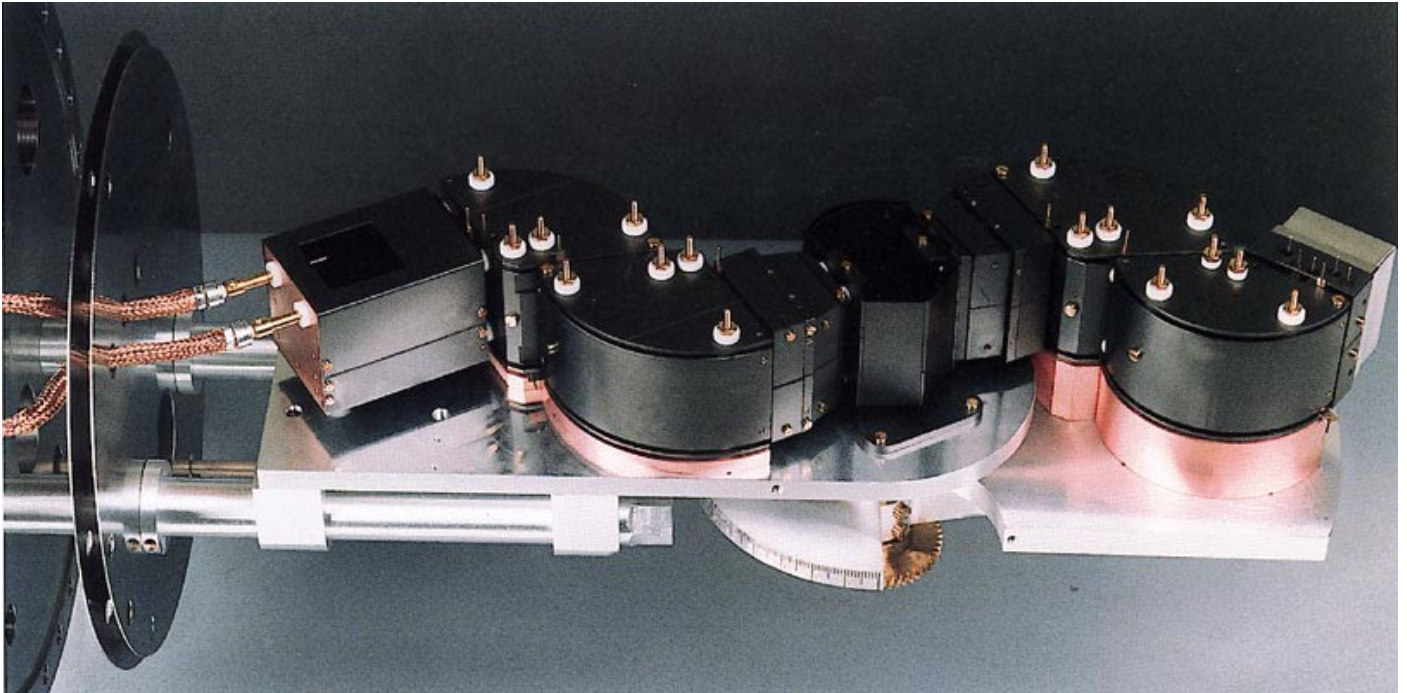


Model ELS3000

High Resolution Electron Energy Loss Spectrometer (EELS)



Performance Features

- ▶ Ultrahigh resolution of 0.5 meV FWHM
- ▶ Guaranteed detector current ≥ 10 pA at 1.0 meV resolution (FWHM)
- ▶ Space-charge optimized, double-pass monochromator with dual analyzer
- ▶ High-transmission zoom lens system for operation from 1-200 eV impact energy
- ▶ Low-noise digital-control electronics with menu driven software and auto-optimization modes
- ▶ User selectable scan ranges up to 50 eV for vibronic/electronic applications
- ▶ Available as a component or with complete UHV system
- ▶ Demonstrated performance and reliability in laboratories worldwide



