

# Investigation of deposition profile for metal structure using focused ion beam

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The FIB system is the one of the most powerful systems for micro and nano scale fabrication.<sup>1-2</sup> In the previous researches, our group reported the metal tip using FIB deposition, but the precise deposition conditions were not sufficiently investigated.<sup>3</sup> In this paper, we examine the deposition profile with respect to deposition parameters.

We use the commercial dual beam FIB system (Helios, FEI company), and select platinum as the deposition material due to conductivity. It is injected in the gaseous state with the fixed injection velocity and angle. The deposited Pt layer flows down, and the base diameter ( $D_b$ ) of the metal structure gradually increases compared with the designed diameter ( $D_0$ ). The  $D_b$  is related with the deposition time, and the resulting structure becomes corn-like shape as seen in Fig. 1.

The inclined structure happens due to the direction of gas injection. As the more platinum is deposited, the inclined structure intensified, and finally the etching phenomenon happens like Fig. 2 (a). Higher part blocks gas injections, and the focused ion beam behaviors as the etching beam in the other part. The etch phenomena start when the  $D_b/D_0$  becomes around 1.26 like Fig. 2 (b).

The etching phenomenon is not observed in the lower beam current and the large based diameter. It means, if the base diameters are large enough so the gas can be supplied backward of the higher part, the etching effect can be minimized. So, in the same beam current conditions, there are some critical diameters. The  $0.1\mu\text{m}$  base diameter is for 1.5pA beam current case, and  $0.5\mu\text{m}$  for 9.7pA case.

As the deposition process is continued after the etching, the deposition profile becomes quite different from the previous profile with the mixture of etching, deposition and flowing down of platinum like Fig. 3. Under this condition, the etching and deposition are repeated, and the layered structure is fabricated.

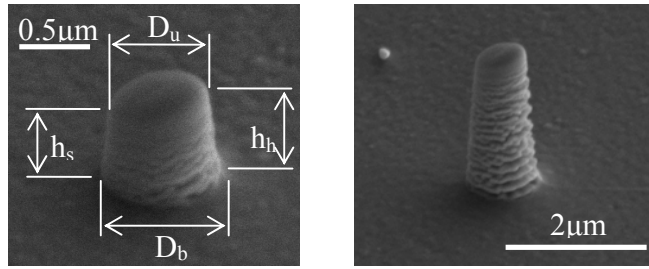
In conclusion, we investigated deposition profile with various parameters in FIB system. First, there are critical diameters where the etching effect happens, and the etching starting point is related with base diameters. Second, during the deposition, the base diameters gradually increases, which is related with the deposition time. Considering these conditions, a metal tip is fabricated like Fig. 4.

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<sup>1</sup> W. Xu et al, Mater. Character. **58**, 961(2007)

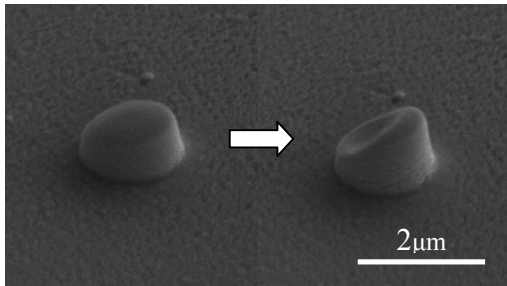
<sup>2</sup> D. Z. Xie et al., Nucl. Instr. and Meth. B 211, 363(2003)

<sup>3</sup> S. H. Lee et al., Ultramicroscopy 108, 1094(2008)

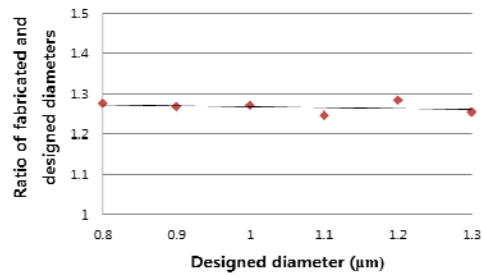


(a) 60sec deposition time (b) 180sec deposition time

Figure 1: Deposition profile with 9.7pA beam current and 0.6μm designed diameter



(a) inclined and etching involved profile



(b) Graph about the ratio of  $D_b/D_0$  at etching start point

Figure 2: Etching involved profile and diameter related property

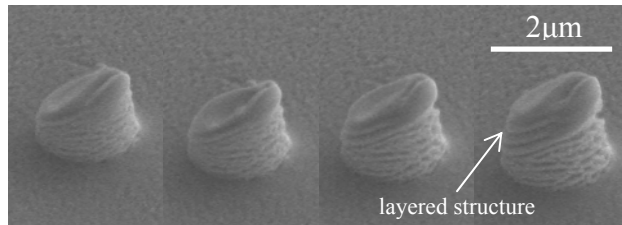
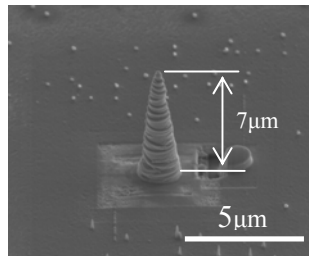
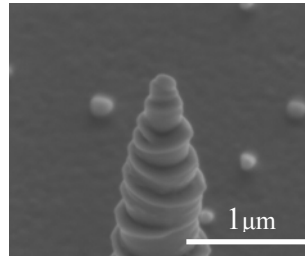


Figure 3: SEM of abnormal deposition process (28pA beam current and 1.2μm designed diameter)



(a) Fabricated Metal tip



(b) Enlarged view of tip end

Figure 4: SEM of fabricated metal tip with investigated deposition conditions (tip height of 7μm is calculated considering 52° inclined angle)