SOP for Micro Mechanical Analyzer

Note: This document is frequently updated; if you feel that information should be added, please indicate that to the facility manager (Currently Philip Carubia; pmc228@cornell.edu; Office, Bard B57; Phone, 845-551-6501).

- **Reservations and enabling on coral**
  - o The Micro Mechanical Analyzer is on the CCMR Coral equipment Reservation and enabling system. You need to have a CCMR user account so that you can reserve and enable the equipment on Coral. More Information on getting an account and using coral is at: http://www.ccmr.cornell.edu/facilities/coral.html
  - o The monitor for this instrument is interlocked with the Coral system and will not turn on until the system has been enabled in Coral.
- **Log book**
  - o Record the date, Sensor number used, material measured, your name and hours of usage. Comment on problems or issues that you may have had.

About the MMA:

- **System components:** The MMA consists of several different components mounted on top of an inverted microscope. The overall design consists of several piezo positioners, manual positioners and a MEMS force sensor.
  - o The MEMS sensor is manufactured by Femto tools and comes in multiple configurations. Please note that these sensors are extremely delicate and very expensive. Currently the replacement cost of a new basic sensor is approximately $650.00. Sensors should be handled with extreme care and caution. Financial compensation or purchase of personal sensor may be required of any excessive breakage to be determined by the CCMR. There are several ways that sensors may be broken which can include crashing the sensor upon approach; measuring a material that is too stiff; applying lateral forces to vertical sensors or vertical forces to a horizontal sensors (AKA: Gripper); crashing microscope objectives into slides while sensor is in contact with sample; and breaking on finger or cable when installing in holder. Utmost care must be used when installing and using sensors on the instrument.
  - o Piezo components: There are several piezo components from several manufacturers that work together to position the sensor. These piezo elements come from two different manufacturers and are controlled differently.
    - ▪ The first set of piezos is manufactured by PiezoJenna. They are referred to as the "fine positioners". They have the ability operate with a closed

feedback loop and thus have very precise position control and will be providing the position/strain data for your mechanical measurement. These positioners are controlled through the Cornell Micromech software. There are three separate positioners that have the ability to move the MEMS sensor in three axes; x, y, and z.

- The other piezo element is manufactured by smar-act and is considered a "motor" due to the fact that the piezos have the ability to run in a stick slip mode. This functionality allows for larger steps to be taken with a smaller accuracy. Due to this fact this positioner is only for sensor placement not for testing. Caution should be utilized here as the large steps can endanger the sensor tip.
- There are also two sets of manual adjustment for sample and sensor. These include two lead screws that will move the sensor in the x,y plane and a positioner that will move the sample around on the microscope stage.

- **Microscope**
  - All of the above components are mounted on a Zeiss axiovert microscope. This is an inverted microscope. Rather than viewing the sample from above, the microscope objectives are placed below the sample allowing for the MMA system to function unhindered above. Mounting the components on a microscope allows for visual placement of the sensor with respect to the sample. Depending on sample type this will often require some amount of forethought. Generally the substrate, and sometimes the sample, must be transparent and must be able to be viewed from below. This is a fluorescence microscope that is equipped with two dichroic mirror sets and a mercury vapor lamp. CCMR is in the process of purchasing a fluorescence camera that will be useable on this system and several others across the facility.
  - **Objectives:** Generally you will be using the standard 10x objective for your entire experiment. There are several other objectives to include: 10x fluorescence 30x fluorescence and a 40X fluorescence.

Starting the system:

- Remove x, y, z USB from the computer.
- Start computer and log in using the MMA user account
  - The password is CCMR_MMA_user
- Turn on D-drive
- Turn on the SmarAct controller

