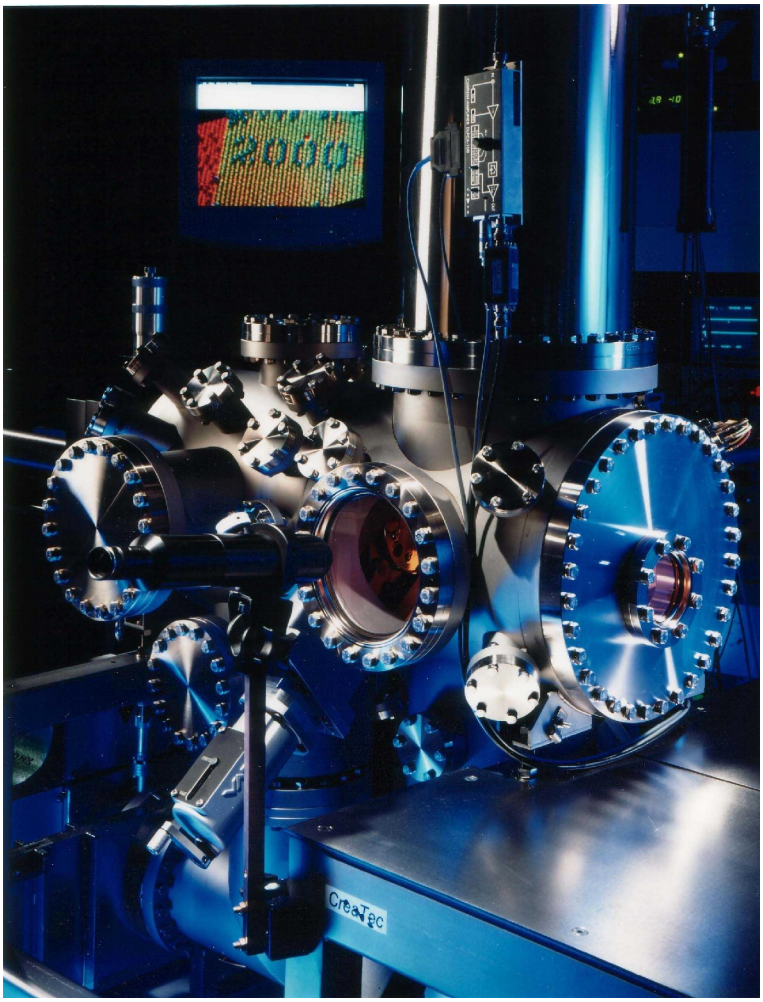
Manual for the LT-STM



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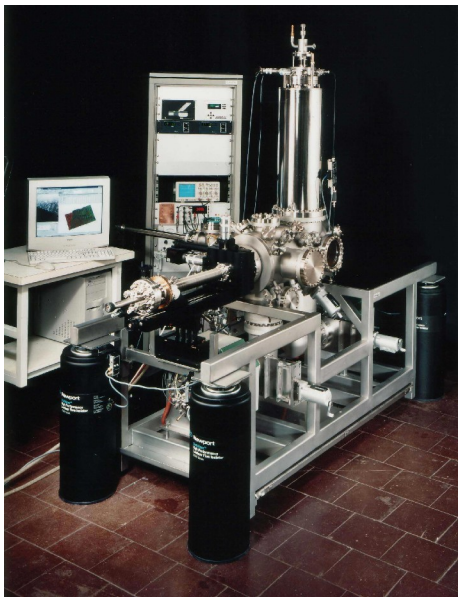
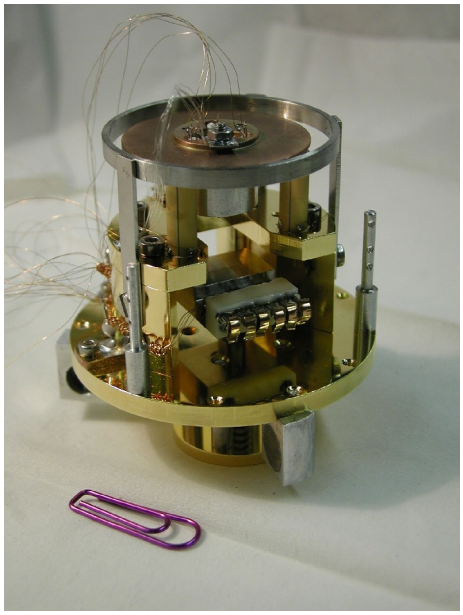
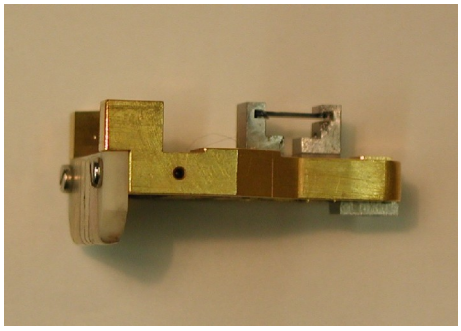
1 The LTSTM-system

1.1 Description of the UHV-system



The UHV-chamber consists of two parts which can be separated by a build-in valve: The preparation chamber with a helium cooled manipulator and the STM-chamber with its cryostat. Both chambers can be pumped separately by ion pumps with integrated Ti-sublimation booster pumps. A pressure of $1x10^{-10}$ mbar can be reached. The helium cooled manipulator has a differentially pumped rotational feedthrough which should be pumped regularly with the turbo-molecular pump of the load lock chamber.
A sample/tip storage (4 samples + 6 tips) with an additional filament has been mounted in the preparation chamber.
When a sampleholder is clamped onto the manipulator there are 4 connections to the sample: 2 for heating and two for a thermocouple (Ni, CrNi). Another 7 cables are already mounted but not connected to the sample.
The STM is a Besocke-beetle-type with some modifications. It is not cooled but hanging free from the inner cryostat surrounded by radiation shields. The minimum temperature of the STM is below 10K (typically 6K). The temperature can be varied between the minimum temperature and room temperature. (But the performance is better at low temperatures.)
Both the STM and the inner cryostat have got eddy current damping. Additionally the whole UHV-system rests on Newport dampers (Use oil-free dry air!) to avoid low frequency vibrational noise.





