MASS SPECTROMETERS FOR

THIN FILMS, PLASMA

AND SURFACE ENGINEERING

HIDEN
ANALYTICAL

MASS SPECTROMETERS

for Thin Films and Surface Engineering

Hiden Analytical have been designing and developing the highest quality quadrupole mass spectrometer based gas analysis systems for over 30 years. We have built a reputation for delivering instruments with superior sensitivity, accuracy and reproducibility together with a first class global service and applications support network.

Thin film processing in research, development and functionalisation of surfaces has a broad application range in microelectronics, nanotechnology, solar, flat panel, mechanics, optics, photonics, textiles, coatings, chemistry, biology and medicine.

Thin film processing utilises a wide range of techniques, including:

Magnetron sputtering
ALD – atomic layer deposition
CVD – chemical vapour deposition
MOCVD – metal organic chemical vapour deposition
PECVD – plasma enhanced chemical vapour deposition
MBE – molecular beam epitaxial growth
RIE – plasma reactive ion etch
IBE/RIBE – ion beam etch and reactive ion beam etch

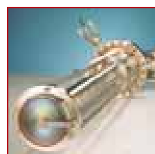
Each technique is often tailored for a specific application, requiring special process parameters to produce the surface/film properties required.

Hiden mass spectrometers provide critical insight into thin film processing and characterisation enabling optimisation of thin film production and surface quality. Hiden systems are individually configured to ensure optimum analyser response for sensitivity and speed.

CONTENTS

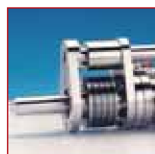
Thin Film Processing:

HPR-30 and RGA – process and residual gas analysis



EQP and PSM – plasma sampling mass spectrometers

ESP*ion* Langmuir Probe – for measurement of plasma properties



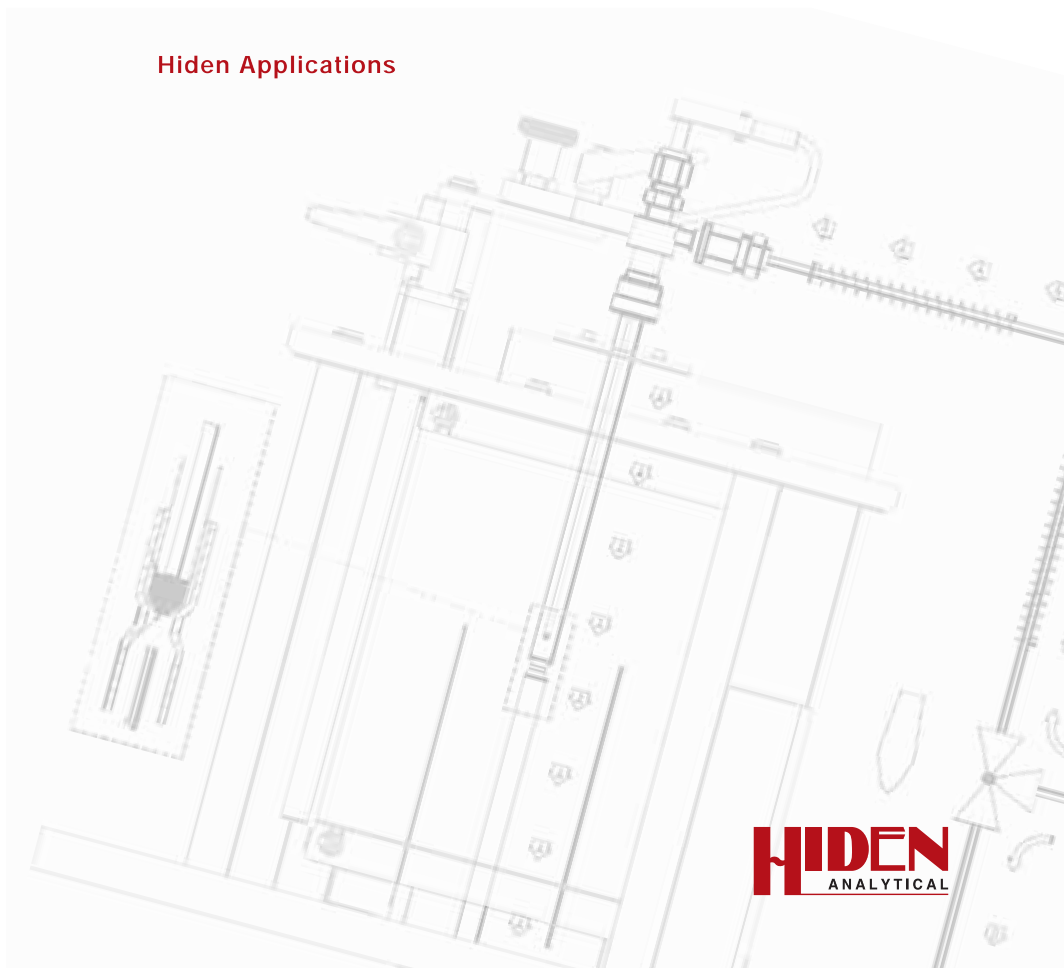
IMP-EPD – end point detector for ion beam etch

