

A New Automated Preparation Process by Electrochemical Corrosion of STM Tungsten Tips

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Abstract. Scanning tunneling microscope (STM) is one of the most important instruments in the field of two-dimensional(2D) materials science while the STM tip is one of the most important parts in STM. Thus, we exhibit a new automated preparation process by electrochemical corrosion of STM tungsten(W) tips based on analog circuit technology in this paper. And the new preparation process is easy and reliable and can save time of researchers. Here, we will elaborate the preparation process and how the system works. In all, we will open up a new road in the field of preparation of STM tips.

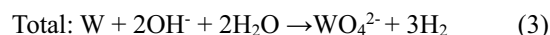
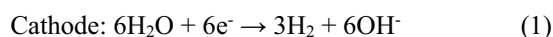
1 Introduction

In 1982, G.Binnig and the H.Rohrer, Zurich laboratory of IBM, invented the first scanning tunneling microscope(STM) in the world[1-3]. Then, researchers were able to observe the physical and chemical properties and the surface electron behavior of individual atoms in real time[4-8]. For STM, the photography of clarity and resolution depends on the quality of STM tips[9-10].

At present, electrochemical corrosion method is a popular method for the preparation of STM tips[11-14]in the laboratory. The advantage of this method is that materials are easily available and the preparation conditions are simple, and more importantly, the cost is low[15-18].In addition, traditional preparation has many disadvantages. For example, researchers have to watch the microscope about 30-45 minutes and it is easy to get eyes discomfort and cervical, lumbar pain. In addition, to protect STM tips, we must cut off the power as early as we can after corrosion finishing and our hands is absolutely slower than automatic control circuit. In all, to solve this problems, we exhibit the new preparation process of STM W tips. We has not only realized the automation of tip corrosion, but also compared with the present many new processes, our method has the advantage of low price, simplicity and reliability.

2 Experimental details

Principle of preparation: According to the principle of electrochemical corrosion, the centre part of W is corroded slowly in NaOH liquid film(electrochemical corrosion equation is below). If there is 5V DC between the W tip and Pt ring, the corrosion rate will be faster. With the progress of corrosion, the centre of the W tip will be thinner and thinner and finally fracture. In the moment of fracture, we should cut off the power and then wash it by deionized water to protect the W tip. Finally, we get a STM W tip and it is single atom in the top if it is good in quality.



Traditional preparation process: Figure 1(a),(b) show traditional preparation process. After the beginning of corrosion, researchers have to watch the W tip and NaOH liquid film under the microscope and cut off the power in the moment of W fracture. On the other hand, if there are errors like NaOH liquid film rupture, we must make a corrosion again. So it seems that there is two advantages. Firstly, researchers have to watch the microscope about 30-45 minutes and it is easy to get eyes discomfort and cervical, lumbar pain. Secondly, our hands is absolutely slower than automatic control circuit and it is bad for our STM tips.

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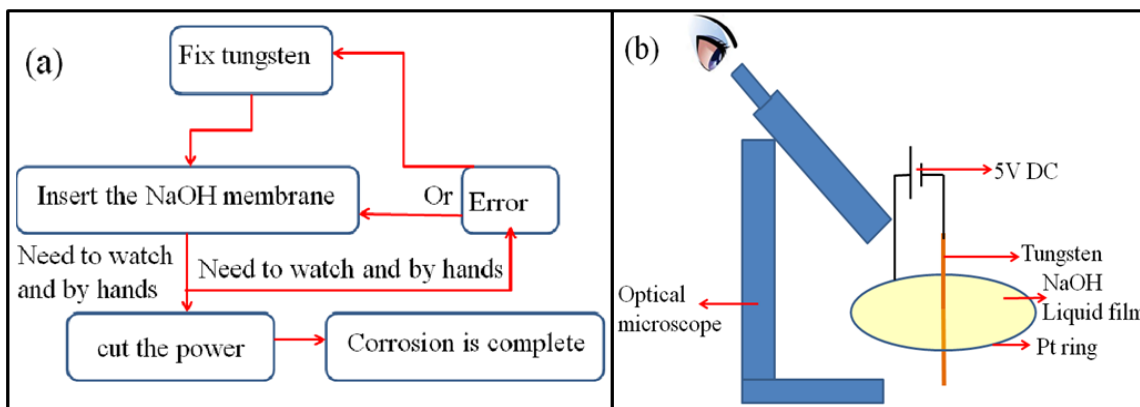


Figure 1. Traditional preparation process by electrochemical corrosion of STM tips. (a) Flow chart of Traditional preparation. (b) Schematic diagram of traditional preparation system (Gripping device is ignored).