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1.2 Baking the UHV-chamber

1. De-float the Newport dampers and open the shutters of the STM.
2. Make sure that the cryostats are empty and warm (~300K).
3. Pull down the STM (sample transfer position) and open the shutter.
4. Open the gate valve between preparation and STM-chamber.
5. Start the pre-vacuum pump and the turbo pump in the load-lock.
6. Open the valves for the differentially pumped rotational feedthrough to pump with the turbo pump for some minutes. (ion gauge switched off)
7. Switch off the ion pumps and open the valve to the chamber.
8. Remove all cables except Ti-sublimator, ion pumps and ion gauges.
9. Mount the thermocouple to the UHV-chamber.
10. Clean all windows.
11. Cover all windows and feedthroughs with Al-foil.
12. Move the manipulator to , , (X, Y, Z).
13. Mount the oven according to the supplied drawing. (Two heaters go next to each ion pump.)
14. Cover all holes in the oven and parts with Al-foil.
15. Connect all heaters, the thermocouple and the **fan** with the bakeunit. It is not necessary to use the heater of the load-lock.
16. Set the temperature of the bakeunit to 125…145°C and bake the system for about 2 days. The turbo pump is used to evacuate the system. (Evacuating with the ion pumps is possible too.) Sublimate Ti from time to time (i.e. every 4…6h).
17. After 2 days start the ion pumps and wait until the pressure settles.
18. Stop baking and remove the oven.
19. Close the valve from the turbo pump to the chamber.
20. Open the valves for the differentially pumped rotational feedthrough to pump with the turbo pump for some minutes. (ion gauge switched off)
21. Slowly cool down the cryostats with nitrogen gas (or oil-free dry air) to ambient temperature. (To avoid thermal stress it is better to wait one day until you fill the cryostats with liquid nitrogen or helium.)

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1.3 Transfer processes

It is strongly recommended to do all sample/tip transfers with two persons or with the help of a CCD-camera. One person (CCD) should always look through one of the windows onto the STM when the other one is moving the manipulator. If the STM or the inner cryostat is moved by the manipulator than the transfer has to be stopped and the settings (X, Y, Z, Φ) have to be corrected.

1.3.1 Sample transfer

If the 'T' (the moveable steel part) at the end of the manipulator is tilted than straighten it with the help of the sample storage.
Clamp the sample as low as possible onto the manipulator. Make sure that all contacts to the sample are connected. When you cool down the manipulator tighten again the micrometer screw that holds the sample after the cooling. Due to the different thermal contraction of copper and steel the sample might become loose otherwise.

To put a sample into the STM use the following parameters:
Manipulator X: 25 (The sample should be in the middle of the STM.)
Y: / / (The hook of the sample holder should be above the block the will lift it up later and also under the baseplate of the STM.)
These parameters are only approximate figures. They might vary depending on the way the sample is clamped onto the manipulator.
Open the STM shutters clockwise and release it some mm when you reached the end. Put the sample into the STM. The second person has to check that the sample fits between the baseplate and the block into the STM (correct Y otherwise). When you put the sample into the STM the second person checks if the inner cryostat is moved. Than STOP the transfer! If Z is behind the red line on the scale ( ) than you have reached the end position. Move out the manipulator by 1mm. Put down the sample (Y) until the hook is >1mm above the block. Loosen the micrometer screw to release the sample. Lift the manipulator (Y= / /) until the 'T' is above the sample holder. Move the manipulator out of the cryostat by 30 mm while he second person checks that the sample remains at its place. Take down the manipulator to Y= / / .
Than push the sample slowly in its place. The second person checks that you push the inner cryostat at Z= . The sample should be slit in its place at Z= at latest. If it is not try at a different height (max. Y±2). Do not push the manipulator further! You might break either the inner cryostat, the STM or the

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Manipulator! Close the shutter anticlockwise after the transfer. Release the sample and the STM with the linear feedthrough. Check the contacts:
The tunneling voltage should be available at the pins 1, 3, 4 and 6. There should be no connection from the sample to the STM or from the STM to the UHV-chamber.

To remove the sample off the STM use the following parameters:
X: 25 (The manipulator should be in the middle of the sample.)
Y: / / (The 'T' should be above the sample holder.)
Pull down the STM and the sample with the linear feedthrough. Open the shutter clockwise and release it some mm when you reached the end. The 'T' of the manipulator should be completely released. Move the manipulator in the STM until you push the inner cryostat. This should be shortly after the red line (Z=). Pull back the manipulator 1mm. Than move the manipulator until the 'T' lies flat on the sample holder (Y= / /). Tighten the 'T' and push the manipulator 1mm into the cryostat. Than lift the manipulator up until you see a gap between the hook and the block (Y= / /). Move the manipulator out of the cryostat and close the shutter anticlockwise.

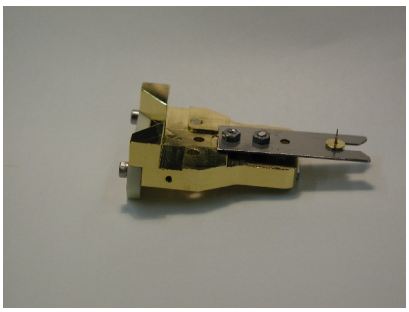
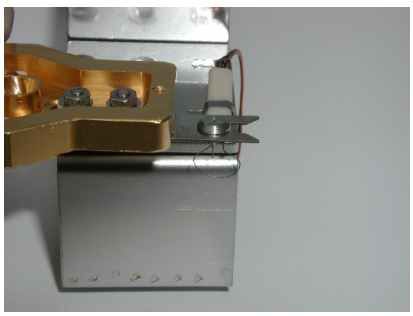
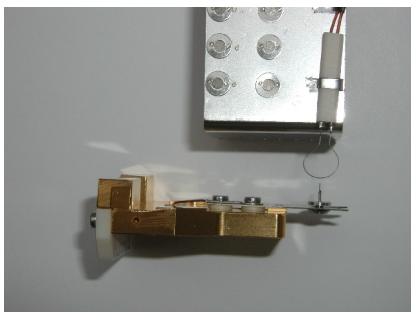
1.3.2 Preparing a tip

There is no strict rule how to prepare a tip. Usually it's done like this:

- Etch a W-wire (ø0.25 … 0.35mm) in a hydroxide solution (e.g. 50g NaOH in 50ml H_2O).
- Rinse with H_2O than with alcohol.
- Put the tip into a tip holder and adjust the height.
- Put the tip holder in the load lock and transfer into the UHV-chamber.

To remove the oxide you can:

- (Some like to remove the oxide with HF after the etching.)
- Sputter the tip (you can measure the ion current)
- Heat up the tip by radiation or by an electron beam from the filament.