XBS for MBE - deposition rate monitor for molecular beam analysis and deposition control

TPD Workstation – complete UHV TPD system

SIMS/SNMS Systems – for thin film surface analysis

Hiden Applications



HIDEN ANALYTICAL

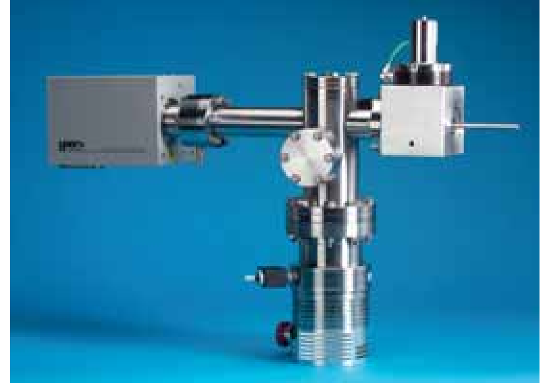
HPR-30 and RGA

Process and Residual Gas Analysis

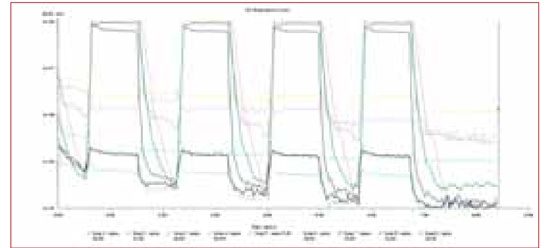
The HPR-30 is a residual gas analyser configured for analysis of gases and vapours in vacuum processes and for vacuum diagnostics. The system is fully configurable for individual process applications such as CVD, plasma etching, MOCVD, process gas purity and in-process contaminant monitoring.

The HPR-30 system features a close-coupled re-entrant aperture for sampling directly within the process region, providing maximum data integrity and fast confirmation of process status. Options include the innovative Hiden 3F series triple filter quadrupole system providing enhanced abundance sensitivity, part-per-billion (ppb) detection levels and high contamination resistance, particularly suited to the analysis of aggressive gases in CVD and RIE applications.

The HPR-30 sampling system configuration is directly suited to analysis of high mass species and precursors used in ALD and MOCVD applications.



HPR-30



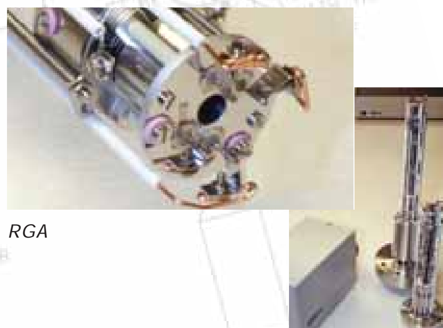
HPR-30 data on TiN deposition

Products

RGA Series – residual gas analysers for vacuum measurement through to fundamental scientific research.

qRGA with separation of He/D_2, ^{3}He/HD/T and deuterated hydrocarbons (e.g. C_xH_y and C_xD_y) with mass range to 200 amu.

HPR-30 Series – vacuum process analysers configured for high sensitivity, fast response gas and vapour analysis of thin film deposition and etching processes: CVD, ALD, MOCVD and RIE for example.



