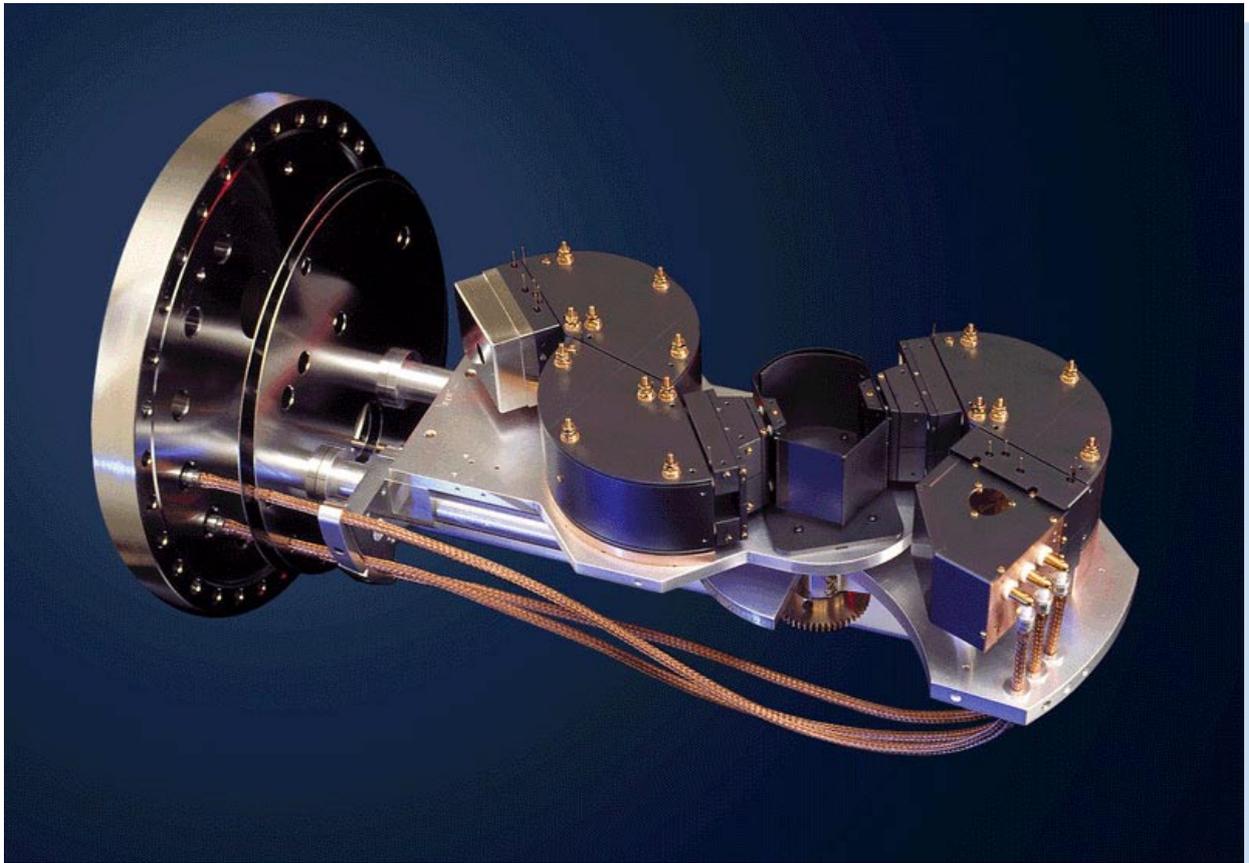


Model ELS5000

High Resolution Electron Energy Loss Spectrometer (EELS)



Performance Features

- ▶ Ultrahigh resolution of 0.5 meV FWHM
- ▶ Guaranteed detector current $\geq 10\text{pA}$ at 1.0 meV resolution (FWHM)
- ▶ Employs new electrostatic deflectors with controlled angular aberrations
- ▶ Low-noise digital control electronics with menu-driven software
- ▶ User-selectable scan range up to 50eV for vibronic/electronic applications



Manufacturer of precision instrumentation for surface analysis including electron spectrometers, ion and electron guns, and LEED/Auger systems.