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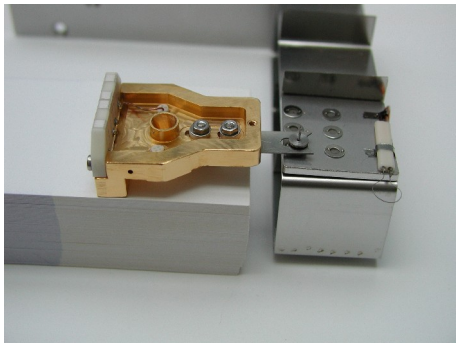
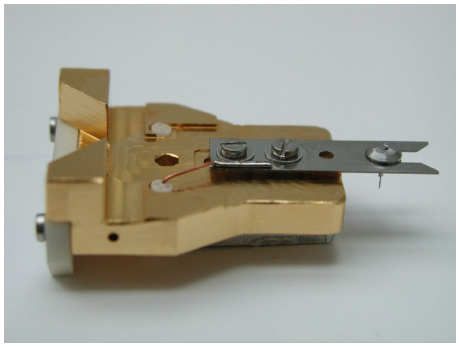
1.3.3 Tip exchange

Pull down the STM and the sample with the linear feedthrough. Open the shutter clockwise and release it some mm when you reached the end. Remove the sample off the STM. Take the sample transfer tool from the sample storage. Move the ramp of the STM to the fare right. Do not release the STM and use the following settings to get out the tip holder off the STM. X: 25 (The transfer tool should be in the middle of the STM.), Y:
These parameters are only approximate figures. They might vary depending on the way the transfer tool is clamped onto the manipulator. Move the transfer tool into the STM until it pushes the cryostat. (Shortly after the blue line on the scale.) Go back 2mm. The fork of the transfer tool should be at the height of the slot in the tip holder. Use the X, Y movement of the ramp of the STM to get the tip holder onto the fork. You might have to correct X, Y, Z, Φ of the fork to catch the tip holder. When the tip holder is on the fork, pull down the manipulator until you see that the tip holder is not attracted by the magnet any more. Now it is safe to go back with the manipulator. Turn it by 180° and lay down the tip holder onto a free storage magnet.
Take a new tip holder from another magnet and turn back the manipulator again. Go to Y= and move the new tip holder back into the STM until it is under the magnet. Move it upwards onto the magnet in the middle of the aluminum cylinder that shields the inner piezo. Pull the tip holder out of the fork by using the X,Y movement of the STM. Make sure that the fork is in the middle of slot of the tip holder all the time. Otherwise you will not be able to get the fork out. Correct all parameters (X, Y, Z, Φ) to do so. Pull out the manipulator and put in a new sample.





The pictures show you how to transfer a new tip into the STM. The tip transfer tool goes to the manipulator in the same way as a sample holder. During the transfer processes the tip has to point downwards! Don't try to use the tip transfer tool 'up-side down' for the transfer. You might harm the STM! It's safe to use it 'up-side down' for the preparation of tips.

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1.4 Cooling down the STM

400K-300K Use nitrogen gas (or oil-free dry air) to cool down both cryostats to ambient temperature after backing out the UHV-system. This takes several hours. You can check the temperature with the Si-diode, which is mounted at the bottom of the inner cryostat.

300K-80K Cool down both cryostats with liquid nitrogen: Slowly to about 100K than faster until they are filled completely. The outer cryostat has two inlets and two outlets. Therefore you have to close one inlet when you are filling in the other. The filling of the inner cryostat with the He-filling-tool takes a long time (~1h) because its inner diameter is only ~3mm wide. It is recommended that you use a stainless steel pipe (ø12mm) for filling/emptying the inner cryostat with liquid nitrogen.
Close the shutters and pull down the STM to the cooling position. Wait until the STM has reached a temperature lower than 100K. This takes about 6h. (Check the STM-temperature with the Si-diode!)

80K-4K Blow out the nitrogen of the inner cryostat: To do this put the stainless steel pipe or the He-filling-tool into the cryostat (to the bottom). Than press some nitrogen gas (or oil-free dry air) into the gas-outlet of the cryostat. The inner cryostat is completely empty, when its temperature goes slowly up.
Than you can fill the inner cryostat with helium: Make sure that the filling tool touches the bottom of the cryostat (otherwise you need more He for cooling down). Open the needle-valve of the filling tool and slowly cool the cryostat to 4-6K (~15min). Than increase the filling speed until the cryostat is full.
All shutters should be closed and the STM in cooling position. The inner cryostat has a content of 4l. This means that you have to refill the inner cryostat when ~3m^3 of helium gas left the outlet (~48h). The outer cryostat is empty when the ice at the gas outlets begins to melt – refill!

Refilling Pull back the STM-tip and stabilize the UHV-chamber by de-floating the Newport dampers. When you are refilling carefully, it is enough to pull back the tip with the Z-offset of the HV-amplifier. If you want to be on the safe side rotate the tip upwards with the ramp controller of the STM-program.

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1.5 Heating up the STM

A Z-diode (V_Z=200V, P_{max}=3W @300K) has been mounted at the baseplate of the STM. It is connected to STM3 (pin F and G (STM-ground)). You can use the Z-diode in two ways to heat up the STM. To use the Z-diode in the 'low power'-regime connect it in the conducting direction. This way there will be a voltage of ~0.5V at the Z-diode. You can use a maximum current of 20mA, which gives you a power of 10mW at the STM. This is sufficient to heat up the STM to ~20K. To heat up the STM further you can use the 'high power' mode. In this case you connect the Z-diode in high resistance direction. There will be a voltage of 160…200V (depending on the temperature of the STM) at the Z-diode. With the maximum current of 20mA you have the full power of the Z-diode available. This mode can be used to heat up the STM to about 300K. Remember that heating the STM consequences in increased helium consumption.
Always **use a current controlled power supply** to heat the STM.
All wires to the STM (incl. the ones to the Z-diode) can withstand a maximum current of 40mA. Therefore it is recommended to use the 'high power' mode rather than the 'low power' mode with a current over 20mA.

1.6 Preparing a sample

To prepare a wafer sample only direct resistive heating is provided. The wires allow a current of 6A thru the sample which limits the maximum temperature to flash the sample. A thermocouple measures the temperature difference between the sample the sampleholder. The sampleholder itself can only be heated up to 170°C (due to the wire connections). If you want to degas the sample for a long time make sure that the sampleholder does not exceed this temperature (by cooling the manipulator with liquid nitrogen or nitrogen gas).
It is best to get the clean sample into the cold STM as fast as possible. Therefore you have to cool down the sample. You can either start with liquid nitrogen (~15min to 80K) and than continue with liquid helium (~10min to 20K) to save some helium or you can also start with helium immediately (which is easier). When the temperature reading at the thermocouple does not change any more than you have reached the lowest possible temperature (80K for nitrogen, 20K for helium). The reading of the thermocouple voltage itself will not be correct at low temperatures.

