

Finishing of flame-etched tungsten tips for AFM via quick post-treatments

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In high-resolution AFM imaging, micro-lithographically fabricated Si tips and single-CO-molecule adsorbed tips have been often used. However, it remains a crucial technical issue to prepare well-defined and sharpened metallic conductive tips that should provide reproducible results in the analysis of sample's physicochemical properties evaluated using AFM; for example, the measurement of sample surface electric conductivity using a dissipation channel of the FM-AFM is sensitive to the tip surface conductivity [1]. Electrochemical etching of polycrystalline tungsten (W) wires is widely used for the tip preparation. However, the electronic states of the tips have not been well-defined; their surfaces are likely contaminated, and the atomic structures of their apexes are not reproducible, resulting in varying surface conductivities. Thus, some post-treatments, such as heating and field evaporation in a vacuum, are necessary. Recently, a conventional method for preparing W tips using a few-second flame-etching technique was invented [2]. This method utilizes the sublimation of WO_3 in a high-temperature flame. We reported that this method also grew a large single-crystal grain at the apex, in less than 1 sec in the flame at $\sim 2800^\circ\text{C}$, leading to a faceted structure of the apex [3]; the apex was rather flattened by two $\{001\}$ developed facets and covered with a nm-thick WO_x layer. Here, we report the post-treatment of flame-etched W tips to remove the WO_x layer and reform the flattened shape into a more symmetric and sharper one using a double-pulsed voltage electrochemical etching in less than 10 seconds. Furthermore, quick blue laser annealing in a vacuum is also presented as a finishing procedure for tip cleaning, which involves removing a very thin WO_x layer that cannot be avoided during tip transfer in air.

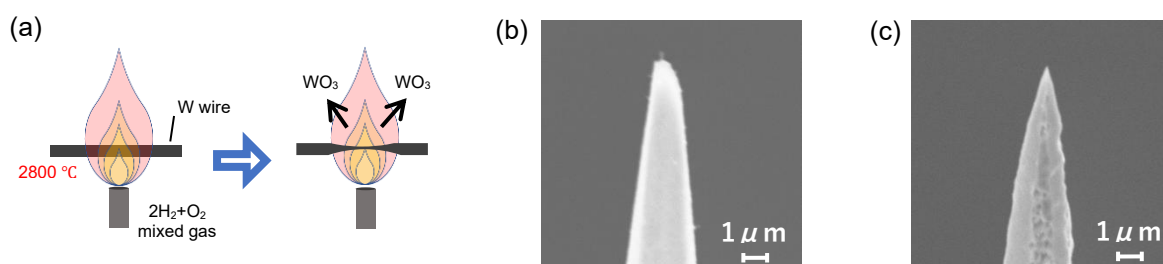


Figure 1. (a) Schematic diagram of the flame-etching using a high-temperature flame of the $2\text{H}_2+\text{O}_2$ gas. (b) SEM images of the W tip flame-etched from a polycrystalline W wire of a diameter of 0.1 mm. (c) after the electrochemical etching of the flame-etched W tip with a double-pulsed voltage (+3 V for 2 sec, followed by +0.2 V for 5 sec, with a baseline of -0.6 V) in a 1M NaOH solution with a Pt-wire counter electrode. Note that the applied voltage of -0.6 V did not etch the W tip, though the voltage of even 0 V etched it on a nanoscale.

References

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