- Plug in x, y, z, USB
- Open MicroMech Application on the desktop
  - o The MicroMech App. window will look similar to below.
  - o Once the software opens up you should have full communications with the Force DAQ and the Piezo jenna d-Drive and fine piezo DAQ. If there is a problem than an error screen will appear and the status indictor will turn red.
  - o The force, digital position and analog position readouts should be reading and the plots updating.
  - o First select the actuator that you wish to control. The Z-axis is normal to gravity and would be used for the vertical force sensing probes. The X-axis is the proper selection for the horizontal sensing grippers.
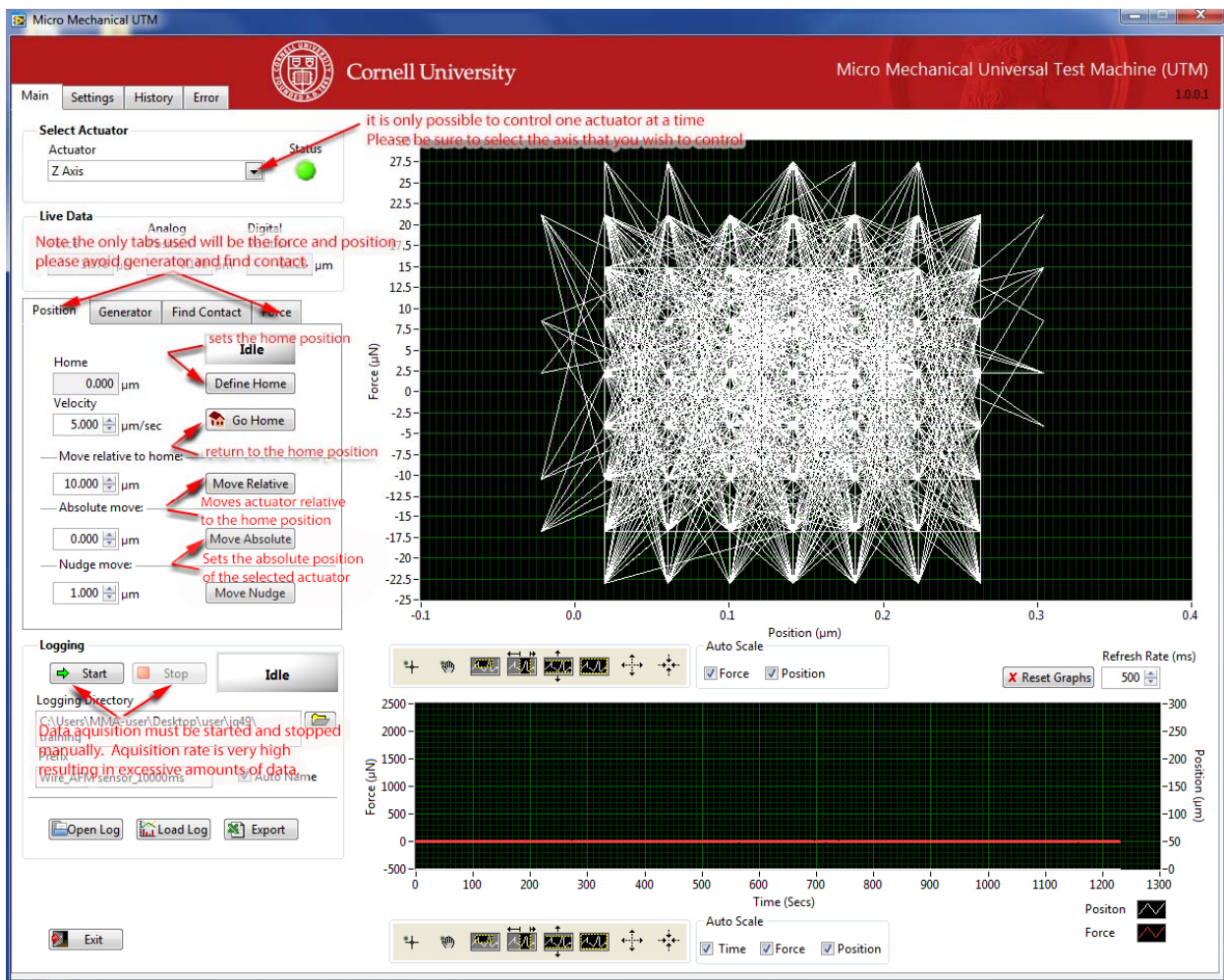

Figure 1

  - o Move the primary axis to the start of the measurement position by using the "Move absolute" function. For the Z-axis the full range of motion of the actuator

is 300µm. The positive direction is considered up and the negative direction is considered down. Typically a move to 100 µm would be sufficient. Once the actuator has finished its move define this location using the "Define Home" function.

Sample mounting:

- Measuring on this system requires some forethought on sample mounting. At current there are two sensor types and sample mounting is dependent on how the sensors are mounted.
    - o Typically all samples should be transparent or small enough to allow for probe positioning.
    - o Likewise the samples should be mounted on a transparent substrate to allow probe positioning from below.
    - o The substrate should be soft to protect the probe from a crash or while determining contact.
    - o There are some instances where samples can be viewed from the side but this configuration is limited.
    - o Sample and substrate are required to be either mounted on a microscope slide or be the same dimensions.
    - o Overall thickness to allow for focusing should be less than 4mm
- There are two sensor types and these will dictate how the sample is mounted and measured.
    - o There is a Z axis probe with a 100µm silica bead glued to the tip for measuring in a compressive or indentation mode.
    - o There is an x-axis probe "gripper" that is typically used for measuring a fiber type sample that is spanning a trench.
- Turn on microscope, objective turret motor and Fiber optic lamp.
- Place microscope slide and PDMS substrate on the microscope slide holder.
- Place sample on the PDMS substrate.
- Focus on the sample either using the microscope objective or from the side using the long working distance microscope.