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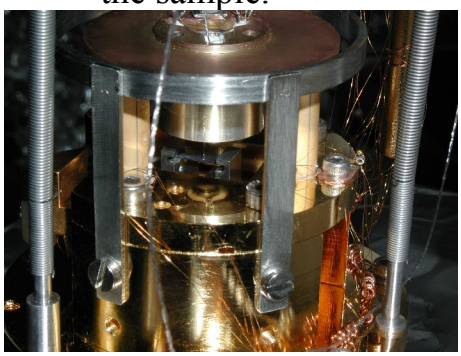
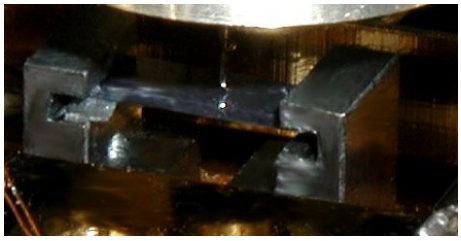
1.7 Measuring with the STM

1. Check all the sample contacts after the transfer into the STM: The tunneling voltage should be available at the pins 1, 3and 4. (If it is only available at one of the pins you can still do measurements.)
2. Rotate the tip upwards as far as possible.
3. Slowly loosen the STM with the linear feedthrough and make sure that the tip does not touch one of the molybdenum blocks which hold the sample. Move the tip otherwise.
4. The sampleholder should touch the bottom of the baseplate with the piezos on it (No gap in between them!) and the STM should hang free on the springs.
5. There should be no connection from the sample to the STM or from the STM to the UHV-chamber. If the STM is connected to the sample or the UHV-chamber you can still do measurements. But if it is connected to both you have to remove the sample again and see why this happened. (May be the sample was not put in correctly.)
6. Approach the tip to the sample with the help of a telescope (Set the HV-amplifier gain to X=30, Y=30, Z=10 when operating the STM at LT, otherwise 10, 10, 10) and the ramp controller of the STM-program until the tip and its reflection in the sample are close to each other. Let the STM-program approach automatically afterwards.
7. Retract the tip manually and set the HV-amplifier gain to the required value. Switch off the ramp controller. Manually approach the tip again and start to measure.
8. Try to find a flat part of the surface first. This makes it easier to figure out the quality of the tip and the sample.





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2 Opening / repairing the STM

2.1 Opening the UHV-chamber

1. De-float the Newport dampers.
2. Pull down the STM to fix its position.
3. Make sure that both cryostats are empty and there temperature is 300K or above. Otherwise warm up the cryostat first!
4. Fix the inner cryostat. (If you loosened any of the 4 nuts to adjust the cryostat before.)
5. Close the valves to the ion pumps.
6. Switch off the ion gauges and ion pumps.
7. Vent the system via the turbo pump and the load-lock.
8. Use a crane to lift up the cryostat slowly.
9. Cover the flange of the cryostat in UHV-chamber before you move the crane.
10. Fix the cryostat on the supplied stand.

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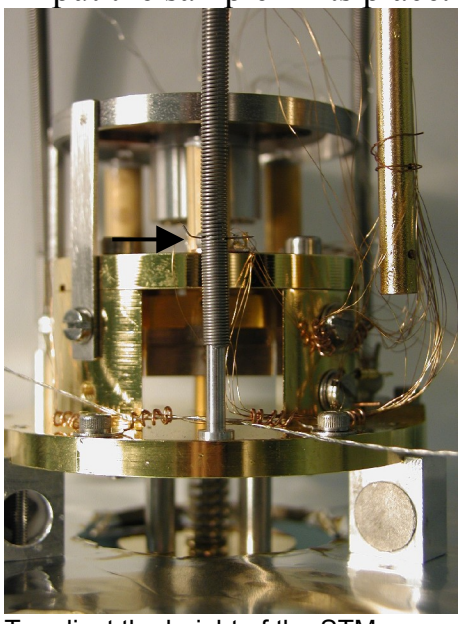
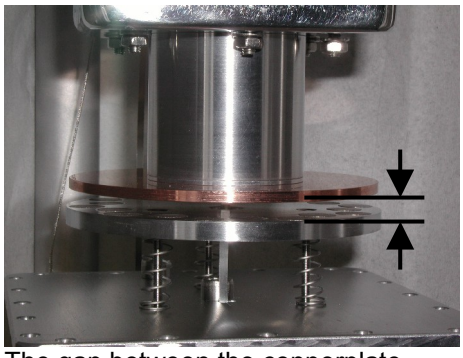
2.2 Repairing the STM

1. Remove the sample off the STM.
2. Loosen the STM completely (linear feedthrough X=0).
3. Open the clamp to disconnect the stainless steel strips for the pulling mechanics.
4. Remove the screw, which holds the opening mechanism for the shutters.
5. Remove the outer radiation shield.
6. Loosen the two nuts in the copper plate at the bottom of the inner radiation shield and remove all the parts.
7. Remove the inner radiation shield.
8. Repair the STM.
9. If you removed the springs, which hold the STM than, you have to adjust the length of the springs with the help of the supplied tool. At ambient temperature the STM should be able to swing about 1mm in height when covered by the radiation shield. (This has to be done with the sample in the STM!)
10. Remove the sample off the STM.
11. Mount the inner radiation shield. Make sure that you do not clamp the wires!
12. Mount the mechanics, which pulls down the STM and the sample. The two screws and the nuts should not stick out of the copper plate (for the damping of the cryostat).
13. Mount the outer radiation shield without its baseplate. Then connect the opening mechanism for the shutters with the stainless steel wire and test it.
14. Put the stainless steel strips (for the pulling mechanics) through the holes in the baseplate of the outer radiation shield and mount it. Connect both ends of the strips with the clamp. Check that the copperplate of the inner radiation shield is not touching the damperplate, which is mounted on the outer radiation shield.
15. Test the pulling mechanics and the shutters.
16. Pull down the STM an put the sample in its place.



To adjust the height of the STM you have to put in the marked tungsten wire at another point of the spring.



The gap between the copperplate mounted on the inner cryostat and the aluminum plate with the magnet should be ~0.5mm. (Here it is too

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large!) Tighten or loosen the nuts at the baseplate of the outer radiation shield to adjust this gap.

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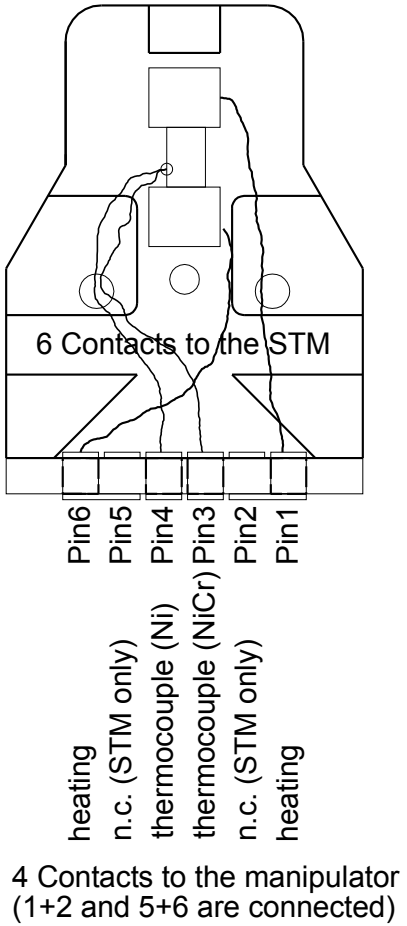
2.3 System cabling

