

**ESP2110 DESIGN PROJECT**

**Scanning Tunneling Microscope**

**[Logbook]**

**Group 3**

Contents

[**Introduction** 3](#_Toc66112285)

[**4/3/2021** 4](#_Toc66112286)

[**5/3/2021** 5](#_Toc66112287)

# **Introduction**

**Group members**

|  |  |  |
| --- | --- | --- |
| Role/Shift Day | Thursday | Friday |
| Group Leader | Goh Kheng Xi, Jevan | |
| Assembly and Test Subgroup members | Thomas Tan Juen Kai  Ye Jiaying | Loke May Chee  Lee Wei Yee Adrianne |
| Fabrication Subgroup members | Lee An Min, Amanda | Miles Su Hao Peng |

**Aim: To design and construct a Scanning Tunneling Microscope (STM)**

# **4/3/2021**

**Assembly and Test Subgroup**

Objective(s): Lab familiarisation

Venue: Physics E lab (S11-03-02)

Outline:

1. General briefing of equipment and lab etiquette
2. Equipment:

1x Keithley 2231A-30-3 Programmable DC Power Supply

1x Rohde & Schwarz 100mHz RTB2004 Digital Oscilloscope

1x Knipex 12 42 195 automatic wire stripping tool

1x Goot KX-60-R soldering iron and stand with sponge pad and helping hands (need to book 1 week in advance)

1. Piezoelectric disc characterization attempt

A picture containing indoor, kitchen appliance, control panel

Description automatically generated- Connect the wires to the DC supply (Not to use waveform settings as the piezoelectric disc will oscillate too fast for any meaningful observation)

A picture containing text, indoor

Description automatically generated

**Fabrication subgroup**

Objective(s): Lab familiarization

Venue: ESP/CIBA Nanofabrication Lab (S7-01-03)

Outline:

1. General briefing of equipment and lab etiquette
2. Equipment:

1x Ultimaker 3 (Requires TA’s permission)

1x Prusd 3D printer (Requires TA’s permission)

1x Prusa Mini 3D printer (To be shared among 3 groups)

1x Oree Laser Cutter (Requires TA’s permission and to be operated by TA only)

1. If soldering is required, safety glasses must be worn and soldering must be done under TA’s supervision.

# **5/3/2021**

**Assembly and Test Subgroup**

Objective(s): Out-of-system Characterisation of Piezoelectric disc

Venue: Physics E lab (S11-03-02)

Tasks: To quantify the response of the piezoelectric disc towards voltage (i.e. to determine how much the piezoelectric moves per volt)

Principle:

Applying of voltage bias across the piezoelectric disc will cause it to deflect. The deflection can be observed under the optical microscope (with accuracy of 1 μm). When the disc moves, the microscope image can be refocused by adjusting the height (z-axis) of the stage. The change in height to focus the image can be used to determine the deflection of the disc in response to the voltage bias.

Methodology:

1. Focus the piezoelectric disc under optical microscope and record the value on the fine adjustment knob
2. Apply voltage bias of -10V using the provided triple channel DC supply
3. Refocus the image on the microscope by turning the fine adjustment knob and record the new value
4. Repeat steps 1-3 with increasing voltage (1V incremental) from -10V to 10V
5. Repeat steps 1-3 but with decreasing voltage of 1V from 10V to -10V

Precaution:

1. Ensure piezoelectric disc is secured on the stage Apply voltage bias of -10V using the provided triple channel DC supply
2. Ensure wire connected to the disc is not fully taut Repeat steps 1-3 with incremental voltage of 1V until 20 readings from -10V to 10V are obtained
3. Do not use too high of a voltage (keep to 10V and below) as piezoelectric disc may be damaged
4. Choose a fixed spot as a reference point for focusing the image of the piezoelectric since the surface of the disc is not uniform.
5. Ensure that the disc is not shifted throughout the experiment and the entire procedure is done in one sitting.

Results:

Chart, scatter chart

Description automatically generated

Based on the results obtained, the graph above was obtained. The gradient of the graph is -1.1448μm/V

Discussion:

1. The point anomalies are due to the disturbance caused by accidental contacts with the wire connected to the piezoelectric disc when turning the knob. These points can be omitted to achieve a more accurate gradient, but it will not be affected much as an in-system characterization will be done later.
2. The line of increasing voltage and decreasing voltage overlaps with each other, which means that no hysteresis is observed. However, this would be a wrong conclusion. The lines are the same for both increasing and decreasing voltage is due to the voltage supply being switched off 0V every time voltage is changed instead of directly increasing/decreasing the voltage while the voltage supply is still running.
3. Negative gradient of the positive voltage is reasonable, when the knob is turned clockwise, the reading decreases, the height of the stage increased, which means the piezoelectric disc deflects upward, this matches the expectation as positive voltage applied will cause upward deflection. However, the negative gradient of the negative voltage is currently unexplained.

Conclusion: The piezoelectric disc deflection of 1.1448μm/V is very close to the given value of 0.1μm/V

**Fabrication Subgroup**

Objective(s): Briefed on 3D printing process

Venue: ESP/CIBA Nanofabrication Lab (S7-01-03)

Outline: Procedure for 3D printing

* + - 1. The file(s) is/are to be uploaded onto Microsoft Teams and the TA is to be tagged. Alternatively, clearance can be obtained during the laboratory session itself
      2. Once clearance is obtained, the file(s) is/are to be saved in SD2 format and onto thumbdrive provided
      3. The thumbdrive is then plugged into the 3d printer

Note: 3D printing can take awhile and it is recommended to compile files (along with other groups) to be printed in one go.

Precaution:

1. Always use mm for all dimensions
2. Only use metric screws
3. Compile files to check if different parts fit together (screw size, etc) before fabricating