Nano-structure fabrication and manipulation by the cantilever oscillation of an atomic force microscope

C. K. Hyon, School of Electrical Engineering, Korea University
Ph.no: 82-2-3290-3234, email id: ckhyon@korea.ac.kr

Scanning probe microscopy has now become a standard technique for the observation of various nano-structures in atomic resolution. These days, other than simple observation of sample surfaces, the probe tips are widely utilized for nano-meter pattern formation. The most common techniques are direct oxidation of sample surfaces or local exposure of PMMA layers. However, they require the electrical current through the tips for the pattern formation and the resolution largely depends on the metal deposition conditions of the tips. We would like to report on direct fabrication and manipulation of nano-structures by using the cantilever oscillation of an atomic force microscope (AFM). The oscillating cantilever exerts a large enough force to break the surface bond and subsequently remove the atoms. Various reliable groove patterns on GaAs, with fully controlled width and depth, are achieved by adjusting the feedback gain of the AFM and the applied force. Furthermore, the selection and the subsequent removal of individual InAs self-assembled quantum dots are also shown to be possible. Commercial AFM cantilevers have been used without further sharpening of the tips and no special modification of the AFM machine has been needed. The width and the depth of the patterned grooves are reproducibly controlled by the force constant of the tips, the scan speed (v,), and the feedback gain (A). Figure 1 (a) shows the AFM images of three grooves patterned by three different force settings of 0.5 pN, 0.75 pN and 1 pN when v, = 0.01 pds and A = 1. Figure 1 (b) shows the AFM images of the patterned grooves with three different A's of 0, 3, and 5 when v, = 0.02 pds. The grooves as narrow as 10 nm are routinely obtained. Figure 2 shows a 1~0.25 pm2 rectangle, and an array of antidots with 30nm diameter. Figure 3 illustrates the local removal of InAs self-assembled quantum dots grown on a GaAs substrate, by utilizing the oscillating cantilever. Complete removal of the quantum dots (except the large 50 sized heuristic dots) in the selected area of 1 x 1 pm2 can be clearly seen. Any degradation of the tips after the pattern formation has not been observed. All the AFM images in Fig. 1 - Fig. 3 have been obtained with the same tip used for the pattern formation.