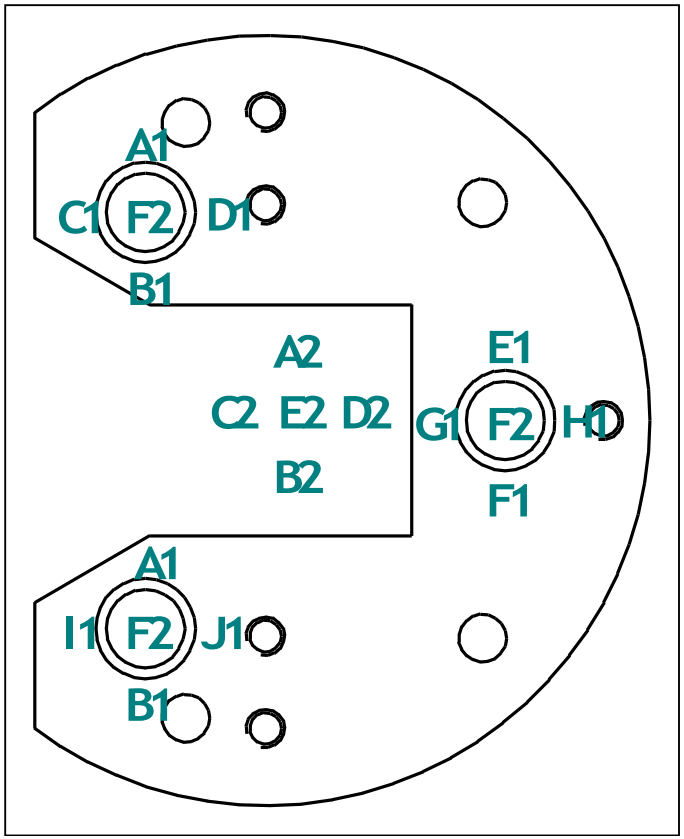
2.3.1 Sample cabling

When the sampleholder is clamped onto the manipulator there are 4 contacts. The two for the heating of the sample are contacted with the pins A and H of the 10-fold feedthrough at the manipulator while the two thermocouple wires are connected to the pins I and J. In the STM there are 6 contacts to the sampleholder but up to now only 4 are used. (You can use pin 2 and pin 5 to connect other points of the sample.) On the right you see a top-view of the sampleholder with the connection to the sample.



2.3.2 STM cabling

The cables from the HV-amplifier (STM1 and STM2) are connected to the piezos of the STM according to the sketch on the right. The inner electrodes of the outer piezos (coarse) are connected to pin F2, the inner electrode of the center piezo (main) is connected to pin E2 (of the 10-fold feedthrough STM2). In the ‘normally’ used scanning modes the coarse piezos are used for scanning X, Y and the main piezo to control the distance Z to the sample. (This way the scanning directions are decoupled.) The unused Z-electrode (in this case the Z-coarse) has to be grounded. You can also use Z-coarse and X, Y-main or any other combination to scan the sample. But remember that due to the STM-design Z-main has to be connected to +Z of the HV-amplifier, while Z-coarse has to be connected to –Z! (Always ground the other Z-electrode.)



2.3.3 Connectors and cables to the STM

There are 2 spare cables in each multi-wire from the 10-fold feedthrough (STM1…3) to 37pin connector of the STM.

UHV-connector	Cable	Connector	Use	Voltage (ScanCoarse)	Voltage (Rotation)	Voltage (Scan Main)
STM1 (10 pin, MDC) A	red	HV-Amp. (11 pin, Fischer) A	Piezo-Voltage	+y	0	0
STM1 (10 pin, MDC) B	black	HV-Amp. (11 pin, Fischer) B	Piezo-Voltage	-y	+x	0
STM1 (10 pin, MDC) C	yellow	HV-Amp. (11 pin, Fischer) C	Piezo-Voltage	-x	+x	0
STM1 (10 pin, MDC) D	black	HV-Amp. (11 pin, Fischer) D	Piezo-Voltage	+x	-x	0
STM1 (10 pin, MDC) E	blue	HV-Amp. (11 pin, Fischer) E	Piezo-Voltage	+y	+x	0
STM1 (10 pin, MDC) F	black	HV-Amp. (11 pin, Fischer) F	Piezo-Voltage	-y	-x	0
STM1 (10 pin, MDC) G	green	HV-Amp. (11 pin, Fischer) G	Piezo-Voltage	-x	0	0
STM1 (10 pin, MDC) H	black	HV-Amp. (11 pin, Fischer) H	Piezo-Voltage	+x	0	0
STM1 (10 pin, MDC) I	white	HV-Amp. (11 pin, Fischer) I	Piezo-Voltage	-x	-x	0
STM1 (10 pin, MDC) J	black	HV-Amp. (11 pin, Fischer) K	Piezo-Voltage	+x	+x	0
STM2 (10 pin, MDC) A	red	HV-Amp. (6 pin, Fischer) A	Piezo-Voltage	0	0	+y
STM2 (10 pin, MDC) B	black	HV-Amp. (6 pin, Fischer) B	Piezo-Voltage	0	0	-y
STM2 (10 pin, MDC) C	white	HV-Amp. (6 pin, Fischer) C	Piezo-Voltage	0	0	-x
STM2 (10 pin, MDC) D	black	HV-Amp. (6 pin, Fischer) D	Piezo-Voltage	0	0	+x
STM2 (10 pin, MDC) E		BNC	Z main			
STM2 (10 pin, MDC) F		BNC	Z coarse			
STM2 (10 pin, MDC) G		BNC	Si-diode STM +			
STM2 (10 pin, MDC) H		BNC	Si-diode STM ground			
STM2 (10 pin, MDC) I		BNC	Si-diode He-cryostat +			
STM2 (10 pin, MDC) J		BNC	Si-diode He-cryo ground			
STM3 (10 pin, MDC) A		BNC	Pin1 (sample)			
STM3 (10 pin, MDC) B		BNC	Pin2 (sample)			
STM3 (10 pin, MDC) C		BNC	Pin3 (sample)			
STM3 (10 pin, MDC) D		BNC	Pin4 (sample)			
STM3 (10 pin, MDC) E		BNC	Pin5 (sample)			
STM3 (10 pin, MDC) F		BNC	U bias (Pin6)			
STM3 (10 pin, MDC) G		4 mm Socket	STM-ground			
STM3 (10 pin, MDC) H		4 mm Socket	Z-diode			
STM3 (10 pin, MDC) I		4 mm Socket	Ramp			
STM3 (10 pin, MDC) J						

