Multi-functional scanning ion conductance and scanning near-field optical microscope

Noritaka Yamamoto, Nao Terasaki, Kaoru Tamada, Mineyuki Hattori, Nobutaka Tanigaki, and Takashi Hiraga
National Institute of Advanced Industrial Science and Technology (AIST)
1-8-31 Midorigaoka, Ikeda, Osaka 563-8577, Japan,

Many types of scanning probe microscope have developed by detecting various phenomena produced between probe and sample. Scanning electro chemical microscope (SECM) offers chemical reactivity images of surfaces and also in quantitative measurements of reaction rates. SECM can be employed to obtain numerous studies with the SECM have now been reported from a number of laboratories all over the world and the instrument has been used for a wide range of applications [1]. However, the resolution of SECM is about sub-micrometer, 50nm resolution is possible [2]. On the other hand, the recent invention of the scanning near-field optical microscopy (SNOM) has opened the way to the study of nanometer scale optoelectronic properties of materials.

In this work, we have demonstrated a nanometer electrode fabrication to perform ion current mapping and near field mapping at the same time.

Figure 1 shows fabrication process of a small electrode for SECM and near-field optical probe for SNOM. Optical fiber sharpened using two-phase etching fluid of 45% HF solution and heptane solvent. The sharpening procedure of the fiber is a method invented by Turner et el. [3]. Organic solvent floated on the HF solution prevents to go to ruin at the fiber surface and prevent to diffuse the HF in the air. First, (A) Single mode fiber is removed outer resist film and is dipped the two-phase etching solution. A part of the fiber in HF solution disappears and sharpened tip is formed at the interfacial layer of the HF solution and heptane solvent in about 45min at room temperature. Second (B), the optical fiber is bent by irradiation of CO_2 laser beam at the near end while the bending angle is monitored by CCD camera. Then the sharpened tip is covered by resist polymer to prevent contamination. In this time, we demonstrate the tip sample distance control by contact mode AFM. So micro mirror is fabricated at the backside of bended fiber. It is used for displacement detection by optical lever control. Third(C), fiber is polished by lapping films to make a micro mirror for optical lever reflection. Lapping films is UF-1200 from BUEHLER Co. and is attached low speed motor and rotated 15min at 110rpm. Then resist polymer was dissolved using acetone solution in ultrasonic homogenizer. Finally (D), 10nm Chromium and 250nm gold films were coated around the fiber in spattering and vacuum evaporation, respectively. An optical aperture and flat electrode face was made to push a flat substrate on AFM apparatus.

The equipment used in this experiments is shown in Figure 2[4]. The fiber probe bring close to the conductive substrate surface within the near-field range. Probe-sample distance control was achieved by contact AFM mode detecting the beam deflection from fiber the probe. Probe and sample are housed in a special homemade holder which immersed in the solution. Electrochemical signal detected fiber probe is used for EC imaging.

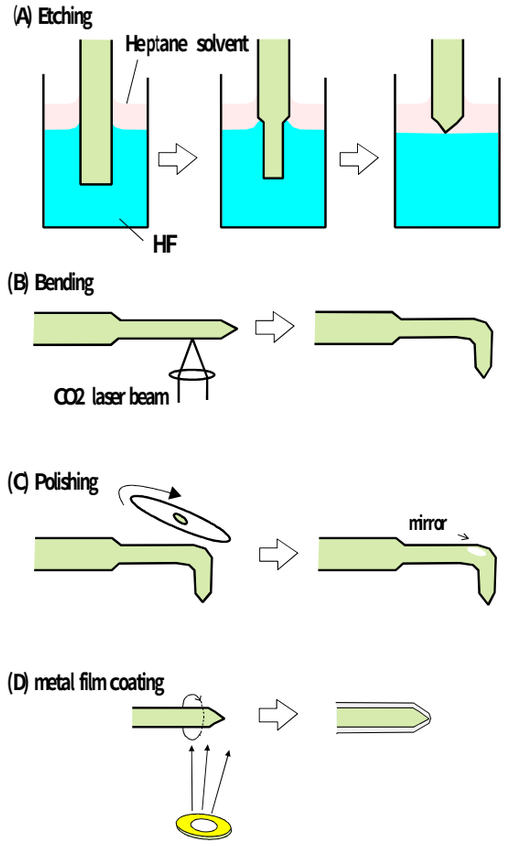

Figure 1. Fabrication process of nanoscale electrode/ near-field optical probe.

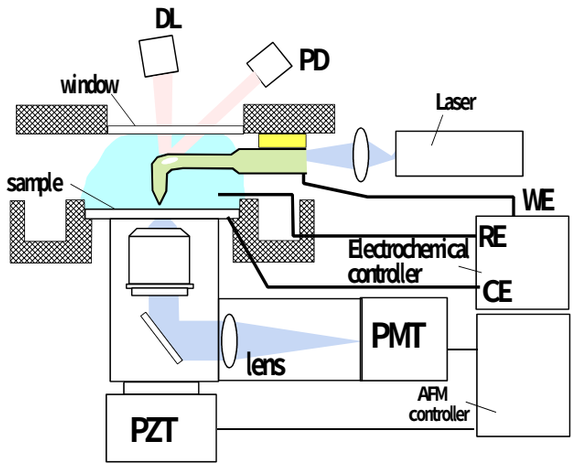

Figure 2. Block diagram of scanning electrochemical/near-field microscope.

Acknowledgments
This study was supported in part by Special Coordination Funds for Promoting Science and Technology Leading Researches.

References

1. (a). A. J. Bard, F.-R. F. Fan, J. Kwak, and O. Lev**,** *Anal. Chem*. **1989**, 61, 132.
2 Korchev,T.H., T.Rayment, and D.Klenerman, *Biophys. J*. **1998**, 74, 2076-2079.
3. D.R.Turner, C.Township, M.County, *United States Patent* **1984**,4 ,469-554.
4. H.Muramatsu, N.Chiba, K.Homma, K.Nakajima, T.Ataka, S.Ohta, A.Kusumi, and M.Fujihira, *Appl. Phys. Lett*. **1995**,66, 3245-3247.