Building A Scanning Tunneling Microscope Using A 3D Printer

Anthony Ornelas

June 10, 2022

1 Introduction

Scanning Tunneling Microscopy is a valuable tool that allows researchers to achieve high-resolution images of conductive samples at the atomic level. STM additionally permits researchers to obtain a three-dimensional profile of the sample. This three-dimensional profile can provide insightful information about the sample, such as roughness and surface defects. Secondly, STM also allows the researcher to dictate the conformity of the sample. An STM is based on the concept of quantum tunneling. Quantum tunneling is a quantum mechanical phenomenon where atoms or subatomic particles, such as electrons, act like waves, allowing them to penetrate barriers and continue through the other side.

 More specifically, an STM works by applying a voltage difference between a very sharp tip and the conductive sample. The microscope's tip is brought down very close to the sample, allowing electrons to travel between the vacuum of the sample and the tip of the microscope. The transmission of the electrons between the sample and the tip creates a tunneling current which can then be registered. The tip of the microscope is then moved across the surface of the sample at small distances measured in nanometers, but it stays at a constant height. The current decreases exponentially with an increase in distance between the sample and the microscope’s tip. Hence, the tunneling current is a sensitive measurement of the distance. The samples that we measure are not uniform at an atomic level. Samples have peaks and valleys which either increase or decrease the distance between the tip and the sample. In turn, the current being measured either increases or decreases depending on the change in distance. From the currents that we measured, we obtain a graph of the current and position of the tip. Using this data, we can create a grayscale and eventually create a picture that can roughly resemble the surface of the sample.

Nonetheless, there are also many limitations and difficulties in scanning tunneling microscopy. STM can be costly, many parts can be fragile, and assembly can be complex. This introduces the possibility of producing a cheaper STM that is easier to build using 3D printed parts. Therefore, my goal for the summer is to design and build an STM using as many 3D printed parts as possible. We are also planning on comparing the results of my STM to those of a scientific STM to find out how efficient a 3D printed STM is.

2 Procedure

1. My project will begin by learning how to 3D print. I am unfamiliar with AutoCAD and slicing, so I need to get familiar with these programs so I can 3D print efficiently.

2. We already have a motor that can move the sample closer to the piezoelectric tube. However, we must design a structure that can attach to the motor and hold the piezoelectric tube.

3. We need to build specific electronics that we can use to measure the tunneling current.

4. Our final step is going to do some imaging with our STM. We want to compare our results to those of a scientific STM.

5. If time allows, we will design a 3D printed motor that is smaller than the motor we are currently planning on using.

**References**

*Scanning tunneling microscopy (STM): An overview*. Oxford Instruments. (n.d.). Retrieved June 9, 2022, from https://afm.oxinst.com/modes/scanning-tunneling-microscopy-stm

*Scanning tunneling microscopy*. Nanoscience Instruments. (2018, July 26). Retrieved June 9, 2022, from https://www.nanoscience.com/techniques/scanning-tunneling-microscopy/#:~:text=The%20scanning%20tunneling%20microscope%20(STM,down%20to%20resolving%20individual%20atoms.

Lincoln, D. (2020, August 7). *Physicists watch quantum particles tunnel through solid barriers. here's what they found.* LiveScience. Retrieved June 9, 2022, from https://www.livescience.com/quantum-tunneling-observed-and-measured.html