2.3.4 Digital I/O of the DSP-board

Header, 34 pin DSP-Board	According to PC32-document	SubD 37-pin PC, Digital I/O	Used for the STM as	SubD 25 pin HV-Amplif.	SubD 25-pin STM-Electr.
1	Digital OUT (DX0)	1	GainPreAmp		1
2	Digital OUT (DX1)	20	GainPreAmp		2
3	Digital OUT (DX2)	2	GainPreAmp		3
4	Digital OUT (DX3)	21	Main/Coarse	4	4
5	Digital OUT (DX4)	3	XY/ROT	5	5
6	Digital OUT (DX5)	22	HighSpeed/LowNoise		6
7	Digital OUT (DX6)	4			7
8	Digital OUT (DX7)	23			8
9	Digital IN (DX8)	5	GainHV	9	
10	Digital IN (DX9)	24	GainHV	10	
11	Digital IN (DX10)	6	GainHV	11	
12	Digital IN (DX11)	25	GainHV	12	
13	Digital IN (DX12)	7	GainHV	13	
14	Digital IN (DX13)	26	GainHV	14	
15	Digital IN (DX14)	8			15
16	Digital IN (DX15)	27			16
17	n.c.	9			
18	EXT_DIG_CLK	28			
19	n.c.	10			
20	n.c.	29			
21	n.c.	11			
22	n.c.	30			
23	n.c.	12			
24	n.c.	31			
25	TCLK0	13			
26	EI0	32			
27	TCLK1	14			
28	EI1	33			
29	XF0	15			
30	EI2	34			
31	XF1	16			
32	EI3	35			
33	DVCC	17		24	24
34	DGND	36		25	25
		18			
		37			
		19			

2.3.5 Preamplifier cables

Sub D Connector (25 pin)	Cable	Sub D Connector (9 pin)	Use	DSP-Board
9	green	4	Gain GND	Dig. GND
10	brown	1	Gain1	Digital OUT (DX0)
11	white	2	Gain2	Digital OUT (DX1)
12	pink	3	Gain3	Digital OUT (DX2)
13	grey	9	AC/DC	Digital Vcc (+5V)
14	yellow	8	HighSpeed/LowNoise	Digital OUT (DX5)
15	blue	6		
20	shield	5		
Lemo (3 pin)		**Tuchel (3 pin)**		
1	brown	3	Vcc +15V	
3	green	2	Gnd	
2	white	1	Vcc -15V	

2.3.6 How to connect the Cables:

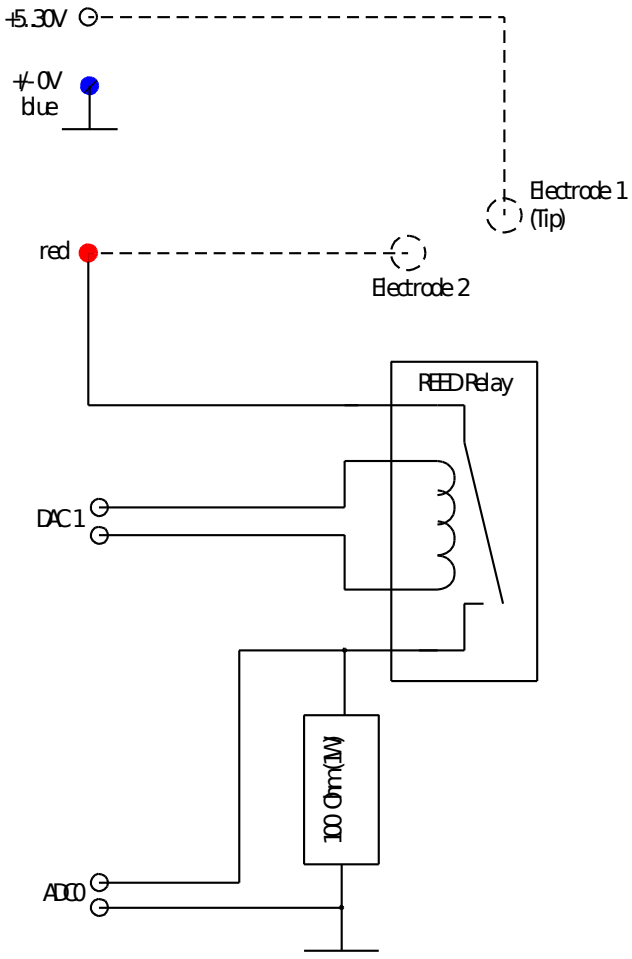
BNC Plugs	Connect with
ADC0	Preamplifier (DLPA 200)
ADC1	Lock in Amplifier (Option)
ADC2	Lock in Amplifier (Option) / Temperature sensor (Option)
ADC3	Temperature sensor (Option)
DAC0	Z in
DAC1	Tunneling voltage
DAC2	X in
DAC3	Y in

Remember to connect the tunneling voltage with the sample in the STM: Connector STM3: pin 1, 2, or 5, 6 (3, 4 if a thermocouple is connected to the sample). Check if the tunneling voltage can be measured at another pin.

3 Appendix

3.1 Etching a tip

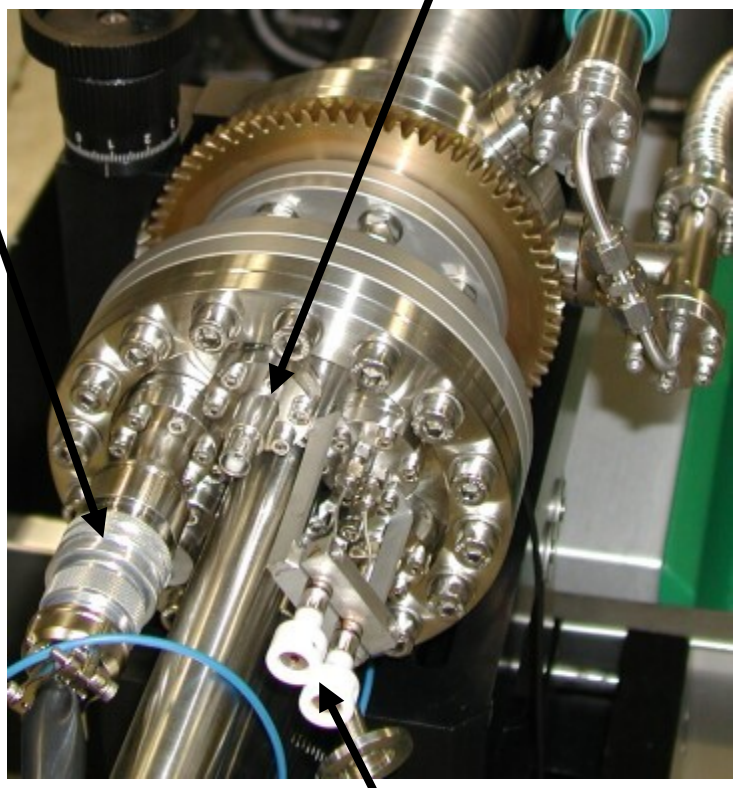
Connect the tip etch module and the etching station according to the drawing with DAC1, ADC0 and an external power supply. The etching should be done on the floating vibration isolation of the STM or a rigid support to prevent vibrations of the etching solution.
A solution of 4g NaOH in 50ml H_2O is recommended to etch tungsten tips. The tip wire should be ø0.25 … 0.35mm.
Start the tip etch program (Ptipetch.exe in the folder \tipetch of the STM-Program) and set the EtchVoltage to 8000 and the EtchCurrent between 10 and 100. The latter parameter determines when the etching will be stopped. You can adjust the EtchCurrent and the voltage of the DC (5-30V) power supply to determine the lenght / shape of the tips. (If you use an AC power supply you have to find a good value for the Current Filter.)
Clean the etched tips with H_2O. (You may use HF to remove the oxide and again H_2O to remove the HF.)
It is also possible to remove the oxide by heating and/or sputtering the tip.
Put the tip into a tip holder, adjust the height (mm) and transfer into the UHV.