Introduction

High-resolution electron energy loss spectroscopy (EELS) is a powerful surface-analytical technique which provides unique vibrational analysis of metal and semiconductor surfaces in a high-vacuum environment. Increasingly, insulators and polymer films are also being studied by means of charge-neutralization techniques. EELS readily provides important information on:

- ▶ adsorbate vibrational frequencies
- ▶ molecular structure of adsorbates (decomposition, polymerization)
- ▶ bond strengths at surfaces
- ▶ adsorption geometry—surface-bonding sites
- ▶ surface chemistry (oxide formation, reduction, intermediates, etc.)
- ▶ overtone and combination vibrational bands
- ▶ surface acoustic and optical phonons

Importantly, EELS affords higher surface sensitivity and wider spectral range than infrared spectroscopy. For example, a spectral range of 200-5000 cm^{-1} can be scanned in a few minutes and less than 10^{-3} monolayers of adsorbed CO may be detected. In contrast to IR spectroscopy, EELS is not limited by strict dipole selection rules, which often hinder observation of important modes and adsorbates. In EELS both long-range dipole and short-range “impact” scattering mechanisms are operable and may be effectively studied as a function of scattering angle and impact energy. For example, molecular adsorbates which exhibit weak dipole activity can be detected in the impact scattering regime. Information obtained from EELS ideally complements data obtained with Auger, ESCA, LEED, SIMS, SPM and other surface probes, and offers ease of interpretation for the experimentalist.

Figure at right:
Defector currents for the ELS5000 in direct beam geometry whereby the analyzer is aligned with the monochromator.

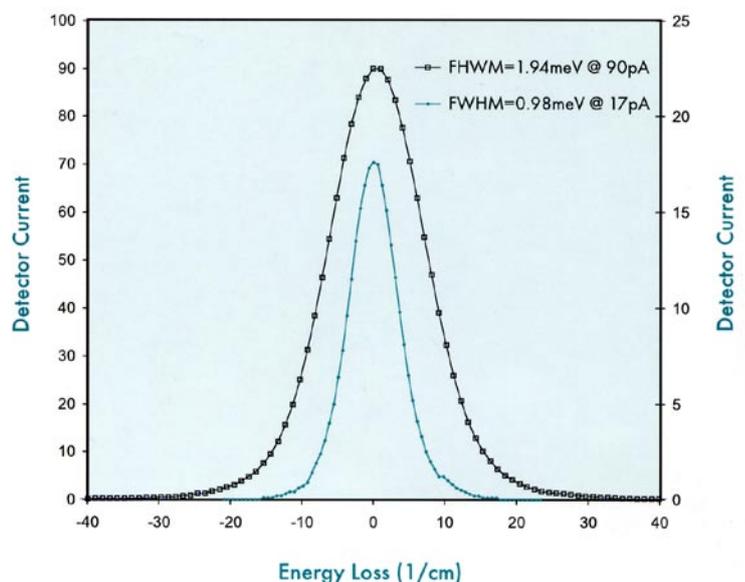
The ELS5000 Spectrometer

The ELS5000 is a state-of-the-art spectrometer based on the development by Professor Harold Ibach and his co-workers at the KFA, Julich, Germany. The instrument is capable of energy resolution to 0.5 meV under optimal conditions. The ELS5000 is manufactured by LK Technologies per a worldwide licensing agreement with the KFA.

The ELS5000 employs a highly optimized double-pass monochromator whereby space charge compensation of the 127° cylindrical deflector is made in both monochromator stages by careful choice of parameters. The pre-monochromator operates as a “retarding” monochromator whereby the kinetic energy of electrons exiting this stage and entering the second monochromator is about 1/5 the nominal pass energy of the pre-monochromator. The second monochromator acts as a non-retarding stage with a deflection angle appropriate for reduced space charge. The electron gun employs a special LaB_6 cathode. An important aspect of this design is the shaping of the electrostatic deflectors in both the radial and axial planes to achieve controlled angular aberrations. Such a device has a limiting resolution of 0.3 meV¹.

The ELS5000 employs a single-pass analyzer which is conveniently rotatable to provide the angular analysis desirable in many experiments. A symmetrical system of input-output “zoom” lenses positioned between monochromator and analyzer is used to focus and decelerate/accelerate the electron beam to and from the sample surface. A patented, non-circular symmetric lens design is employed that yields excellent transmission characteristics. The combined monochromator-analyzer system with this high transmission lens results in exceptional detector currents as a function of energy resolution.

¹ H. Ibach, *Journal of Electron Spectroscopy and Related Phenomena*, 64/65 (1993) 819-823



Model ELS5000-DAC Digital Control Electronics Package

The ELS5000 series electron spectrometers are available with a fully computer-based control electronics which is unique in the field of high-resolution electron energy loss analysis. This innovative PC-based system features menu-driven software that permits setup and optimization of all spectrometer voltages and monitoring of critical current levels. The ability to read and store complete tables of spectrometer settings on disk allows a speed and flexibility not possible with conventional EELS power supplies. This integrated system includes signal recovery electronics and menu-driven software for acquisition, display and analysis of the EELS vibrational spectra.

