Well Self-aligned Fabrication of Ultrasharp Nanotip Arrays

Chi-Chang Wu[1,2], Ching-Ya Wang[1], Yi-Jen Tsai[1], Fu-Hsiang Ko[1*]
(fhko@mail.nctu.edu.tw)
[1]Institute of Nanotechnology, National Chiao Tung University, Hsinchu 300, Taiwan
[2]National Nano Device Laboratories, Hsinchu 300, Taiwan

Nanoscaled tips are received much attention recently due to its versatile applications such as near-field optical microscopy, scanning tunneling microscopy, flat panel displays, and high-efficiency field emission. A sharp tip can induce the stronger field enhancement effect, and therefore, increase the field emission current. Similarly, the sharp tip is also beneficial for improving the spatial resolution in scanning probe microscopy. In this work, well aligned nanotip arrays by combining the electron beam lithography and reactive ion etching (RIE) technology are fabricated. From the SEM observation in Fig. 1, a nanoscaled tip with apexes of about 12 nm radius and 500 nm height is achieved. The tip-end radius can be further sharpened by a subsequent oxidization and wet etch process to achieve a very smaller apex (in Fig. 2) at about 3 nm radius.

The etching mechanism to form the nanotips is also discussed in this paper. We find the remained photoresist on top of the tip is gradually reduced with increasing the etching time. The photoresist serves as the purpose of shielding mask to protect the underlying silicon. As the photoresist is fully etched away at the final, a pyramid-like shape in Fig. 3 is formed at the tip-end due to the etch probability of incident ion on the sidewall. We find a pyramid shape is formed although the initial pattern is defined as cylinder. Figure 4 shows the shape conversion at various etching times. Interestingly, the initial shape is cylinder, and will turn into pyramid with tapered sidewall after 3 min etching. The tip becomes pyramid shape with slope sidewall after 6 min etching, and become pyramid with recessed sidewall after 7 min etching. The shape of the nanotip can influence the field emission property, and more field emission results will be given in the conference.

Reference

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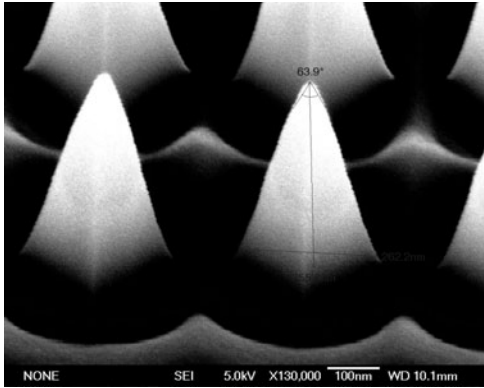

Fig. 1. Nanoscaled tips with top apexes of about 12 nm radius.

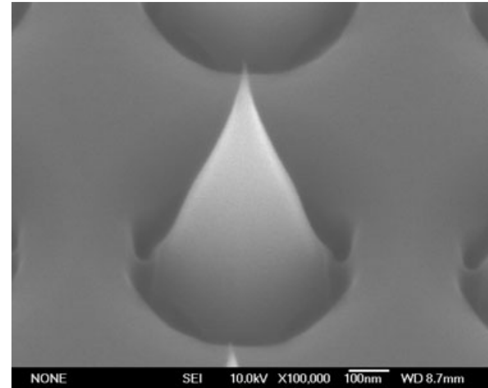

Fig. 2. The sharp tip with apexes of 3 nm radius after further oxidation and wet etch process.

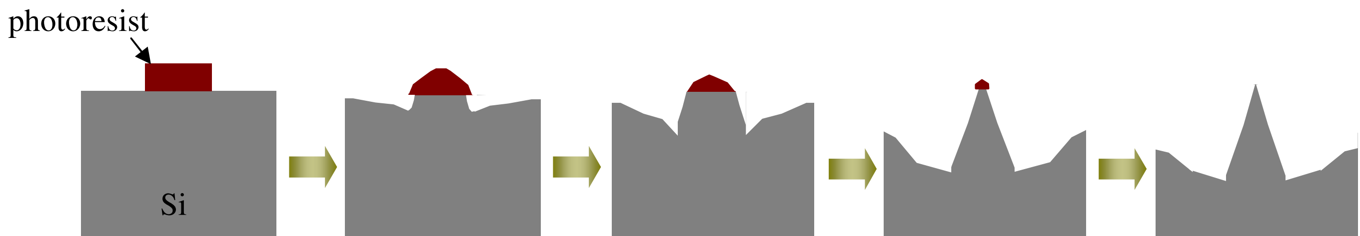

Fig. 3. The proposed model for the formation of nanoscaled tips by the reactive ion etching.

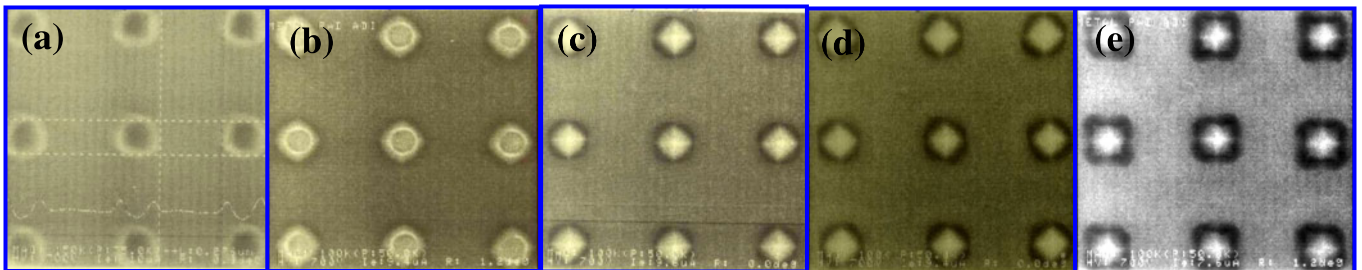

Fig. 4. Top SEM view for the samples after RIE: (a) as patterned (0 min), (b) 3 min, (c) 4 min, (d) 6 min, and (d) 7 min. The morphology of nanotip pattern is gradually transformed from cylinder shape to pyramid.