3.2 The connectors of the manipulator

This BNC connector is not used. But it is cabled to the manipulators head using coaxial wire.

The 10-fold feedthrough connects the temperature diode (Pins A and H) at the head of the manipulator (not the sample!) and the heating contacts of the sample holders (Pin 1/2 and 5/6 of the sample holders are connected to Pin I and J). Pins B, C, D, E, F,G are not used but cabled to the head of the manipulator.

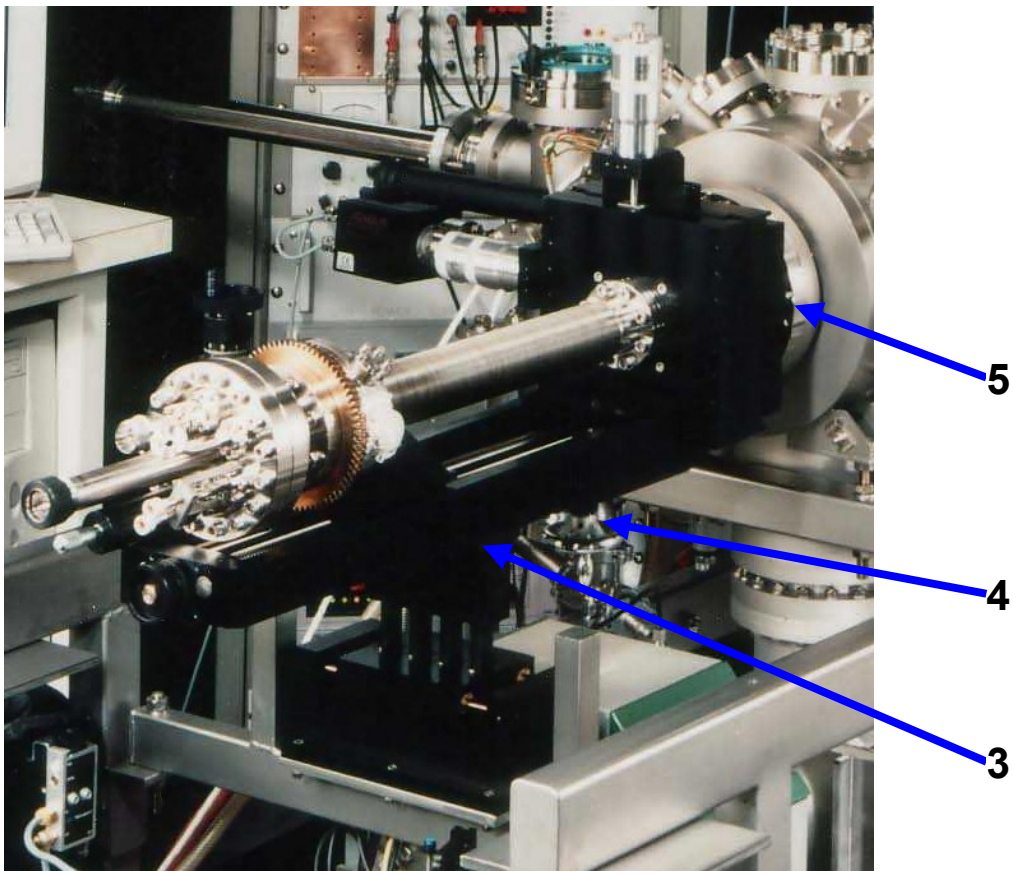


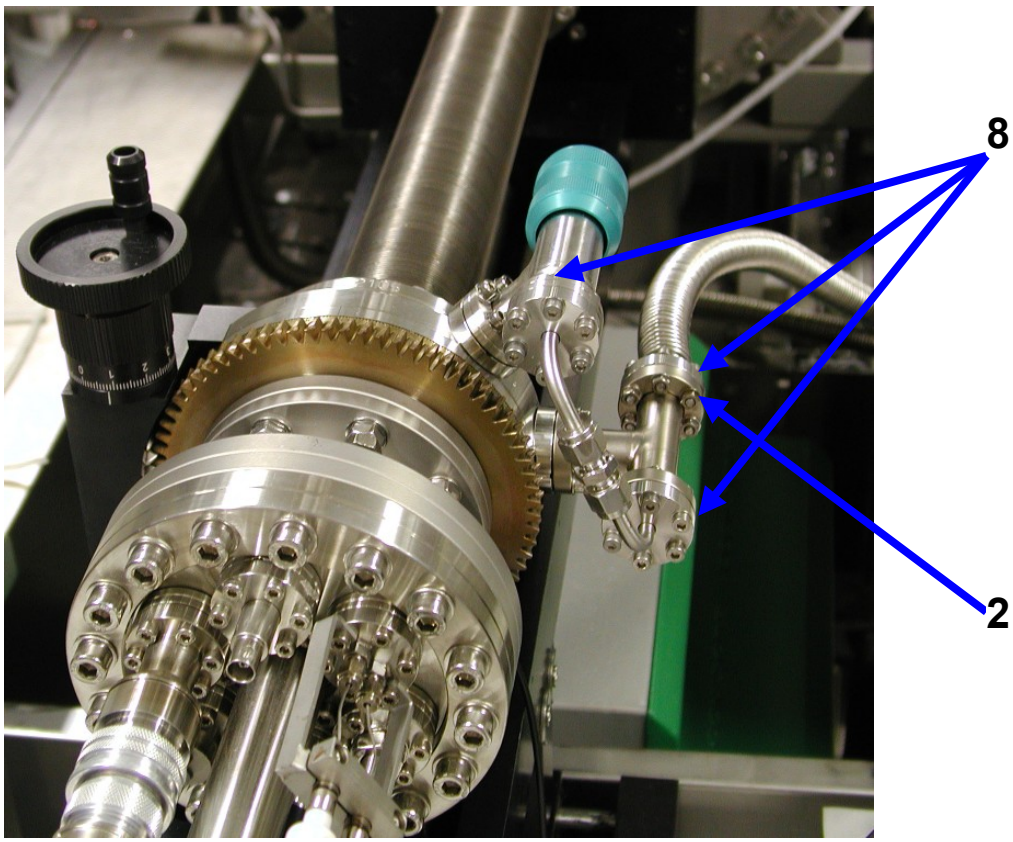
These connectors allow you to heat up the manipulators head (e.g. during the cooling) to set a precise temperature. Imax=2A

Not in this image: The connector for the thermocouple type K. It measures the sample temperature.