RGA

RGA series

FEATURES/OPTIONS:

- custom inlet systems with optimised sampling for metals and metal organic vapours
- high mass range options available – 500 and 1000 amu
- high sensitivity RGA for UHV quality chamber base pressure measurements and leak detection
- re-entrant sampling orifice for fast response to process gas/vapour composition changes
- gas/vapour sampling systems optimised for response and sensitivity over a wide pressure range

EQP and PSM

Plasma Sampling Mass Spectrometers

EQP

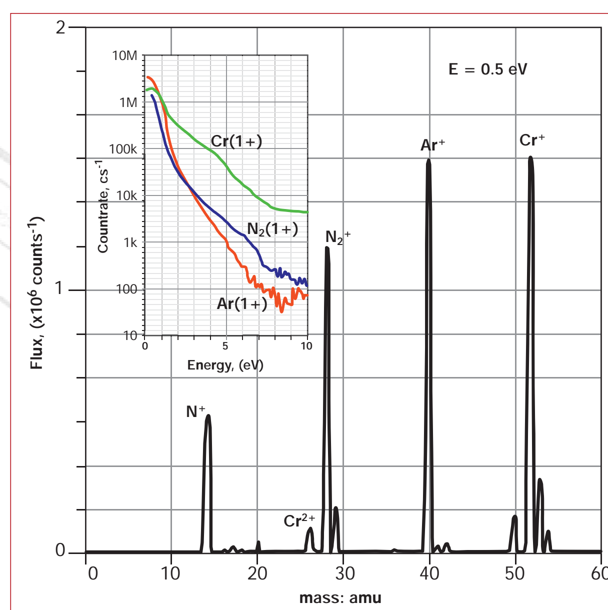
EQP system – in plasma

A wide range of industrial processes use electrical plasmas, and new applications are developing rapidly. In the microelectronics industry the demands of higher yields and shrinking device geometries mean that process reproducibility and understanding is vital.

Hiden plasma probes measure some of the key plasma parameters and provide detailed information relating to plasma reaction chemistry.

Detailed understanding of the reaction kinetics of plasma ions and neutral species plays a key role in the development of advanced surface engineering processes such as HIPIMS.

The EQP system directly measures mass and energy of both positive and negative process ions, measuring masses up to 2500 amu and ion energies up to 1000 eV. The integral electron bombardment ion source provides for analysis of neutrals and, with the addition of the EAMS (electron attachment mass spectrometry) electron attachment mode, for separation and identification of electronegative radical species.



Example EQP data

FEATURES/OPTIONS:

- mass and energy analysis of positive and negative ions
- neutrals and neutral radical analysis
- magnetic shielding options for magnetically confined plasmas
- integral signal gating with automatic timing control for detailed pulsed plasma analysis
- PSM analyser includes an in-line energy analyser for positive ion analysis
- EQP analyser includes a 45 degree sector field energy analyser for positive and negative ion analysis

HIDEN ANALYTICAL

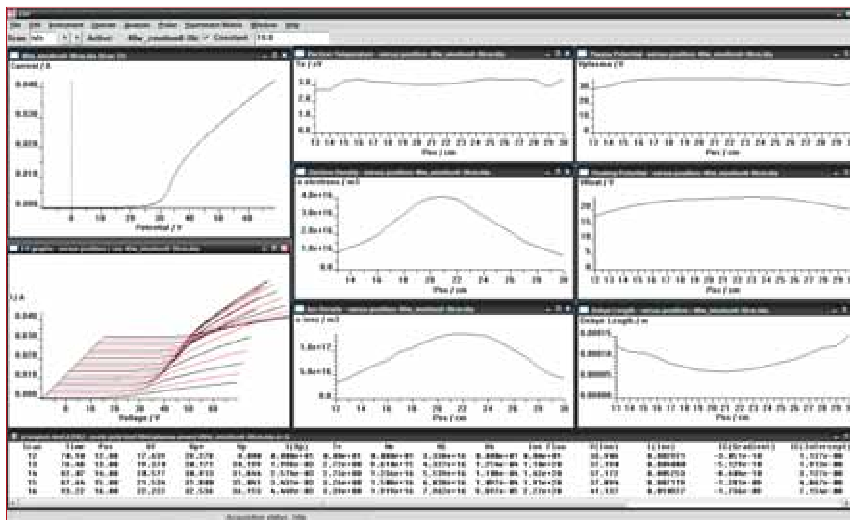
ESP*ion* LANGMUIR PROBE

for Measurement of Plasma Properties

The ESP*ion* Langmuir probe provides for measurement of the electrical properties of plasmas including:

- Plasma Potential
- Floating Potential
- Electron Temperature
- Electron Density
- Ion Density
- Electron Energy Distribution
- Ion Flux

ESP*ion with 300 mm automatic Z-drive*



ESP*ion data*

Routine monitoring of the I-V plasma characteristic by the Hiden ESP*ion* probe gives direct information relating to plasma stability and reproducibility. Automatic real-time extrapolation of plasma parameters gives detailed information on plasma properties for use in characterisation and uniformity monitoring.