ELS5000-DAC Software

The program is menu-driven and includes mouse control. In the "DAC mode" the user is provided with a complete color screen view of all the spectrometer voltages. A readout of user-selected current levels or count rate at the channeltron detector is also displayed in this mode. By use of the mouse the user may change any of the displayed voltages in order to optimize current

levels, counts, etc. Importantly, all current spectrometer voltages may be rapidly stored on disk or recalled from disk when desired. This latter feature is very convenient when moving to different beam energies or changing spectrometer resolution. There is also an "auto-tuning" mode for computer controlled optimization of signal level and peak shape. In the signal recovery section, or "SCAN mode", acquisition of spectra is controlled in terms of scan range, channel size, time per channel and number of repeated scans. The scan is displayed in real time with a readout of counts/sec and the ability to change vertical scales during the scan. After a scan is completed the entire data is displayed and one is given access to an interactive inspection of the data with the ability to inspect different energy loss regions and to readout the energy loss peak positions in terms of meV or cm^{-1} and to readout intensity in counts/sec. Additional data may be accumulated or the spectrum may be stored on disk. Former data may be recalled from disk for similar interactive inspection. Once stored the data may be analyzed and plotted by a variety of user-selected software packages.

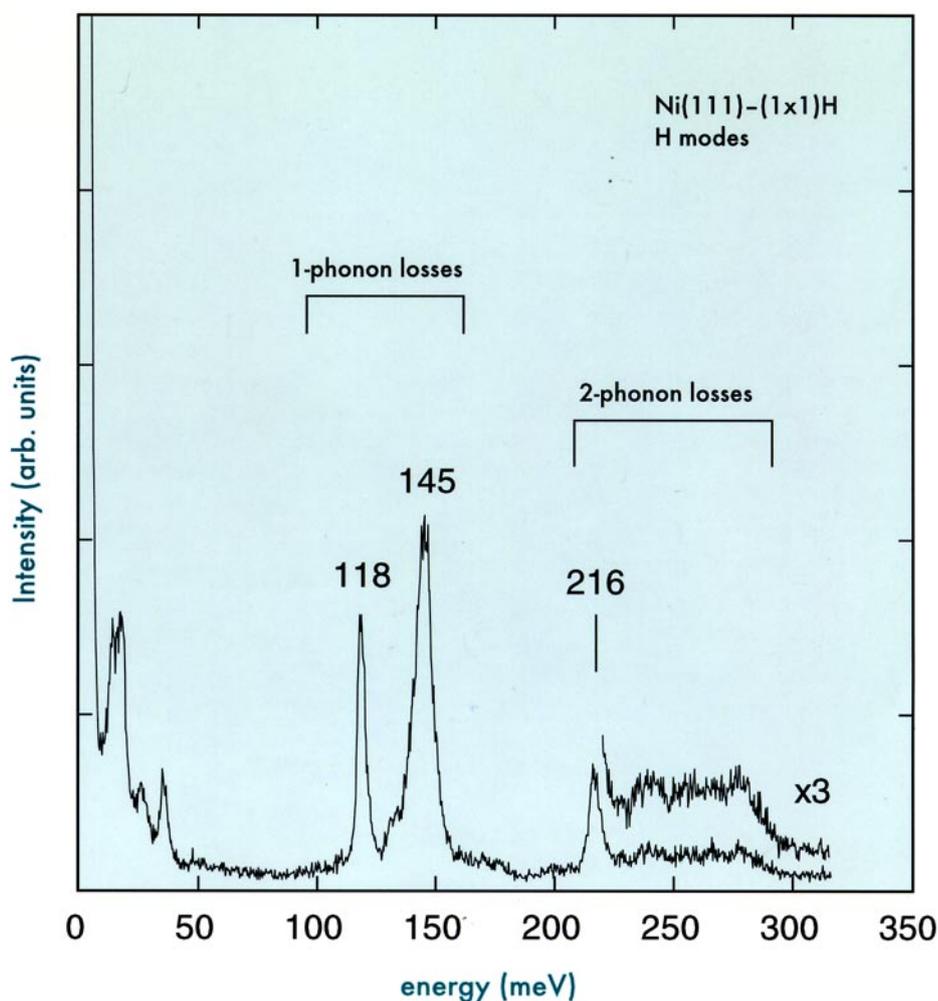
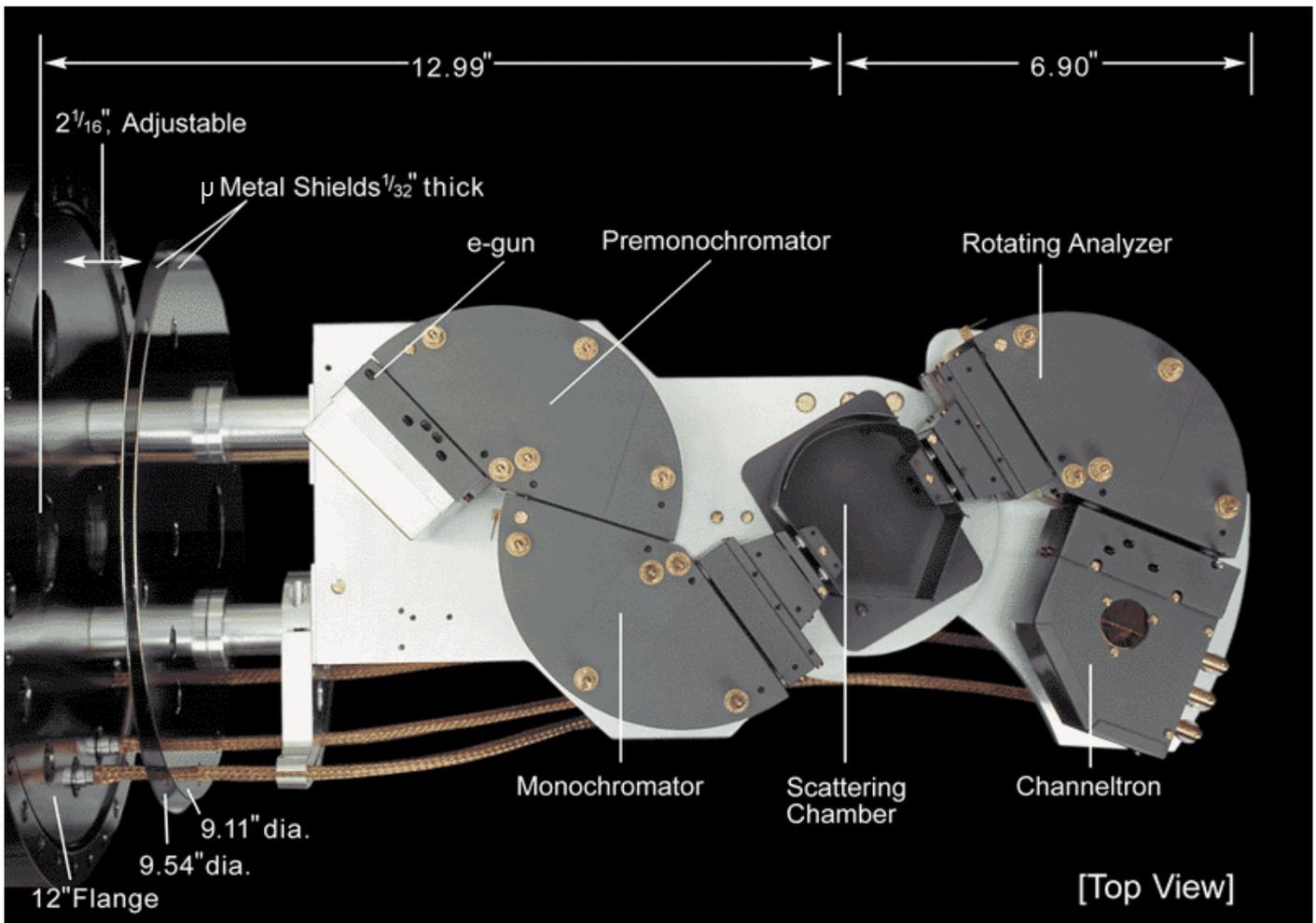


