Platinum nano-pillar growth by Helium Ion Beam Induced Deposition

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Ion Beam Induced Deposition (IBID) is a direct writing technology in which precursor molecules adsorbed on a substrate surface are decomposed by an ion-beam-induced reaction, resulting in localized material growth. So far, most IBID works employ a focused Ga^+ ion beam. The smallest pillars grown by a focused Ga^+ beam in spot mode have diameters on the order of 100 nm, despite the small probe size of typically 10 nm. Moreover, these pillars have rough sidewalls and relatively blunt tips.

Recently, Helium Ion Microscopy with a sub-nanometer probe size has become commercially available. In the present study we report pillar growth by He^+ IBID for the first time. The experiments were performed in a Carl Zeiss Orion® Plus scanning helium ion microscope (SHIM) equipped with an OmniGIS gas injection unit. $(CH_3)_3Pt(C_PCH_3)$ was used as precursor. We have investigated He^+ IBID pillar growth by changing the ion beam current, dwell time, refreshment time, and exposure time at a fixed beam energy of 25 keV. We found that He^+ ions have slightly higher deposition yields than Ga^+ ions. Moreover, the He^+ IBID pillars are about three times as narrow and display smooth sidewalls and sharp tips, see Fig. 1.

For fixed dose and gas supply, the pillar width increases and its height decreases with increasing beam current (Fig. 2); however, the pillar volume remains almost constant. Comparison with Monte Carlo simulations reveals details of the ion- and secondary-electron-induced growth mechanisms of He^+ IBID.

In conclusion, a Helium Ion Microscope is a new, promising instrument in direct writing nanotechnology. It combines the advantages of Ga^+ IBID and Electron Beam Induced Deposition.

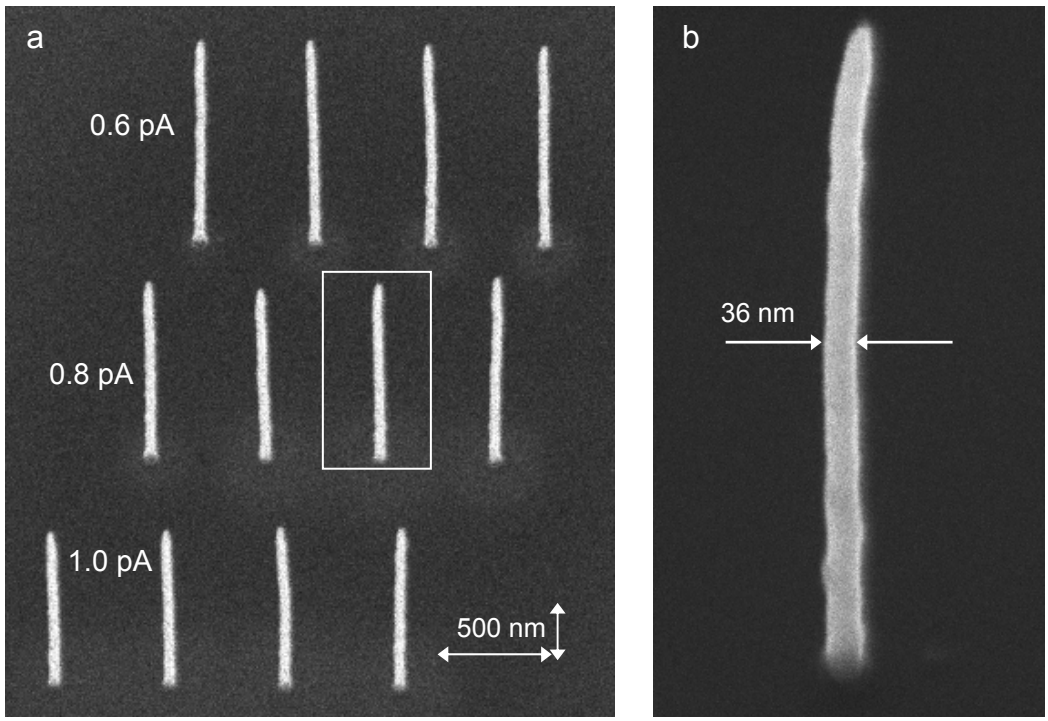

Figure 1. He^+ IBID grown pillars (25 keV He^+ in spot mode; total charge per pillar is 6 pC; $4.4x10^{-6}$ mbar $(CH_3)_3Pt(C_PCH_3)$; beam diameter <1 nm). Imaging by SHIM at 30° sample tilt. a) Overview for 0.6, 0.8 and 1.0 pA ; b) Detail of the third pillar from left in the central row. The bending is caused by the imaging with the He ion beam.

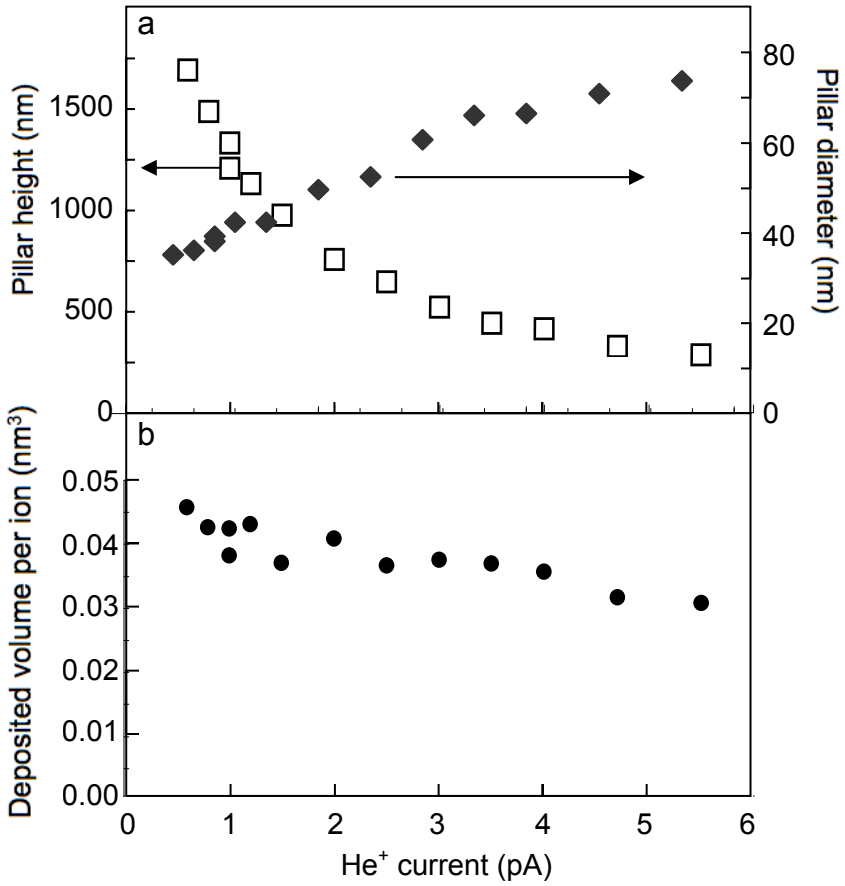

Figure 2. Current dependence of He^+ IBID pillar growth.
a) Height and diameter (at half height) of the pillars as a fucntion of beam current (dose is 6 pC); b) deposited volume per incident ion.
The decrease in height in a) indicates that the mass transport limited regime is operative. Nevertheless, the deposited volume per ion remains almost constant with increasing current.