Installing the MEMS probe:

- Once the computer and piezos are set up and the sample is installed in the microscope, the Force probe can be installed. This is a very delicate operation and typically is what results in the majority of breakages. When installing the force probe be sure to remove all extraneous items from the area.

- Adorn the anti-static bracelet and be sure that it is connected to ground.
- Turn on Smaract controller and move the Coarse Z piezo all the way to the top of its stroke.
- Set up the MicroMech app. For the proper load sensor. Contact facility manager if the proper sensor isn't shown in the software.
- If you will be using the newer sensor types you will need to install the adapter plate before removing the sensor from its housing.
- Place the entire mounting assembly on the anti-vibration table facing left to right. And arrange all wrenches and bolts that you will need within easy reach.
- Open the sensor case and delicately remove the sensor. Be very cautious of your fingers it is very easy to break the sensor tip with a careless finger.
- Place the sensor on the mounting bracket and install two screws for the older style mounting and one screw for the newer style. Use care to not drop any screws or wrenches here. A falling screw can break off the sensor tip.
- Once the sensor is mounted, gently and deliberately raise the entire assembly into the measurement well and place it on the fine-Z Piezo positioner, being careful not to hit the sensor on anything.
- Install the two mounting screws.

Finding contact:

- Once the sensor is mounted the user needs to locate it in the microscope objective and then contact the surface of the substrate. This is typically done with the coarse Z motor.
- The coarse Z motor is controlled through the Smaract control box that is located next to the microscope. See figure 2 below.
    - The box has three dials of which only the leftmost dial will be used.
    - The single dial controls two things: step size and step.
    - When the step size is selected turning the dial clockwise will increase the step size and turning to the left will decrease the step size.
    - If step is selected (by pushing in the dial) turning the dial clockwise one click will raise the motor by the step size specified. Turning the dial one click counterclockwise will lower the motor by the step size specified.

Figure 2

- Visually inspect the relationship of the sensor to the substrate from the side of the MMA and ensure that there is ample room to move the sensor down without hitting the substrate or sample.
    - It is recommended to start with a step size of 200µm or less.
    - Also it is recommended that your first step is up away from the substrate so that you can judge the step size in relation to the distance from the substrate.
- The sensor should be brought within 1-2 mm of the substrate visually so that it can be located in the microscope objective.
- Once the sensor is close to the substrate find the sensor tip using the microscope.
- Once the sensor tip is located in the microscope you can slowly step the sensor down to the substrate by taking small steps with the Z motor and refocusing on the sensor tip.
    - As the sensor approaches the surface of the substrate the step size of the motor should get smaller. It is much better to take an extra 10 minutes to find the surface rather than chance breaking the sensor.
    - The stiffness of the substrate should dictate your final approach step size. The softer the substrate the larger the step possible.
    - The step size will decrease with decreasing sensor capacity. For example a 1000µN sensor requires a smaller approach step than the 10000µN sensor.
    - A PDMS of modulus 3MPa will generate approximately 100µN of force with a 1µm step. Thus a comfortable approach step for this substrate is 1µm. If you are approaching a stiffer substrate your step size will have to be lowered accordingly
- You can tell that contact has been made once a load is apparent in the MicroMech Application software.

- Once contact is found you can now raise the sensor and position the sample for a measurement.
  - Please note that no substrate is perfectly flat and that when you are positioning your sample the sensor needs to be raised accordingly.

<u>Taking a measurement:</u>

- Once the sensor is placed you are ready to take a measurement.
- Go to the force tab in MicroMech application and tare the load sensor
- Set the velocity of the test
- Double check that the home position is set properly
- Set the displacement that you wish to move the sensor in the move relative box.
  - For the Z-piezo down is considered the negative direction and up is positive
  - For the X piezo the positive direction is toward the user
- Set the logging directory to the correct file path. Once all values are set press the start button to begin logging data and press the move relative button to begin sensor motion.
- Monitor the test closely to ensure that the sensor doesn't exceed its maximum load capacity.
- Once the sensor reaches full extension press the "go home" button to return to the home position.
- Once the home position is reached than press the stop button in the logging section to end data logging.