The ESP*ion* system employs Orbital Motion Limited (OML) and Allen Boyd Reynolds (ABR) as standard plasma analysis models.

The Hiden automatic Z-drive provides for spatially resolved measurements across the plasma volume. The standard Z-drive translation options are: 300, 600 and 900 mm.

ESP*ION* PROBES MEASURE:

- ion and electron density over the range 10^{14} - 10^{19} m^{-3}
- electron temperature up to 10 eV
- Electron Energy Distribution Function (EEDF)
- plasma potential
- floating potential
- Debye length
- developed for pulsed, DC, RF and ECR plasma
- integrated signal gating for pulsed plasma analysis

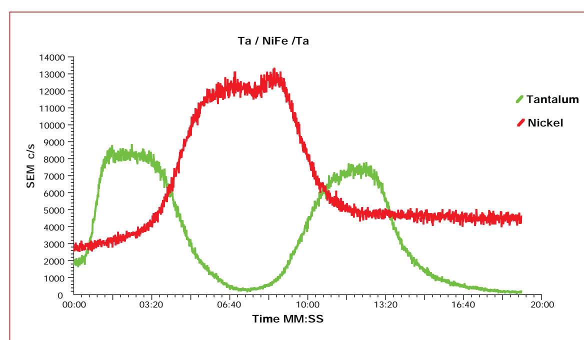
IMP-EPD

End Point Detector for Ion Beam Etch

IMP-EPD with Z-drive

The IMP-EPD is a differentially pumped, ruggedised secondary ion mass spectrometer for the analysis of secondary ions and neutrals from the ion beam etch process. The system includes integrated software with process specific algorithms developed for optimum process control.

The IMP-EPD system is process proven for the production of high specification thin film devices for applications including magnetic thin films, high temperature superconductors and III-V semiconductors.



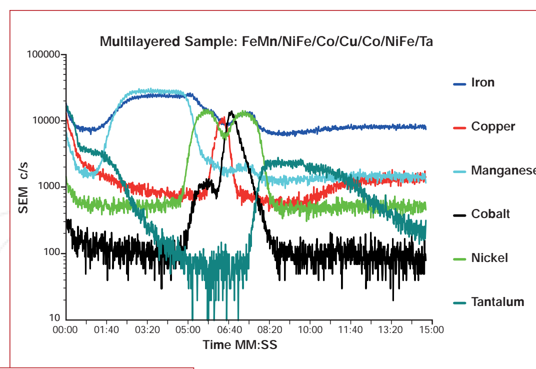
IMP data

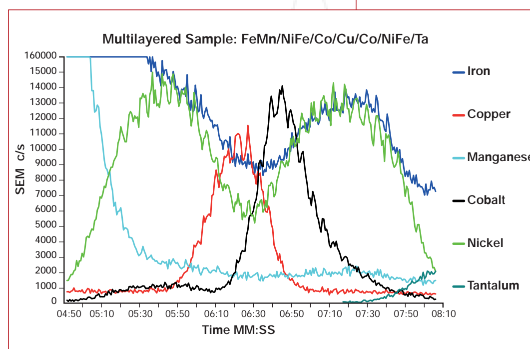
End point controls:

- Rising and falling edge algorithms
- Layer counting for end point on a selected interface in a multilayered stack
- Endpoint relative to a reference peak
- Automatic signal correction due to wafer rotation

APPLICATIONS:

- end point analysis
- target impurity determination
- quality control/SPC
- residual gas analysis
- leak detection





HIDEN ANALYTICAL

XBS DEPOSITION RATE MONITOR

for Molecular Beam Analysis and Deposition Control

The Hiden XBS system is a quadrupole mass spectrometer designed for monitoring multiple beam sources simultaneously and uniquely offers beam acceptance through a 70° cone. Species-specific analogue signals are used for beam intensity output to the users' source control modules.

