

Mapping of Surface with scanning probe electron energy spectrometer

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Synopsis A specially designed STM is combined with a home-made double toroidal electron energy analyzer to develop a novel scanning probe electron energy spectrometer, which is capable of simultaneously topography imaging and spectroscopic mapping in situ. By scanning the tip over electron-beam modified Ag surface, the spectroscopic spatial resolution of this spectrometer is measured to be better than $0.7 \pm 0.2 \mu\text{m}$, at a tip sample distance of $7 \mu\text{m}$.

The increasing level of control over the properties of materials on the nanometer scale is driving the creation of new types of instruments for nanometrology. Recently we developed a new instrument called scanning probe electron spectrometer (SPEES)^[1], the schematic diagram of which is shown in Fig.1. Briefly it is composed of a home-made STM and a home-made double toroidal analyzer^[2]. The STM can be operated in tunneling mode for topography imaging, or field-emission mode for spectroscopy mapping. During the spectroscopy measurement, the electron field emitted from the STM tip collides with the sample, and the backscattered electron is collected and analyzed by the analyzer.

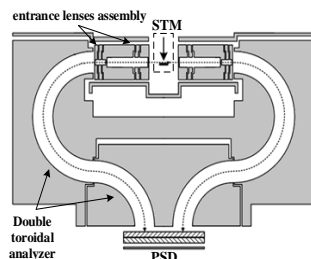


Figure 1 Schematic diagram of the SPEES

This new spectrometer provides simultaneously topography imaging and electron energy spectroscopy mapping of surface in-situ. An experiment is carried out to study its properties. The STM tip is made from 0.25 mm diameter polycrystalline tungsten wire by electrochemical, and the sample is prepared by thermal evaporating a 40 nm thick silver film on a Si substrate. During the experiment, the STM tip is approached to the tunneling region to scan a topography image, which is shown in Fig. 2(a), then the tip is withdrawn $7 \mu\text{m}$ and applied a voltage of -112V to field-emit electrons and measure electron energy loss spectrum (EELS), which is shown in the upper section of Fig. 2 (b). The energy loss peak located at about 3.6 eV is attributed to the excitation of Ag surface plasmon. After one-hour's

electron-beam irradiation, it is observed that the sample surface is modified, resulting in a reduction of the energy loss peak in EELS, which is shown in the lower section of Fig. 2 (b).

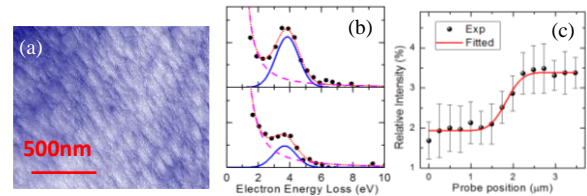


Figure 2 (a) The topography of the sample. (b) The EELS of the sample surface obtained before (upper) and after (lower) the electron-beam modifying. (c) The dependence of the relative intensity on the probe position.

By scanning the tip from the modified to the unmodified sample surface and measuring EELS point by point, the spectroscopic spatial resolution can be determined. The result is shown in Fig. 2 (c) as a dependence of the relative intensity, which is defined as an area ratio of inelastic scattering peak to elastic scattering peak in EELS, on the tip position. The experimental data is fitted by a convolution function of a normalized Gaussian function and a unit step function, thus the spectroscopic spatial resolution of this spectrometer is determined to be better than $0.7 \pm 0.2 \mu\text{m}$, which is improved by nearly one order as compared to our previous spectrometer^[3]. Furthermore, the diameter of the electron beam spot on sample surface is also estimated, which is $3.6 \pm 0.8 \mu\text{m}$. This proves that the spatial resolution of the SPEES technique can be much better than the size of the incident electron beam.

References

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