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Scanning Probe Energy Loss Spectroscopy

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Scanning Probe Energy Loss Spectroscopy (SPELS) is a new technique [1] that can be viewed as a hybrid between scanning tunneling microscopy (STM) and electron energy loss spectroscopy (EELS). The fundamental attraction of SPELS is the potential to provide local, 10nm–scale spectroscopic and therefore chemical/electronic information from surface features, correlated with the surface topography. A tungsten STM tip operated in field emission mode (e.g. at 100 V) is used as a local source of electrons, and an energy analyzer is used to collect the energy loss spectra of the backscattered electrons, fig. 1. Simulations [2] indicate a theoretical spatial resolution below 10nm. Experimental SPELS spectra from a variety of surfaces will be presented, e.g. graphite, silicon, gold, silver particles. Our present energy resolution (down to 0.6 eV) allows us access to plasmon excitations and interband transitions as well as molecular electronic transitions from ~1–100 eV.

To work at the highest spatial resolution, it is vital to obtain spectra with tip-surface distances below 100 nm. We thus present SPELS spectra taken for the first time at a distance of only 50 nm from the sample surface, fig. 2. We also demonstrate the instrument's ability to detect local secondary electron emission (SEE) peaks [3] at such distances, fig. 2, and how one can differentiate such features from energy loss peaks. For example, the SPELS spectra of the graphite surface show a strong energy loss peak, at around 6.5eV, which can be assigned to the π band plasmon. In addition, further "energy loss" peaks are observed which shift in energy loss position as the incident energy is changed – they correspond to features of fixed kinetic energy. For graphite these secondary-electron emission peaks appear at 6.9eV, 9.9eV, 15.2eV and 21.1eV (kinetic energy relative to vacuum level), assigned to unoccupied graphite π or σ bands in harmony with macroscopic surface measurements. New results on the silver surface again show not only a strong surface plasmon energy loss peak, but also two secondary electron emission features at around 2eV and 5eV. SEE measurements with SPELS thus has the potential to provide band structure information from surface features, again on the 10nm̃length scale.

The spatial reolution in SPELS, fig. 3, is now established as not more than 10–20nm [4]. Our latest experimental tests, using patterned surfaces, of the information content and spatial resolution will be discussed.

References

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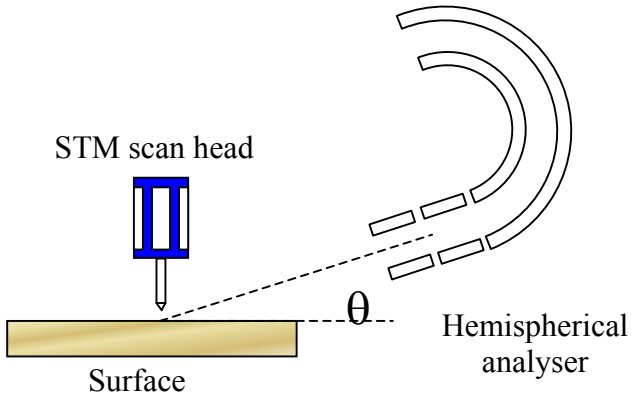

Fig. 1 Schematic diagram showing the set-up of the Scanning Probe Energy Loss Spectrometer (SPELS).

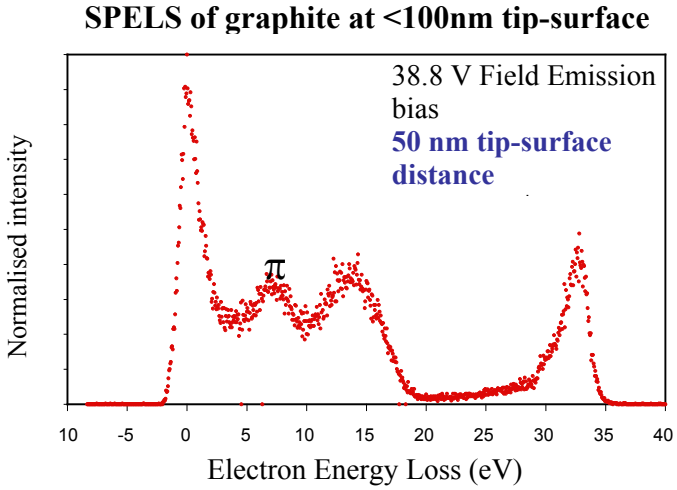

Fig. 2 SPELS spectrum from graphite at a tip-surface distance of 50nm, showing the π band plasmon at 7eV and two secondary electron emission peaks.

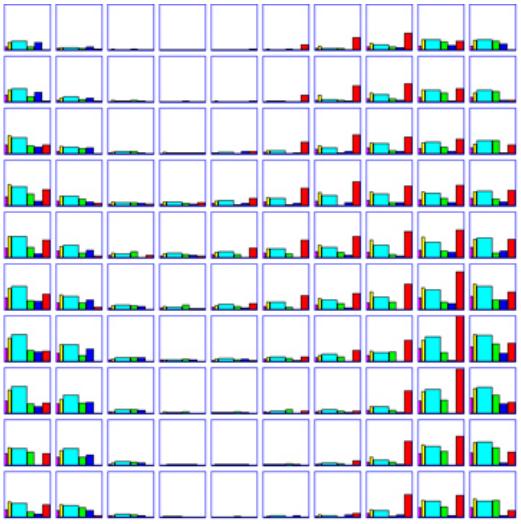

Fig. 3 Local SPELS spectra from individual 50x50 nm squares on a roughened Si(111) surface, where a spatial resolution down to 10-20nm has been recorded.

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