Beam acceptance apertures are configured individually for each specific process chamber source position, manufactured as replaceable plug-in elements to enable retrospective modification in event of chamber alteration. Purpose-designed with high contamination resistance for monitoring evaporating components and fragments in MBE processes. Manufactured with a triple stage mass filter and water-cooled fully-shrouded probe to protect the probe from the radiant heat sources and to inhibit probe contamination.

- monitor and control in MBE processes
- molecular beam studies
- multiple beam source analysis
- photoionisation studies
- desorption/outgassing studies
- monitor and diagnostics of contaminants in the process chamber
- high performance RGA with high-sensitivity helium leak check mode for vacuum quality verification

XBS probe

XBS probe with water-cooled shroud and Z-drive

FEATURES:

- high sensitivity – minimum detectable partial pressure 2.5 x 10^{-14} mbar
- mass range: 320 or 510 amu
- crossbeam ion source, beam acceptance through +/- 35° to transverse axis
- beam acceptance apertures configured for beam source positions
- growth rate determination typically < 0.01 Å s^{-1} (species dependent)
- optional water-cooled shroud

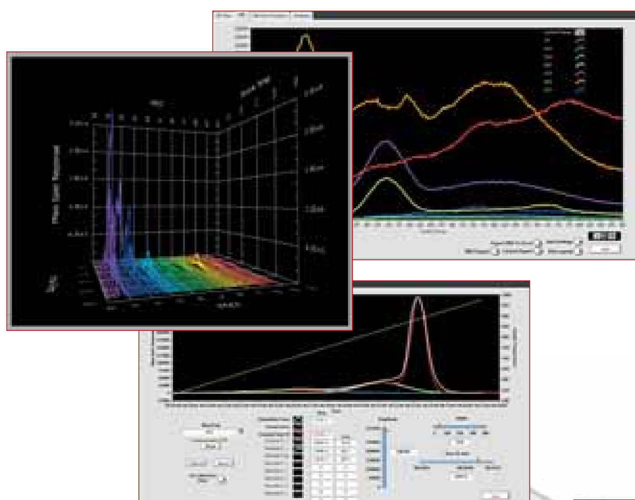
TPD WORKSTATION

Complete UHV TPD System

TPD Workstation viewport

The Hiden TPD Workstation is a complete experimental system for UHV temperature programmed desorption (TPD) studies. The TPD Workstation features a multiport UHV chamber with heated sample stage coupled to a high precision triple filter analyser with digital pulse ion counting detector for ultimate sensitivity and time resolution. The triple filter mass analyser is configured with a cooled shroud giving minimum outgassing with optimum sensitivity of the analyser to desorption products from the sample. A fast sample load lock with sample transfer mechanism is included to provide for rapid sample change.

Hiden's TPDsoft thermal analysis PC software included with the Workstation provides automatic control of sample temperature integrated with analyser control. TPD analysis routines (e.g. peak integration, deconvolution and background subtraction etc.) are also included in this package.



TPDsoft for control and analysis of TPD experiments

TPD Workstation

FEATURES:

- Hiden 3F PIC mass spectrometer for fast data acquisition (> 500 data points per sec)
- multiport UHV chamber for attachment of additional instrumentation (e.g. ellipsometry)
- sample transfer mechanism and loadlock, including gate valve and viewport
- heated sample stage to 1000°C
- Z-drive for optimum sample/detector positioning
- bakeout jacket (200°C max)
- integrated software control of experimental protocols

HIDEN ANALYTICAL

SIMS/SNMS SYSTEMS

for Thin Film Surface Analysis

SIMS is a high sensitivity surface analysis technique for the determination of surface composition, contaminant analysis and for depth profiling in the uppermost surface layers of a sample.

Applied to analysis within the first few microns of a surface, Hiden's SIMS systems provide depth profiles with depth resolution to 5 nanometres.

The Hiden SIMS Workstation provides for high performance static and dynamic SIMS applications for detailed surface composition analysis and depth profiling.

Hiden's elemental SIMS imaging facility provides for high resolution surface chemical mapping.

The SNMS facility complements the SIMS technique, providing quantification for thin film composition measurements.

Hiden's new SIMS-on-a-Flange provides a complete SIMS facility on a single UHV conflat type flange.