Figure at right:
ELS5000 spectrum for the H/Ni (111) surface. The spectrum was acquired in off-specular geometry of a primary energy of 9.5 eV and an energy resolution of 2 meV (used with permission of H. Okuyama, T. Ueda, T. Argua, and M. Nishijima, Kyoto University).



Mechanical Specifications

Flange mounted spectrometer with all necessary electrical and mechanical feedthroughs. Dual magnetic shields are provided at the flange to interface with the chamber magnetic shields. Consists of cylindrical double pass monochromator and single pass analyzer. Nominal mounting is on 12" O.D. conflat flange. Analyzer rotatable from straight through position to 78° away. Note that chamber magnetic shielding is not supplied with this item.

General Performance Specification

Typical performance specifications guaranteed are as follows, based on direct beam geometry:

- ▶ 1 meV FWHM Detector current >10pA
- ▶ 2meV FWHM Detector current >70pA

Electronics Specification-Model ELS5000 DAC

Digital control electronics package for control of the Model ELS5000 spectrometer. Includes digital control of spectrometer voltages and readout of critical currents. Package includes picoammeter, noise reduction filter, power supply, PC compatible computer and interface equipment.

Package also includes Model LK2000-CE counting electronics package with necessary interface. Includes software for data acquisition and control of spectrometer voltages. Operation is for 2-200eV kinetic energy. Scan range nominal 50eV. Ripple on voltages less than 250 microvolt p-p. Electronics is based on grounded sample method (no need to bias sample to achieve beam energy).



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