Design and Fabrication of an Electrolytic Atomic Force Microscope

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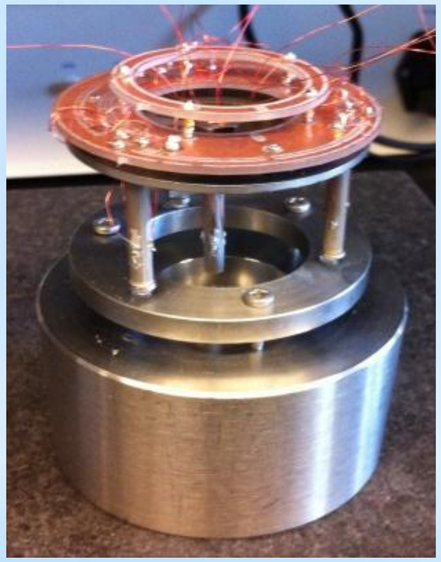
Overview

The Atomic Force Microscope (AFM) is a scanning device that reads the topography of a surface at the nano-scale.



This AFM operates in a non-contact mode. The scanning probe is immersed in an electrolyte covering the specimen's surface. A topographic image is produced using a DAQ system (GXSM).

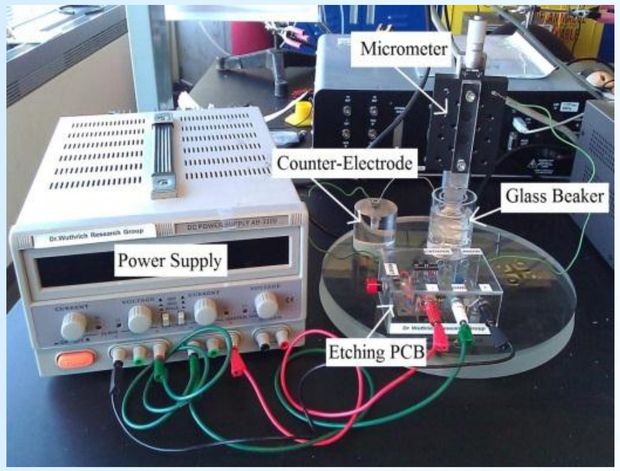
Objectives

1) Building an electrochemical etching device that etches tungsten wire to form sharp scanning tips.

2) Designing an electrolytic cell which holds the specimen during the scanning process and contains a layer of an electrolyte that covers the specimen (at a height of 200 μm).

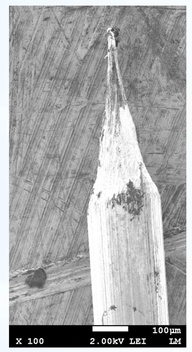
3) Improve the coarse approach system (stick-slip) by redesigning the slider and optimizing it's motion.

Electrochemical Etching Device



A tungsten wire is immersed in a KOH solution.

A SEM image shows that the tungsten wire is etched into the desired shape for accurate scanning.



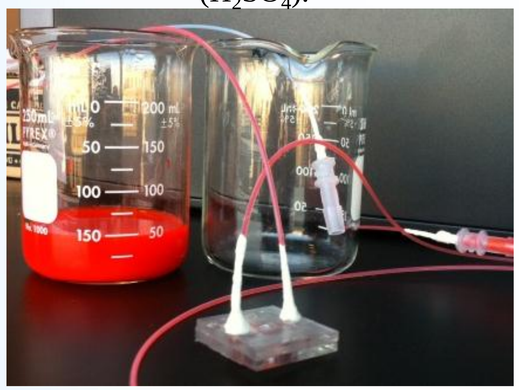
Cathode: $6H_2O + 6e^- \rightarrow 3H_2(g) + 6OH^-$ [1]

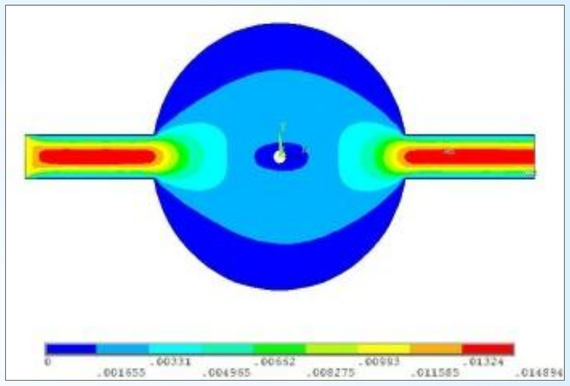
Anode: $W(s) + 8OH^- \rightarrow WO_4^{2-} + 4H_2O + 6e^-$

Overall: $W(s) + 2OH^- + 2H_2O \rightarrow WO_4^{2-} + 3H_2(g)$

Electrolytic Cell

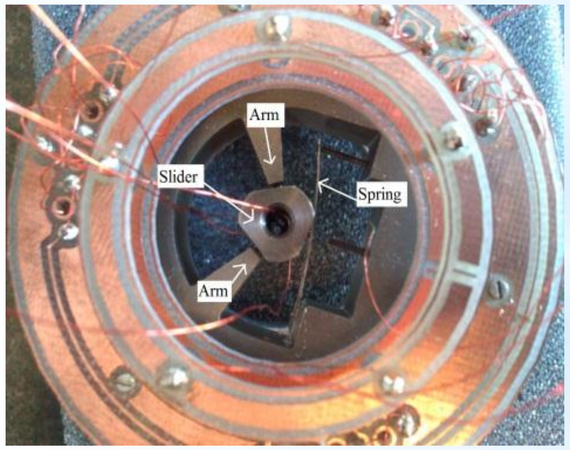
A micro fluidic system used to deliver and contain an electrolytic solution (H_2SO_4).





CFD analysis of the velocity gradient in the electrolytic cell in its top view. The sulfuric acid flows from left to right. The center dot represents the scanning tip.

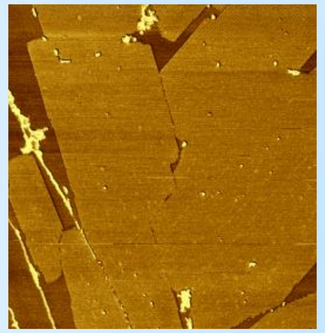
Atomic Force Microscope



The slider will be used to approach the scanning tip to the specimen using stick-slip method.

Six sapphire hemispheres were mounted on the frame (two on each arm and spring) and are used to ensure a smooth and unconstrained vertical movement of the slider.

A high surface finished slider enhances the incremental steps induced by the stick-slip motion.



High quality image produced by the AFM . [2]

Impact of this Project

Once implemented, the Electrolytic Atomic Force Microscope will be used to conduct electrochemical research on the specimen while scanning it's surface topography.

Project Management

The project was performed on a period of two academic semesters. In the fall, the electrochemical etching device was completed and designs of the electrolytic cell were under development. During the winter semester, the electrolytic cell design was completed and manufactured. The coarse approach system was remodeled and tested during both these semesters. The project was done just short under budget.

Conclusion

Overall, all objectives were met. This has been a stimulating and challenging experience for the team. Such project inspires researchers everywhere to conquer the world of nano technology.

Reference

[1] Anne-Sophie Lucier, *Preparation and Characterization of Tungsten Wire Tips Suitable for Molecular Electronic Studies, 2004*

[2] Image from Dr. Prokhorov, Shemyakin & Ovchinnikov Institure of Bioorganic Chemistry, RUS, Moscow, Russia, 'http://www.nanotech-america.com/?cat=3', 2011