SIMS Workstation

SIMS-on-a-Flange

EQS spectrometer

SURFACE ANALYSIS COMPONENTS:

SIMS Workstation – full SIMS/SNMS facility

SIMS-on-a-Flange – a complete SIMS analysis system on a single conflat flange

MAXIM – SIMS/SNMS analyser

EQS – surface science analyser

SIM – low cost SIMS/surface science analyser

SIMS/SNMS SYSTEMS

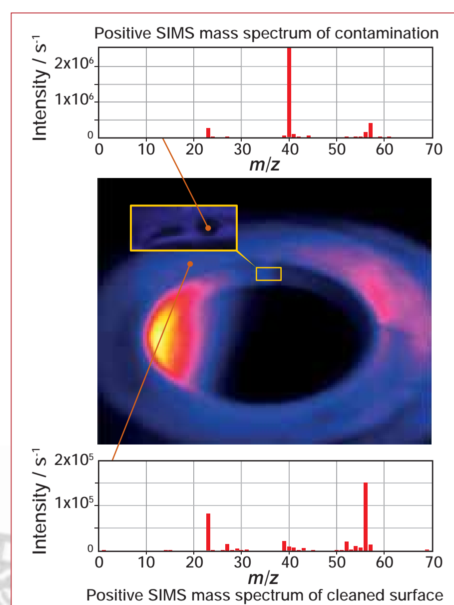
for Thin Film Surface Analysis

IG20 gas ion gun

SIMS offers very high sensitivity, PPM/PPB level contamination analysis; significantly higher in sensitivity than routine XPS analysis (for example), by several orders of magnitude

SIMS provides unrivalled performance for depth profile and interface analysis, vital in the development of coatings

SNMS uniquely offers quantitative surface analysis (for example, dopant levels)



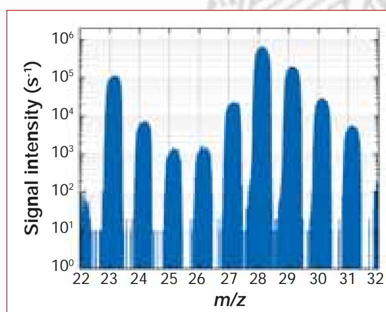
The ^{56}Fe image of a hard steel engine component shows Fe, Cr (and Na and K) on the clean surface. A mass spectrum in the region of a stain, which masks the iron signal, shows surface contamination by calcium – a bio-diesel contaminant

IG5C caesium ion gun for high sensitivity negative ion SIMS analysis of electronegative species

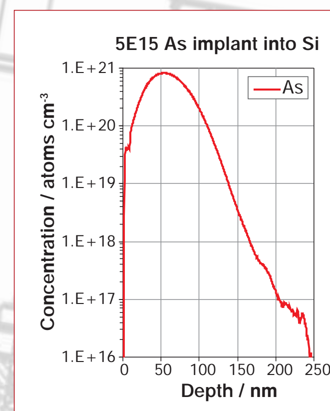
IG20 – general purpose argon/oxygen ion gun for depth profiling

IG5C – caesium ion gun for electronegative species for thin film depth profile and surface imaging analysis

Surface Analysis Systems – modular UHV grade surface analysis platforms



Dopant depth profiling – SIMS detects and quantifies semiconductor dopants and impurities with high sensitivity and accuracy making it suitable for the study of redistribution and diffusion phenomena as well as production monitoring. The analysis shown was made using 5 keV Cs^{+} primary ions from the IG5C whilst collecting $AsSi^{-}$ secondary ions



Positive SIMS mass spectrum from Si target, 5 keV Ar^{+} primary ions

HIDEN ANALYTICAL

HIDEN APPLICATIONS

Hiden's quadrupole mass spectrometer systems address a broad application range in:

Gas Analysis	Surface Science	Plasma Diagnostics	Vacuum Analysis
dynamic measurement of reaction gas streams	UHV TPD	plasma source characterisation	partial pressure measurement and control of process gases
catalysis and thermal analysis	SIMS	etch and deposition process reaction kinetic studies	reactive sputter process control
molecular beam studies	end point detection in ion beam etch	analysis of neutral and radical species	vacuum diagnostics
dissolved species probes	elemental imaging – surface mapping		vacuum coating process monitoring
fermentation, environmental and ecological studies			

quadrupoles for advanced science

Hiden Analytical Ltd.
420 Europa Boulevard
Warrington
WA5 7UN
England

Tel: +44(0)1925 445225
Fax: +44(0)1925 416518
Email: info@hiden.co.uk
Web: www.HidenAnalytical.com

© Hiden Analytical E & O E