New automated preparation process: There are three major differences between new and traditional preparation process. Firstly, we add a new system of cutting off the power automatically and alarm. Secondly, we add an alarm system and it will work if the NaOH liquid film rupture. Thirdly, the microscope is deleted. Thus, researchers do not have to watch the microscope 30-45 minutes and avoid getting eyes discomfort and cervical, lumbar pain. On the other hands, researchers are able to find the problem and solve them timely.

Figure 2(a) shows that there is an important difference between new and traditional preparation that researchers are replaced by automatic analog circuit. That means researchers do not have to watch the microscope and be on guard and automatic analog circuit is able to solve the problems timely. Figure 2(b) shows there is metal-rubber-metal(MRM) system to detect the signal of tips falling down and notice the automatic analog circuit and relay to cut off the power and alarm.

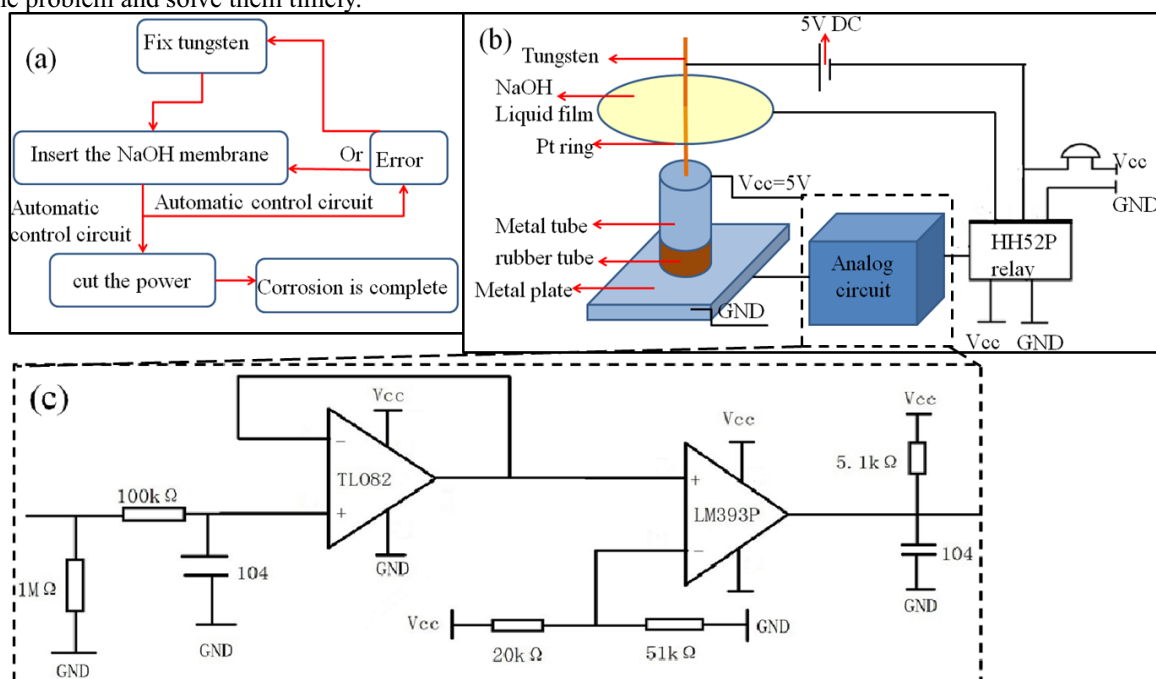


Figure 2. New automated preparation process of STM W tips. (a) Flow chart of new automated preparation. (b) Schematic diagram of new automated preparation system (Gripping device is ignored). (c) Automatic control circuit.

Working principle of the new system: Figure 3(a) shows the status that the W tip is in corrosion. In this state, the power of 5V DC is connected and the W tip is complete, while the socket 1 is on and socket 2 is off in the HH52P relay. On the other hands, figure 3(b) shows that the status that corrosion is over. In this state, the W tip fractures and falls down the MRM system, and one side of the W

touches the metal tube while the other side touches the metal plate. Simultaneously, the automatic analog circuit runs and the socket 1 turns off and socket 2 turns on of HH52P relay. Thus, the power of corrosion is off and the alarm is on. Finally, figure 3(a) shows the automatic analog circuit (It is mainly composed of dual operational amplifier TL082 and comparators LM393P).