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

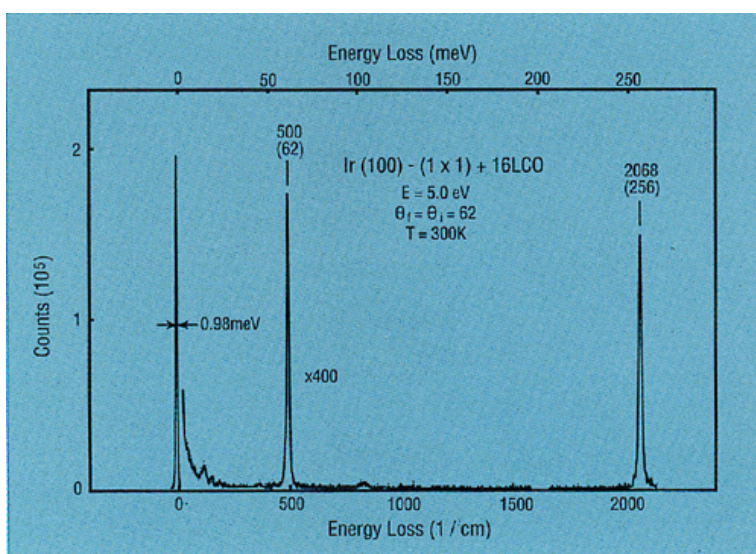
Importantly, EELS affords higher surface sensitivity and wider spectral range than infrared spectroscopy. For example, a spectral range of 200-5000 cm^{-1} can be scanned in a few minutes, and less than 10^{-3} monolayers of adsorbed CO may be detected. In contrast to IR spectroscopy, EELS is not limited 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, STM and other surface probes, and offers ease of interpretation for the experimentalist.

The ELS3000 Spectrometer

The ELS3000 is a state-of-the-art instrument based on the development by Professor Harald Ibach and his co-workers at the KFA, Jülich, Germany. This instrument design initially led to the first reported resolution below 1.0 meV [0.98 meV (FWHM) for CO adsorbed on Ir (100) (see figure below)]. The ELS3000 is now manufactured by LK Technologies per a worldwide licensing agreement with the KFA. The ELS3000 version of this design has obtained a resolution as high as 0.5 meV in direct beam geometry and less than 0.8 meV on a polymer film (see figure below). The ELS3000 was the first instrument to achieve such a high resolution on a polymer surface.

The ELS3000 takes advantage of a highly optimized double-pass monochromator design whereby space charge compensation of the 127° cylindrical deflector is made in both monochromator stages by careful choices 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 monochromator with a deflection angle appropriate to reduced space charge. The electron gun employs a repeller geometry with a LaB₆ cathode.

The ELS3000 analyzer is also of double-pass geometry. 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 (Table 1).



Spectrum of CO on Ir (100) at an energy resolution of 0.98 meV (courtesy of Dr. H. Ibach)

General Performance Specifications

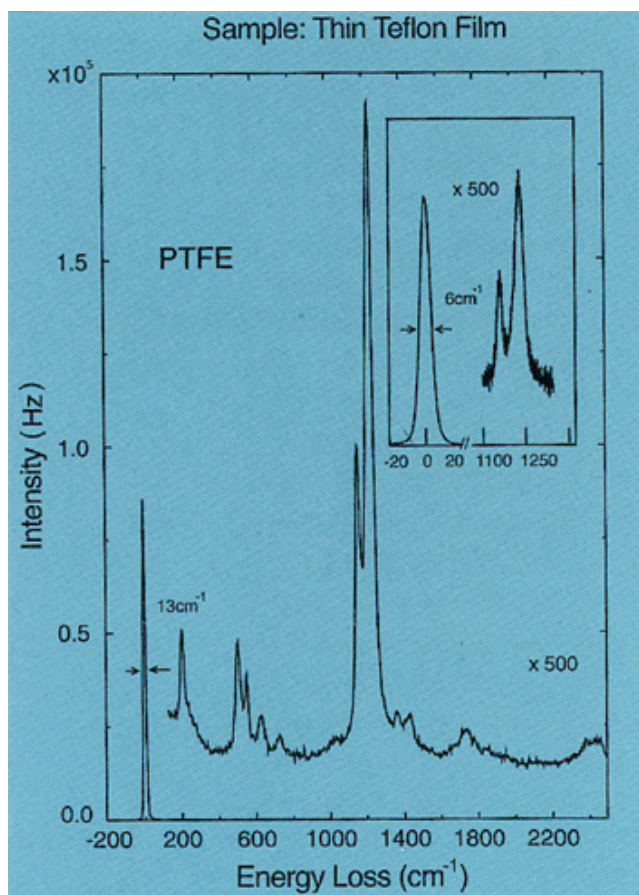
The ELS3000 has achieved a resolution of 0.5 meV in direct beam geometry and 0.8 meV on a polymer film (PTFE) while maintaining high detector current and counting rates. The Table 1 below shows both guaranteed specifications as well as optimal results which have been achieved in our testing laboratory. Every ELS3000 is carefully tested before shipment to meet or exceed the guaranteed specifications. Since improvements are made on a regular basis, the prospective customer should consult the company for the latest specifications.

