Robust, High Aspect Ratio Columnar Diamond Atomic Force Microscope Probes For High Relief Imaging

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ABSTRACT

We report on the fabrication of a high resolution, high aspect ratio columnar diamond atomic force microscope probe using a simple two-step batch fabrication method [1-2]. The process utilizes a low energy gallium ion implant into the first few nanometers of the surface of diamond substrate using focused ion beam (FIB). The implanted regions form a hard mask against plasma etching allowing production of well controlled high relief structures over the exposed surface of the substrate. This technology has an advantage over the other conventional resist based lithographic techniques since it can write a mask pattern on any non planar surfaces viz., spheres, cones etc. and has the capability to form high aspect ratio, high resolution patterns in all varieties of diamond including natural, synthetic HPHT and CVD films, at various levels of doping.

For the fabrication of diamond columnar AFM probes, Ga ions were implanted at the apex of the tip of a commercially available diamond probe. Subsequently the probe was etched to achieve the columnar shape at the tip as shown in figure 1. Improved lateral resolution of the AFM images is demonstrated using these columnar probes as compared to the standard probes. A standard calibration grating with step height of 18±1 nm, width of 1.5 µm and pitch of 3µm, and a high resolution grating with step height of 35 nm, width of 35 nm and pitch of 70 nm is used in contact mode for resolution test. In addition, the diamond columnar probes are shown to exhibit low wear compared to the other commercially available columnar probes. These probes can be also utilized for video rate AFM imaging applications considering its low wear and high resolution qualities.

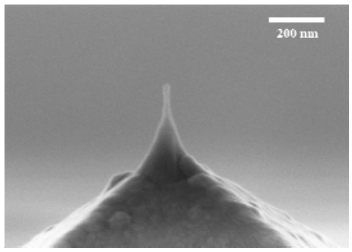

FIGURE 1. Columnar diamond AFM probe having a diameter of 23 nm and height 130 nm (aspect ratio ~ 6:1)

REFERENCES

1. W. McKenzie, J. Pethica and G. Cross, "A direct-write, resistless hard mask for rapid nanoscale patterning of diamond" (Communicated)
2. S. K. Tripathi, D. Scanlan, N. Hara, A. Nadzeyka, S. Bauerdick, L. Peto and G. Cross, " Resolution, masking capability and throughput for direct-write, ion implant mask patterning of diamond surfaces" (Communicated)