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# Fabrication of Scanning Force Microscope Sensor

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Scanning force microscopy(SFM) is a newly developed high resolution microscopy technique invented by G. Benning, C.F. Quate, and C. Gerber. SFM is capable of mapping interaction forces near surfaces with nanosize resolution. Therefore, SFM can resolve individual atoms on both conducting and insulating surfaces, unlike to a current-imaging technique such as scanning tunneling microscopy. A crucial component for SFM is a very flexible force sensing cantilever stylus with a sharp tip. The properties of a cantilver should have a low force constant, i.e., a spring constant weaker than the equivalent spring between atoms, high mechanical resonance frequency. These prerequiste conditions can be met by reducing the size of the cantilever using microfabrication techniques.[1] A sharp tip with radius less than 20 nm was fabricated using photolithography, reactive ion etching(RIE), and sharpening oxidation followed by oxide etching by buffered hydrofluoric acid. The first fabrication process is the growth of 1000Å of a thermal $SiO_2$ as a masking film on the surface of boron doped (100) Si wafer. The diffused boron concentration is about $10^{20}/cm^3$ and 5 μm deep in Si wafer. The tip with 2.5 μm radius is photolithographically patterned. The isotropic characteristics of the $SF_6$ plasma etching was utilized in order to get a very sharp Si post. For sharpening oxidation procedure, an oxidation at 1100℃ was performed in order to get a sharp tip even after oxidation and etching the oxide of the tip.

Fabrication for a cantilever include 1000Å $SiO_2$ film thermally grown at 1100℃, followed by 2000Å $Si_3N_4$ deposition by low pressure chemical vapor deposition (LPCVD) on both sides of the Si(100) wafer. The film is patterned photolithographically to form openings on top and bottom of the Si wafer. The deposited $Si_3N_4$ film is supposed to protect the $SiO_2$ film during the backside etch of silicon by KOH solution. The KOH solution has a property of either concentration-dependent or orientation-dependent etching.[2] The 35 wt percent KOH solution etches silicon 600 times faster in the <110> direction than in the <111> direction. However, the heavily boron doped silicon($>10^{20}/cm^3$) will reduced the etch rate by about 5 to 100 when etching with KOH. During this anisotropic etching of the rear-side silicon, the $Si_3N_4$ thin film is not attacked by KOH solution. Dimensions of the fabricated cantilever will be 10 μm wide, 400 μm long, and 2 μm thick. The bottom side of the cantilever will be coated with a mirrorlike 0.4 μm Al thin film for the optical deflection detector in the SFM. The other front side will be also coated with a 40nm Pt thin film. The bimetallic effect from the Al and Si will enhance angular bending of the cantilever.

1. T.R. Albrecht, S. Akamine, T.E. Carver, and C.F. Quate. J. Vac. Sci. Technol. A Vol 8, No.4, Jul/Aug 1990.
2. Kenneth E. Bean, IEEE Transactions on Electron Devices, Vol. ED.25 No.10, 1185(1978).