on the tip of the cantilever and maximize the signal. Tune the detector position so that the signal is at the center of the PSD.
- In the Scanning Condition, leave "overscanning" checked at 15% to avoid artifact in the edge of the image. Use high gain for all axes for full 100 μm scanning range. Using low gain for better resolution at the expense of smaller scanning range.
- To fine tune the PID gain, Observe the "Height" profile. The trace-retrace line should be tracking with each other. If this is not the case, increase the I-gain. Oscillation of the profile indicate too high of the I-gain and the goal is to be close to, but not beyond the point at which oscillation appears. The usual P-gain is about 2~4 times higher than I-gain and can be optimized similar to I-gain.

Contact Mode

- To prevent excessive force on the sample, contact mode usually use a soft cantilever (smaller *k*-factor, lower frequency).
- Use a setpoint of +1.0~+2.0V and perform auto engage. After the system is engaged, the Scan window will appear.
- Note that the setpoint indicate the degree of cantilever bending. Higher setpoint means more bending, hence stronger force between the tip and sample.

- The default P.I.D. gain of 4~8, 1~3, 0 is a good starting point. The system usually starts to oscillate when I-gain > 5.
- Turn on the active vibration isolation. Select appropriate signal channels and start a small area scan (1~3 μm) with a slow scan rate (1 Hz).

Tapping Mode

- Stiff cantilevers with high resonance frequencies are generally used for tapping mode.
- Before engage the system, the resonance properties of the cantilever need be tuned. Select 0..1000kHz frequency range with "Target Tapping Signal" of +1.0~+2.0V (for 4× input gain) in the "AutoTune" is a good starting point. For phase image, the default +7.49V and 4× input gain is also a good starting point with the expense of higher probability of tip/sample damage.
- Check the frequency and the value should be close to that provided by the manufacture.
- The autotune will leave the system at the frequency where highest amplitude is observed. The amplitude will be close to the "Target Tapping Signal".
- The autotune will adjust the phase so that at the resonance frequency, the phase is 0V and change rapidly with frequency for maximum sensitivity to the frequency change.
- The default setpoint will be automatically set at 60% of "Target Tapping Signal".
- After the system is engaged, the Scan window will appear.
- Note that the setpoint indicate the magnitude of the tapping. Higher setpoint means larger magnitude, hence the tip is further away from the sample and the tapping force is smaller.
- The default P.I.D. gain of 1.0, 0.3, 0.0 is a good starting point.
- Turn on the active vibration isolation. Select appropriate signal channels and start a small area scan (1~3 μm) with a slow scan rate (1 Hz).
- To enhance the contrast of phase signal, higher drive voltage can be used. Note that increasing the drive voltage will also increase the tapping range. Therefore, the setpoint should be lowered to prevent sample damage.

Lift Mode

- Set desired lift height and enable the function. The tip will be at this constant distance during backward scan. The start height is only used to move the tip far away at beginning to make sure the tip is not stick to the surface.
- For better height tracking, turn on the Z Linearizer to enable the close-loop at Z-axis.
- If the measuring property is sensitive to light, the laser can be turned off during backward scan (Dark-Lift mode).
- If the measuring property will be interfered by mechanical force, the tapping piezo can be turned off during backward scan (Dither Grounded mode)
- If bias is applied, Bias Line can be used to ground the tip or sample to dissipate the voltage.

Surface Potential Microscopy

- In most case, 75 kHz conductive tip is a good start. Plug the connector lead to the black port on the stage.
- Before tuning the cantilever, make sure the "AC Bias Amplitude" is set at 0 V and SEPM Feedback is off in the SEPM control window.
- Obtain a good image in tapping mode and setup the lift parameter. Make sure "Dither Grounded" is checked so that there will be only one frequency in backward scan. Ground all the bias beside of the tip at backward direction.
- Make sure following channel is selected: "Height – Forward", "Tapping Amplitude – Backward", "SEPM Error – Backward", and "SEPM Potential – Backward".
- In the SEPM control window, make sure the tip bias is enabled, 40 kHz LP filter is off, and Synchronize to TM frequency is on.
- Begin scanning and look for reasonable contrast in "Tapping Amplitude – Backward" by increasing "AC Bias Amplitude". For 100 nm lift height, 2-5 V should yield good contrast. Set lift height as small as possible to get better spatial resolution.
- Monitor "SEPM Error – Backward" and select "Lock-in Gain". A typical value of 10-40× should give good signal strength and not saturate the contrast.
- Tune the "Lock-in Phase" to obtain minimal "SEPM Error" then add or subtract 90° for maximum "SEPM Error". Once the "Lock-in Phase" is set, check "Lock-in Gain" again to optimal the signal.
- Set both "PI Corner Frequency" and "Overall Gain" at middle and enable "SEPM Feedback". The SEPM Error should become smaller. If the SEPM Error becomes larger, toggle "Polarity Inverted" and the SEPM Error should become smaller.
- Turn on "Integrator". And the "SEPM Error" should converge toward 0. Use "Offset" if needed and tune "PI Corner Frequency" and "Overall Gain" to improve the result.
- Obtain the SEPM image.

Conductive AFM

- Conductive tip is required. Plug the connector lead to the amplifier. To filter noise, 50 Ω feed-through can be added between the amplifier and stage connector (not between the tip and amplifier).
- Obtain good image in contact mode.
- Select desired position and use "Point Spectroscopy" to collect the IV Curve.
- Select appropriate gain of the amplifier (10^3-10^{11} V/A, Low-Noise or High-Speed).

  Without 50 Ω feed-through, $I = \frac{V}{Gain}$

  With 50 Ω feed-through, $I = \frac{V}{0.15 \times Gain}$

- Obtain the CAFM image.