NANONIS APPLICATION NOTE

FEENSTRA TYPE OF SPECTROSCOPY: MAKING USE OF THE PROGRAMMING INTERFACE

Spectroscopic measurements in STM are an important tool for the investigation of the electronic states at surfaces. When combined with the variable tip-sample separation technique this type of spectroscopy leads to high dynamic range, 5 to 6 orders of magnitude, in the measured current and conductance even on the semiconductor surfaces with low surface state density.

To operate the Omicron STM we use the Nanonis STM controller together with the *Nanonis LabVIEW programming interface*. We have written our own routine making use of the programming interface and performed a special type of measurements, namely the Feenstra-type spectroscopy. I-V and dI/dV curves while sweeping the tip sample separation along some user specified contour can be in this way easily recorded. For convenience the z position is varied in a linear fashion; see equation 1. Fig. 1 shows a typical spectroscopy result of the p-type GaAs(110)(Zn-doped, $p = 1 \times 10^{19}$ cm^{-3}) surface. The I-V spectrum can be converted to the constant tip-sample separation by multiplying the measured current values by $\exp(2\kappa s)$ where a value of κ (8 nm^{-1}) is determined experimentally from measurements of the tip-sample distance (s) dependence of the tunneling current.

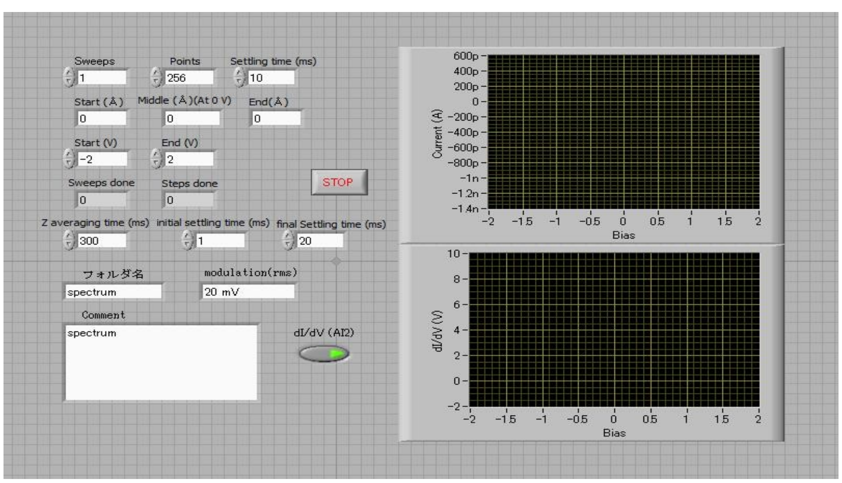

Fig. 2. Relative tip-sample displacements at the start, middle (at 0 V) and end of the bias sweep are given by the user. Values of coefficient ***a*** in Eq. 1 at the positive and negative bias ranges are not necessarily the same.

Using this method the electronic signature of any surface of interest can be obtained in a precise and fast manner.

Reference:

[1] R. M. Feenstra, PRB 7, 4561, 1994.

Authors:

N. Ishida, K. Sueoka, Hokkaido University, Japan

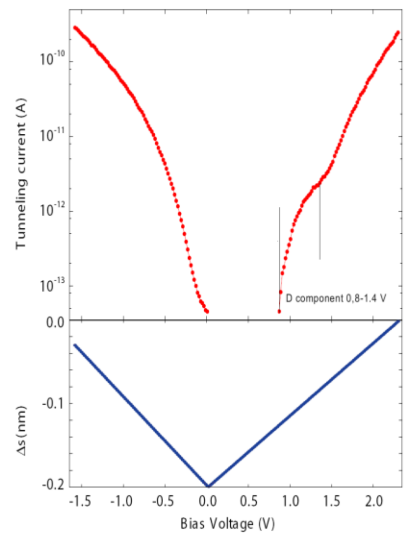

Fig. 1. p-type GaAs(110) surface.
(a) I-V spectrum converted to the constant tip-sample separation. (b) offset of the tip-sample separation (bias dependent). Non-zero current and conductance due to the empty valence-band states for p-type materials, the so-called D-component, is clearly observed in the bias range 0.8- 1.4 V.

Eq: (1) $\Delta s(V) = s_0 - s_1 + a|V|$, where ($s_1$) is the starting point, and s_0 is the displacement at 0 V.

Nanonis Modules in Use:

- Base Package
- Omicron interface
- LabVIEW Programming Interface
- Atom tracking module

System:

- Omicron UHV-AFM/STM and VT-STM

NANONIS
The SPM Application Experts

SPECS Zurich GmbH, Zürich, Switzerland
www.specs-zurich.com