Table 1

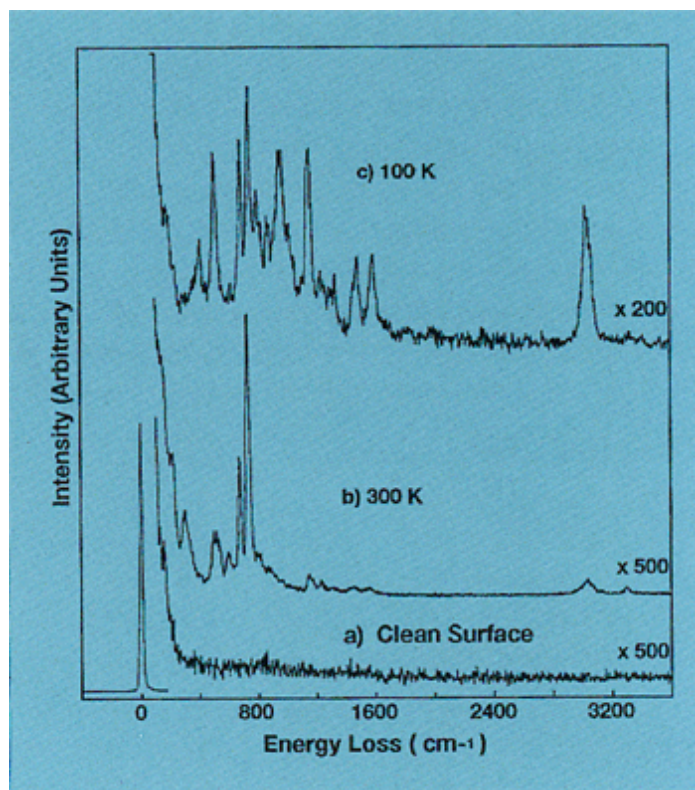
FWHM	Guaranteed Detector Current	Optimal Detector Current
1 meV	10 pA	>14 pA
2 meV	70 pA	>95 pA