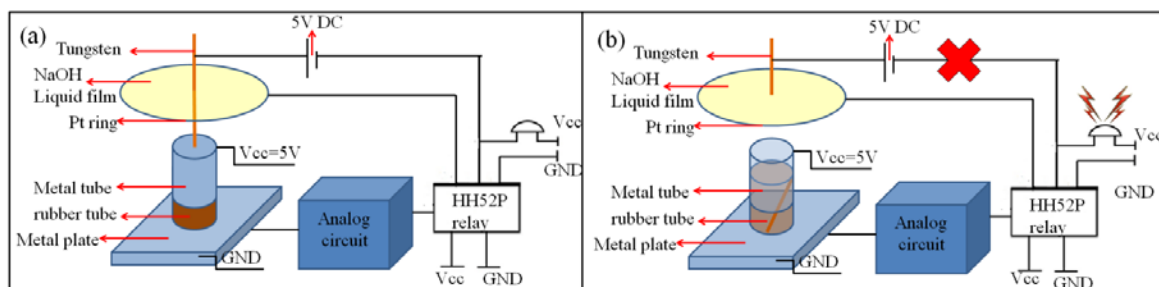


Figure 3. Schematic diagram of how the new automated preparation system runs. (a) Schematic diagram of the system is in corrosion. (b) Schematic diagram of the corrosion is over.

3 Results and Discussion

Characterization of W tip fabricated by the new automated preparation process: we characterized the W tips, fabricated by the new automated preparation process,

in STM. Figure 4 (a), (b) shows the photography of Bi_2Te_3 and MoSe_2 in the STM which is scanned by our W tip. Definitely, the problem of double-tips did not appear. So it seems that the photographs possess high resolution and high definition and means the W tip, fabricated by the new automated preparation process, is great in quality.

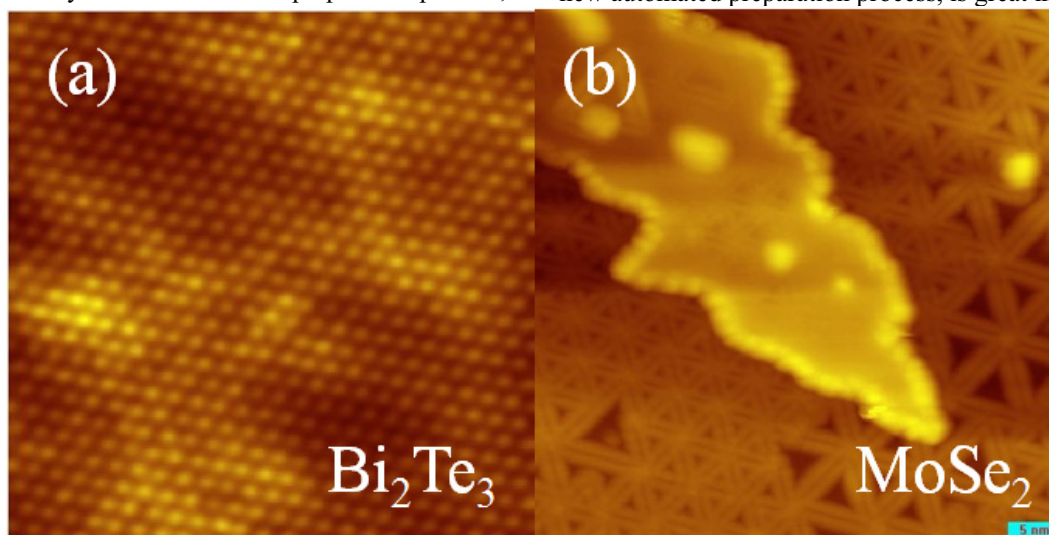


Figure 4. (a) Photography of Bi_2Te_3 in STM which is scanned by our W tip, fabricated by the new automated preparation process. (b) Photography of MoSe_2 in STM which is scanned by our W tip, fabricated by the new automated preparation process.

4 Summary

We exhibited a new automated preparation process by electrochemical corrosion of STM tungsten(W) tips based on analog circuit technology in this paper. And we elaborated the principle of tip preparation and the circuit system. Then, there are many advantages of the new automated preparation process compared to traditional preparation process, like saving time of researchers, low cost and high reliability. Finally, we characterized the W tip in STM and the photographs Bi_2Te_3 and MoSe_2 of possess high resolution and high definition. In a word, this new automated STM tungsten(W) tip preparation process will open up a new way in the field of STM tip preparation.

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