M-12

Sensor Structure Improvements for Electrostatic Force Microscopy for Accurate Measurement as well as Measurement on Photosensitive Materials

*Toshio Uehara[1], Hiroaki Takatsu[2], Tomoya Suzuki[3], Jumpei Higashio[1], Yoshito Ashizawa[3], Katsuji Nakagawai[3]

We developed an apparatus having high spatial resolution for electrostatic surface voltage measurement. Since the apparatus is designed to measure electrostatic force derived from surface voltage with optical lever method, this apparatus can be classified as Electrostatic Force Microscopy. (a.k.a. EFM). A new technology for improvements of surface voltage measurement is introduced. Sensor part of EFM is designed longer as compared to the sensor of conventional Scanning Probe Microscopy (SPM) for accurate surface voltage measurement. We deployed an electrostatic shield underneath cantilever and sensor. The sensor tip was protruded through an aperture located on electrostatic shield. Leakage laser light from optical lever method is significantly strong and it easily exposes photosensitive surface under test (SUT). We can eliminate electrostatic force appeared on flank of sensor as well as light leakage from laser diode for optical lever method.

1. Introduction

A Scanning Probe Microscopy (SPM) has been introduced for electrostatic voltage measurement with super high spatial resolution. Whereas, we have been working on the development of an Electrostatic Force Microscopy and our goal for the EFM is different from what the measurement of the SPM offers. Our goals are;

(1) The spatial resolution which we aimed to obtain was 10μm in diameter, whereas SPM offers the spatial resolution in the range of 1μm or higher. Although the spatial resolution of EFM is lower as compared to the spatial resolution of SPM, EFM can scan much wider area so that we can obtain surface voltage distribution in wide area.

(2) We found that the usage of conventional micro cantilever/sensor, which is commonly utilized for most of commercially available SPM would develop significant reading error and it could not be ignored. We have developed a cantilever/ sensor to accomplish super high accuracy in voltage measurement.

(3) Optical lever method is used for SPM in general. EFM employs the optical level method as well. The laser light which detects the fine bending amount of cantilever may be reflected and scattered on cantilever. The reflected and scattered laser light may expose the surface of photosensitive materials. We have obtained an apparatus which enables to measure surface voltage on any photosensitive materials through the elimination of the leakage light.

(4) We have deployed a cantilever with longer sensor to accomplish highly accurate electrostatic voltage measurement with high spatial resolution. Since the sensor is rather long, we realized that the force appeared on the flank of senor could be an issue. We have deployed an extended electrostatic shield and applied an aperture on the electrostatic shield. We have put the sensor through the aperture. We were able to eliminate the force appeared on flank of sensor with the electrostatic shield.

2. Accurate Voltage Measurement

Ideal measurement with SPM is shown in Fig. 1 [2-5]. However, since the electric force lines from the surface under test (SUT) appear uniformly through entire area of SUT, we can easily expect that electric force lines should land not only the sensor part but also the cantilever part as shown in Fig. 2. The electric force lines landed on cantilever would generate reading error.

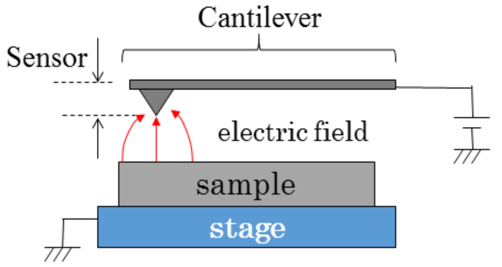

Fig. 1 Ideal Surface Voltage Measurement with SPM

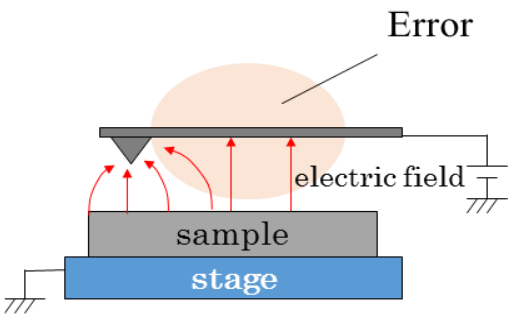

Fig. 2 Actual Surface Voltage Measurement with SPM

This means that the surface voltage measurement with any SPM should not offer accurate measurement as long as a short sensor is being employed.

In order to minimize the force appeared on cantilever, we have deployed an electrostatic shield underneath cantilever as shown in Fig. 3.　Additionally we intentionally utilized a long sensor to make the position of cantilever away from SUT.

3. Electrophotography Application

One of the disadvantages of optical lever method is that the laser light may be reflected on back of cantilever and the reflected laser light could be scattered. Eventually, the reflected/ scatter light could easily expose photosensitive materials so we could not measure surface voltage on any photosensitive materials.　For the purpose of eliminating scattered laser light to expose the SUT, we have extended the shield and we put an aperture through which the sensor is protruded as shown in Fig. 4.

With the sensor configuration shown in Fig. 4 we were able to eliminate the light leakage so that the measurement on photosensitive materials was accomplished as shown in Fig. 5.

4. Elimination of Force Appeared on Flank of EFM Sensor

As explained, we need a long sensor for accurate surface voltage measurement.　However we had to realize that there was a disadvantage for the long sensor.　The force appeared on the flank of long sensor would cause inadequate voltage measurement results. In order to define the amount of force appeared on the flank of long sensor with shield and without shield, we have done a computer simulation to define the force appeared on the flank of long sensor.　Through the computer simulation, we found that the force appeared on the flank of long sensor could not be ignored.　The sensor configuration for compensating the force appeared on the flanks of long sensor was shown in Fig. 4.　We have acknowledged that the force appeared on flank of long sensor was very well compensated with the sensor configuration shown in Fig. 4.

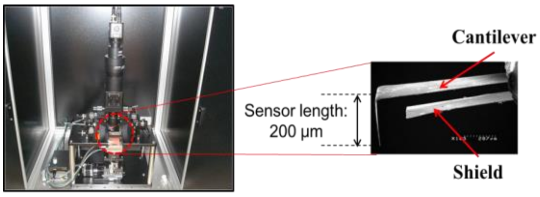

Fig. 3 EFM and cantilever

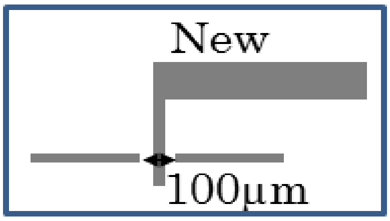

Fig. 4 Electrostatic Shield with 100 µm Aperture (New Sensor)

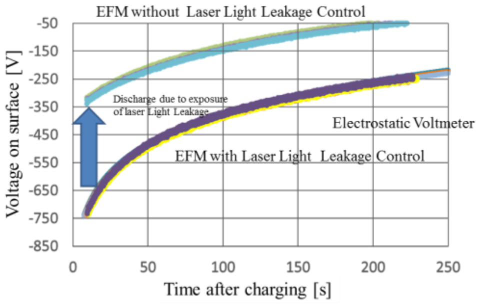

Fig. 5 Comparison with Electrostatic Voltmeter

5. Conclusions

A new apparatus for measuring surface voltage with high spatial resolution was introduced.　We have realized that surface voltage measurement with SPM would contain serious reading error.　We have developed a new sensor configuration to provide an accurate voltage reading.　We also introduced a sensor configuration which enabled voltage measurement on photosensitive materials.　The sensor configuration allowed us to compensate force appeared on flank of long sensor.

6. References

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