A microprobe device for chemical scanning probe microscope applications

Jun-Hyung Ahn [a] and Dong-Weon Lee [b]

[a] *Graduate School of Mechanical Engineering, Chonnam National University,Gwangju,500-757 Korea*
[b] *School of Mechanical Systems Engineering, Chonnam National University,Geangju, 500-757, Korea*
Phone : +82-62-530-1684, e-mail: mems@chonnam.ac.kr

Summary

In this study, we described the design and fabrication of a multi-functional microprobe for chemical identification of surface atoms. The microprobe devices consist of a probe body with an integrated biomorph actuator, a piezoresistive deflection sensor and an extraction electrode. All components were fabricated on a same wafer and process. The microprobe device was specially developed to combine two different analysis systems, scanning probe microscope (SPM) and mass spectrometer (MS). The new system with the microprobe device can show topographical and chemical identification analysis of solid surface to be performed in the same way with the conventional scanning probe technique.

Motivation

Over the past 20 years, the SPM has become one of the most widely used tools for topographic imaging at the atomic level and for observing various forces and quantum effect localized in nano scale structures [1]. These SPM techniques have opened up entirely new possibilities for studying the structure and dynamics of individual molecules and atoms in surface science, biophysics, and the semiconductor industry [2]. In spite of strike achievements, these SPM-based techniques have the drawback that they do not have capability of chemical identification analysis of solid surface. In order to realize an ultimate microscope, we propose a new chemically sensitive SPM (C-SPM) method. The C-SPM method is based on a conventional SPM system for surface imaging with atomic resolution and a TOF-MS system for the chemical analysis of single ions. This paper was only focused to develop the microprobe device that provides a reasonable time for a switching process. Another advantage of the microprobe device is a short tip-electrode distance comparable to the dimension of the cantilever, which significantly reduces bias voltage needed for field evaporation. Other topics for the C-SPM system will be presented later. Figure 1 shows the operation principle of the C-SPM with the microprobe device.

Results

Figure 2 shows a schematic diagram of the multi-functional microprobe. Figure 3 (a) and (b) show finite element method (FEM) analysis results. The spring constant of the microprobe is about 3.8N/m and the resonance frequency is about 50kHz at first resonance mode(1st). Figure 4 shows fabrication process of the microprobe. The n-type SOI wafer (3/1/325μm) was chosen as the starting material. The microprobe with the sharp in-plane tip is fabricated using a new process. Figure 5 shows optical and SEM images of the fabricated microprobe device. Detail for the microprobe device fabrication for chemical identification of surface atoms will be presented at the conference

Acknowledgements

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Reference

[1] G. Binning, C.F. Quate, C. Gerber, Phys. Rev. Lett. 56, 1986, pp.930-933
[2] R. Wiesendanger, Scanning Probe Microscopy and spectroscopy, Cambridge University Press, 1944

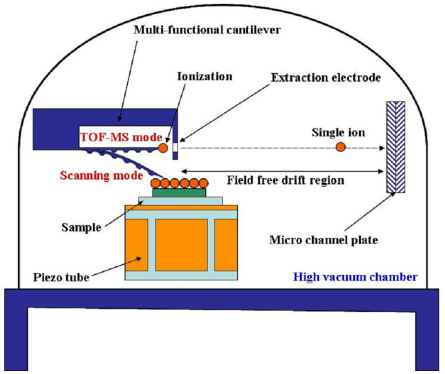

Figure 1. Operation principle of a microprobe device for chemical SPM applications.

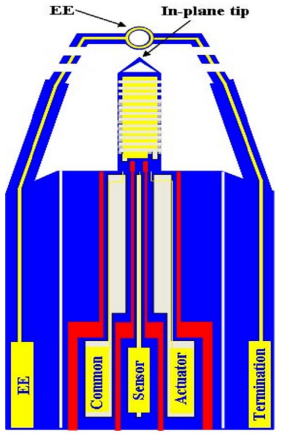

Figure 2. A schematic diagram of the microprobe.

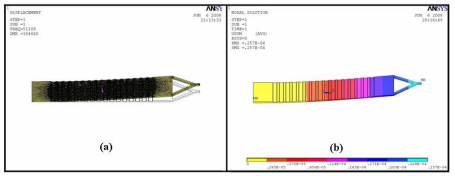

Figure 3. Simulation results of the microprobe device. (a) Resonance frequency and (b) spring constant of the microprobe.

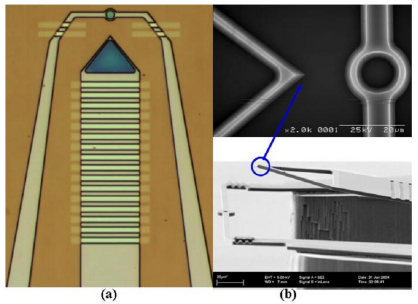

Figure 5. (a) Optical and (b) SEM images of the fabricated microprobe with an actuator, a sensor, and a local electrode.

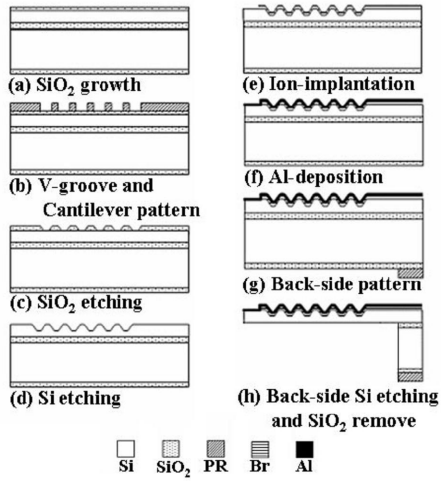

Figure 4. Process flow of key steps in the fabrication of the microprobe.