3.3 How to remove the manipulator off the UHV-System

1. Set the manipulator to X= 25, Y=25, Z=400 (fully retracted).
2. Remove the bellow from the differentially pumped freedthrough: Disconnect the bellow from the T at the manipulator (2).
3. Press down the support (3) for the manipulator, so that the manipulator hangs free:
    - Set the Y micrometer screw to a low position Y=5.
    - Lock the support of the manipulator in this position e.g. using a thick wire.
    - Lift up the manipulator to the middle position Y=15…25 supporting it with your hand. No force is allowed on the micrometer screw!
    - There should be a gap (5mm) between the frame of the manipulator and its support now. If not, go higher in Y.
    - Check that the support is tightened firmly!
4. Remove the handle (4) (for Z) off the manipulator.
5. Open the DN150CF flange to the UHV-chamber.
6. Remove the manipulator off the chamber with 2 people: One holds the end of the manipulator (at the DN150CF flange), the other slowly navigates the manipulators head out of the chamber grabbing the X,Y table. Never attempt to do this alone!
7. Watch out for the axis of the Z-handle! It sticks out and might interfere with the manipulators support.
8. Put down the manipulator on a flat surface with the side opposite the X micrometer screw. Put a piece of wood or Styrofoam underneath the differentially pumped feedthrough, so that you don't have any load on the DN16CF flanges (8).
9. Repair the manipulator and put it back in.


5
4
3


8
2

3.4 All checks:

3.4.1 Check the STM-cabling:

Let the STM hang free. Check all cables for ground connections using an ohm meter at the feedthroughs STM1-3 and Tip. Check all cables at STM1 (Coarse scanner) and A-F (NOT G-J) at STM2 (Main scanner, Z) for connections in between them using 200V from the HV-Amplifier and an ampere meter. If you measure a current, there is a high voltage leak. Repair the cabling inside or disconnect the appropriate wire at the UHV-feedthrough. Usually the STM can be operated with one or two unconnected electrodes. – Remember to rescale the STM-images!

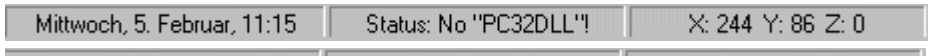
3.4.2 Check the HV-Amplifier:

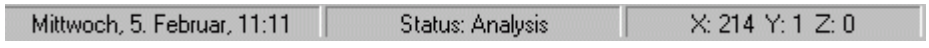
Start the STM-Program (to switch the HV-Amplifier to XY, Coarse). Connect a voltmeter to –Xout and slowly increase / decrease the Xoffset to the maximum / minimum. The voltmeter should show the negative voltage of the analogue display of the HV-Amplifier. If it shows ±200V permanently, the HV-Amplifier is broken. If you can't set the offset to ±200V, than the output is grounded somewhere. – Switch off the HV-Amplifier and check for broken wires in the STM (and outside). Repeat this for the Y and Z channel.

3.4.3 Check the DSP-board:

Check the driver installation:
Start the program. On the left side of the bottom line it states the actual time and date. The next field to the right should be empty (A). If it shows 'Status: NO PC32dll' (B), than it could not detect the DSP-board. This means that either the board is broken or the driver not correctly installed. 'Status: Analysis' (C) means that another instance of the program is running – Switch to this instance instead.

A.

B. 

C. 

Start and Stop a scan – to check the communication with the computer (no sample needed). If this does not work, close the program and start the test program 'Download.exe' in the same folder. Click on 'File' – 'DSP-Reset'. You should get 'Talker init ok'. Otherwise the DSP-board is not installed correctly or broken.

3.4.4 Check the digital I/O of the DSP-board:

Change the gain of the preamplifier with the STM-program and see if the according LEDs on the front panel of the Connecting Box do switch as well.

Change the gain of the HV-Amplifier. Start and stop a scan. Now the actual gain value should appear in the SCAN parameter table.
Use the RAMP controller to switch between COARSE and MAIN as well as between ROT and XY. You should hear a ‘click’ from the HV-Amplifier and see the according LEDs on the front panel of the Connecting Box switching.
Check the analogue I/O of the DSP-board:
Connect DAC0-3 to the oscilloscope. Be changing the set point current to the lowest possible value DAC0 (Z) should go to –10V. DAC1 should give you the value of the tunneling voltage stated in the STM-program. Start a scan: You should see a saw tooth voltage on DAC2 (X) and a slowly rising voltage on DAC3 (Y). To simulate an input at ADC0 you can use the tunneling voltage (DAC1) or an external voltage source. If the input at ADC0 is below the set point current of the STM-program, DAC0 (Z) should be positive (max. +10V), above the set point negative (min. –10V).

3.4.5 Check the preamplifier:

Set the gain of the preamplifier to ‘Remote’ and use the STM-program to set the gain value. Measure the noise with the oscilloscope. The noise should scale (usually not by the same factor) with the gain: higher gain = more noise. Switch from ‘Remote’ to the same gain as in the STM-program. You should have the same noise as before.

3.5 Troubleshooting

What's wrong	Possible reason	What to do
Sample transfer		
Sample does not click in.	Position not correct	Look through the windows in the transfer axis to check the position and reposition the sample
	You don't push the sample at the correct height (therefore the friction between sampleholder and Stempel is too high)	Try a different height. (±2mm)
	Sampleholder is jammed somehow.	Move the sampleholder out (by 1cm) and put it in again.
Sampleholder does not come up to the baseplate, when it's released.	Pulling mechanism is jammed.	Pull down and release it again.
Shutter does not close.	Shutter is jammed.	Use the manipulator to force it down. When you open the chamber next time see why this happened.
Approach		
Rotation fails.	The ring of the Beetle can't be moved in all the directions (±X, ±Y, Rotate UP, Rotate DOWN)	Check the cabeling
	The RAMP parameters are wrong.	Check the parameter setup
	HV-amplifier chips (PA85) are blown.	Check the voltages at the HV-amplifier (±X, ±Y)
Tip does not reach to the sample surface.	The tip is too short (long).	If you can't rotate the beetle any further to approach (check with the telescope) you have to use a longer (shorter) tip
	There is a gap between the baseplate of the STM and the sampleholder.	First rotate the tip upwards. Then pull down the sampleholder (with the linear feedtrough) and release it again. Check if the gap is closed now. If it's not transfer the sample again.