Table 2

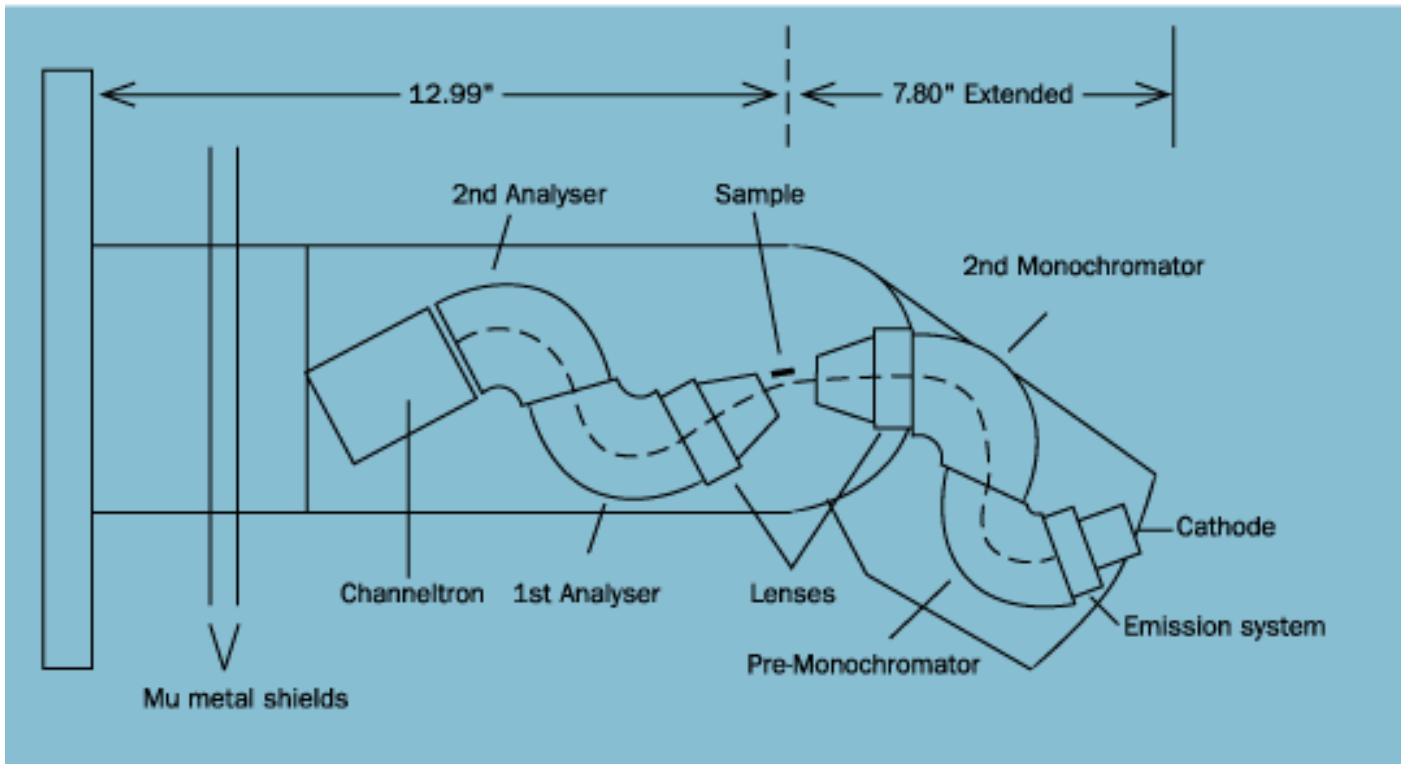
Energy Beam	Acceptance angles of analyzer unit:
4 eV	$\pm 1.5^\circ$ (dispersive plane) $\pm 1.7^\circ$ (non-dispersive plane)
100 eV	$\pm 0.4^\circ$ (dispersive plane) $\pm 1.7^\circ$ (non-dispersive plane)



Spectra of thin PTFE film at 6 eV impact energy. Wide scan taken at 1.6 meV resolution. Inset: Scan of elastic peak and CF₂ stretching region at 0.8 meV resolution.



ELS3000 spectra for (a) clean Cu (110), (b) Cu (110) saturated with aniline at 300K, and (c) Cu (110) dosed with 20L of aniline at 100K. The energy resolution of 1.6–2.0 meV allows the assignment of 23 modes for the multilayer (used with permission of R. Plank, J.M. Vohs and N.J. Di Nardo).



Mechanical Specifications

The ELS3000 is mounted as an integral unit on a 12 inch (305 mm) O. D. vacuum flange. Construction materials are all non-magnetic to insure the lowest possible stray magnetic field (e.g. no stainless steel is utilized). Dual magnetic shields are provided at the flange to interface with the chamber magnetic shields. Angle-dependent studies are accomplished by rotation of the monochromator from "straight through" position to 90° away from straight through by means of a precision, linear-feedthrough/rack-and-pinion gear system. Importantly, a direct readout of the monochromator angle is provided by a scale which is viewed through a port on the mounting flange. This removes the uncertainty associated with gear backlash or drive calibration.

Electronics Specification -- Model ELS3000 DAC

Digital-control electronics package for control of the Model ELS3000 spectrometer. Includes digital control of spectrometer voltages and readout of critical currents. Package includes picoammeter, noise reduction filter, power supply, PC compatible computer, floppy drive, and interface equipment. Includes Model LK2000-CE counting electronics package. Includes menu-driven software for data acquisition and control of spectrometer voltages. Operation is for 1-200 eV kinetic energy. Scan range up to 50 eV. Ripple on voltages less than 250 microvolt p-p. Controller operates with sample near earth ground.



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