Poster

HIGH-SPEED NANOSTRUCTURING

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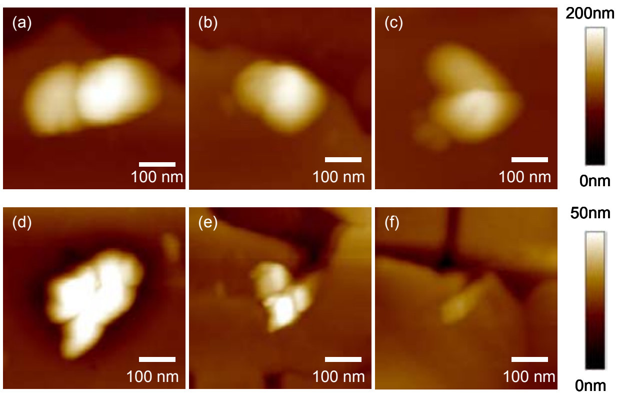
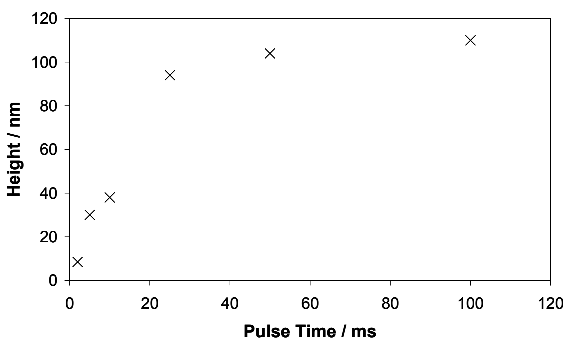
The ability to pattern surfaces on the nanometre scale in short timescales is of great importance in the fabrication of nanostructures and nanoscale devices. Previous work has focused on two nanostructuring techniques, and the application of these on millisecond timescales and beyond. In addition, this work had assessed the potential of these processes to be used on a high-speed Resonant Scanning Microscope (RSM), a new member of the SPM family of microscopes.

The two nanostructuring techniques in use are the ionic conduction of silver sulphide films and the local oxidation of titanium and silicon surfaces.

Silver sulphide is a solid electrolyte, the chemical properties of which allow the conduction of both electrons and ions through the material, under the influence of an electric field. Silver sulphide films were prepared from silver substrates by immersing in a sodium sulphide solution. The chemical composition of these samples was confirmed with x-ray photoelectron spectroscopy (XPS) analysis. By using a conventional atomic force microscope (AFM) in contact mode, a bias was applied between a platinum coated tip and the sample, inducing a flow of silver ions through the silver sulphide layer and onto the surface. The resulting structures were then imaged in intermittent contact. Previous work has confirmed that nanostructures with sizes ~ 60 nm in width and 10 nm in height can be patterned on timescales of 2 ms. However, it is believed that shorter timescales are possible.

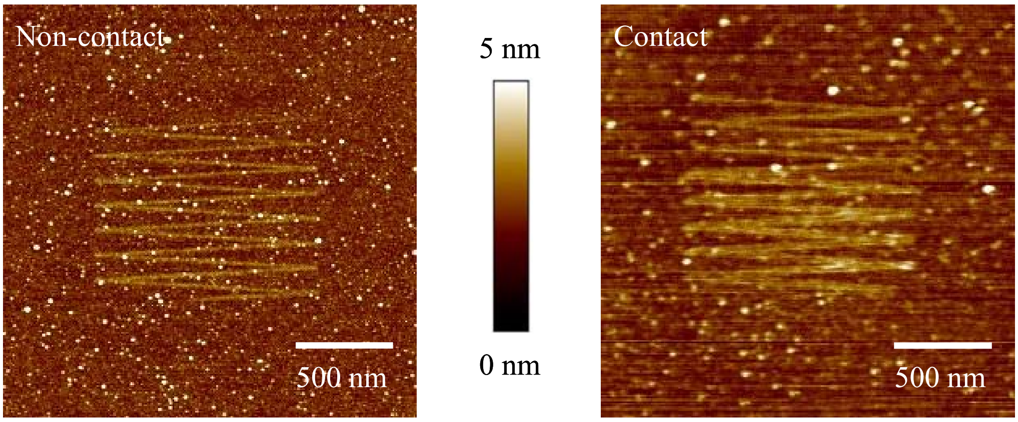


Silver nanostructures grown using a -4.0 V tip bias, showing decreasing size with decreasing pulse times: (a) 100 ms, (b) 50 ms, (c) 25 ms, (d) 10 ms, (e) 5 ms and (f) 2 ms. N.B. (a) – (c) 200 nm height scale, (d) – (f) 50 nm height scale.



Graph showing the dependence of nanostructure height with pulse time.

The local oxidation technique has been applied to titanium and silicon films. Local oxidation of these samples is achieved by applying a negative voltage between the tip and surface. The resulting electric field induces the formation of a water bridge between the tip and surface. Oxygen anions produced from the water molecules are driven towards the sample by the electric field and oxidise the sample. Recent results have demonstrated that local oxidation can occur on timescales of the order of 10 nanoseconds, in both non-contact and contact operating modes, using a conventional AFM.



Examples of oxide patterns generated by continuously pulsing the tip with 10 ns pulses of -12 V while moving the tip across the surface. Both patterns are created using a conventional AFM, with the tip being operated in both non-contact and contact modes.

Present investigations are primarily concentrating on applying these techniques to the RSM, operating in its high-speed AFM mode. Typically the tip is scanned at speeds of ~ 2 cms^{-1} (which corresponds to 10 nm every 500 ns), and hence nanostructuring timescales of ~ 100 ns are required in order that the tip remains stationary with respect to the size of nanostructure created. Initial results suggest that the local oxidation technique could be a viable nanostructuring process for use on this instrument.

Furthermore, a conventional AFM is continuing to be used to create more complex structures, with the aim of being able to fabricate simple nanoscale devices. These two lines of investigation go hand in hand towards future high-speed device fabrication using the RSM.