Batch fabrication of AFM probes with direct positioning capability

Shuo Zheng, Bo Cui
Waterloo Institute for Nanotechnology (WIN), University of Waterloo
200 University Ave. West, Waterloo, ON, N2L 3G1,
shuo.zheng@uwaterloo.ca

Atomic Force Microscope (AFM) probes are mostly pyramidal-shaped defined by wet chemical etching of crystalline silicon.[1] One common problem for most commercial AFM probes is the location of the tip relative to the cantilever. Because of issues such as alignment accuracy in photolithography, most commercial AFM probes have tips 10-30 μm away from the very end of the cantilever, and it is thus impossible to know where exactly the tip is because the camera in an AFM system shows only the backside of the AFM cantilever. This uncertainty of the tip location has raised up some major problems, e.g. the initial scanning area must be set very large in order to ensure that the area of interest is within the scanning field. It is therefore very desirable for the tip to be located at the very end of the cantilever so that it can be viewed clearly by the optical microscope of the AFM system.

Such direct positioning tips are currently commercially available.[2] However, they are made by a complicated fabrication process, leading to its high price roughly twice that of a regular probe. Here we will show a straightforward fabrication method that will convert a wafer of regular pyramidal-shaped probes (380 probes for 4" wafer) into direct positioning probes. As seen in Figure 1, we first coat one side or sides of the pyramid with a metal by angled evaporation, then we used this metal as the mask to etch away the silicon on the other side, finally we remove the metal mask by wet etching. This fabrication procedure gives two types of tips, located either at the very end of the cantilever, or in front of an etched hole that is visible when viewed from the back side of the cantilever. Thus both types offer direct positioning capability. An exhibition of results for both types is presented in Figure 2.

The direct positioning capability is demonstrated in Figure 3, the tip locates in front of a through-cantilever hole. Moreover, because our process etched away half of the tip pyramid, the resulted tip is sharper than the original one, which offers higher resolution when scanning of high aspect ratio structures, as shown in Figure 4.

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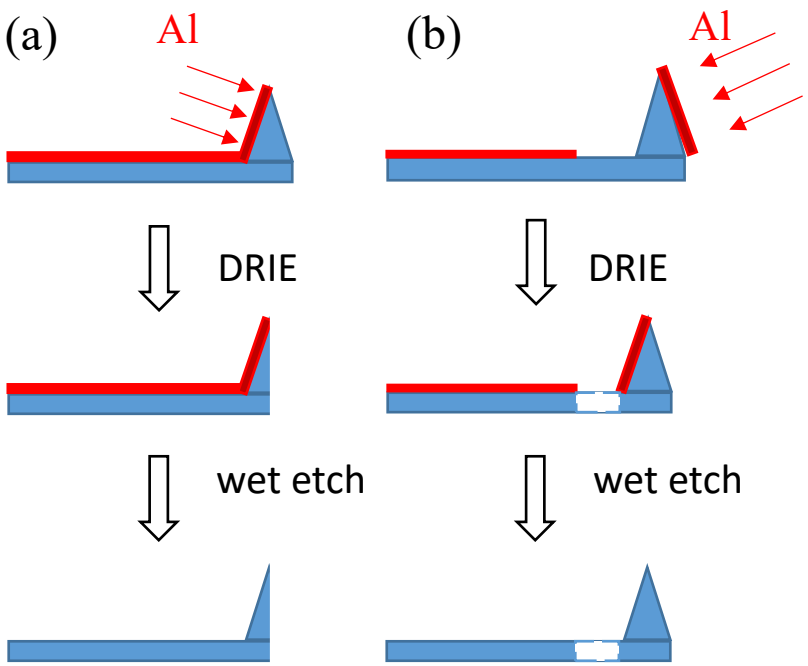
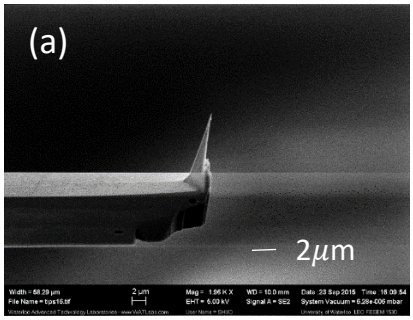
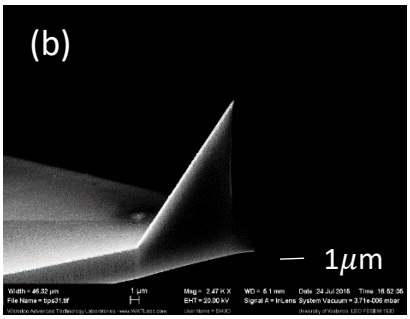
[1] TR Albrecht, S Akamine, TE Carver, CF Quate, "Microfabrication of cantilever styli for the atomic force microscope". Journal of Vacuum Science & Technology A, 8 (4): 3386–3396 (1990).

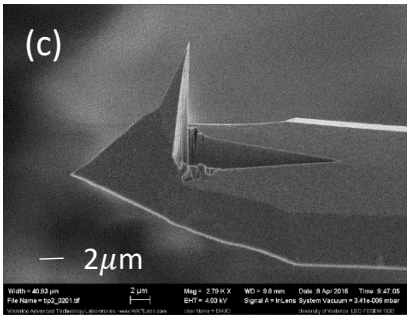
[2] http://www.opustips.com/en/afm-tip-160ac-na.html, http://probe.olympusglobal.com/en/feature/#anchor01.



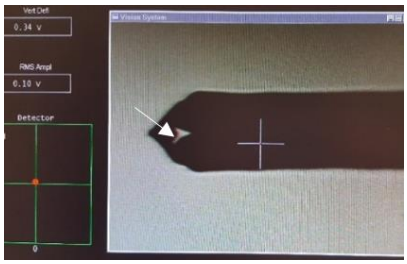
(above) Figure 1 A schematic of the process flow for both types of direct positioning tips.



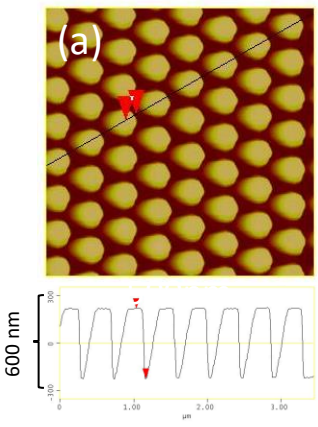


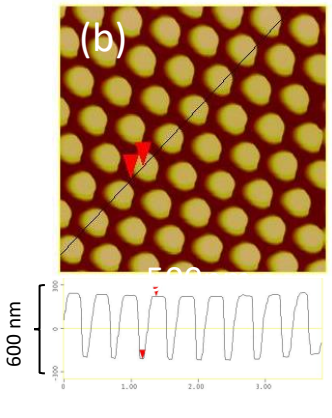


(right) Figure 2 SEM images of tips with various shapes made by our process. The tip is located at the very end of the cantilever (a-b), or in front of the hole (c).



(right) Figure 3 A pictures of AFM probe taken by the built-in camera of Veeco AFM system. The arrow indicates the exact location of the tip (in front of the hole).





(left) Figure 4 Comparison of AFM images scanned using the original tip (a), and the tip after our process (b), and their section analysis. The original tip can hardly reach the bottom the pillar, whereas the processed tip can reach it.