

MASS SPECTROMETERS FOR  
THIN FILMS, PLASMA



AND SURFACE ENGINEERING

**HIDEN**  
ANALYTICAL

# MASS SPECTROMETERS

## for Thin Films and Surface Engineering

Hidden Analytical have been designing and developing the highest quality quadrupole mass spectrometer based gas analysis systems for over 25 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

## Thin Film Processing



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.

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

### CONTENTS:

**HPR-30 and RGA residual gas analysers**

**PSM and EQP plasma ion analysers**

**ESPion Langmuir probe**

**IMP-EPD end point detector for IBE/RIBE**

**XBS - MBE deposition flux rate monitor**

**SIMS systems & components**

**UHV TPD workstation**

# HPR-30 & 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.

### Products

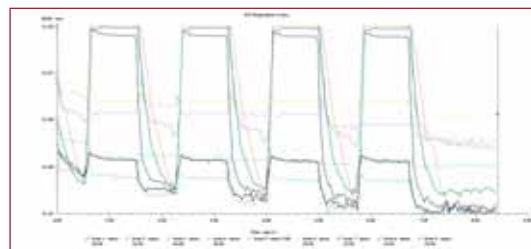
RGA Series - residual gas analysers for vacuum measurement through to fundamental scientific research.

qRGA with separation of  $\text{He/D}_2$ ,  $^3\text{He/HD/T}$  and deuterated hydrocarbons (e.g.  $\text{C}_x\text{H}_y$  and  $\text{C}_x\text{D}_y$ ) with mass range to 200 amu.

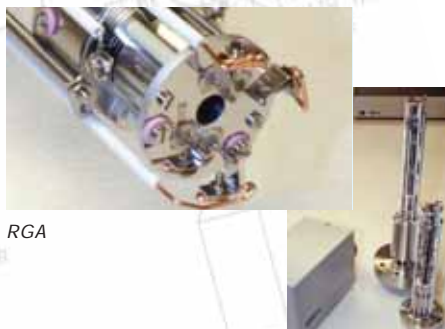
HPR-30 Series - vacuum process analysers configured for high sensitivity, fast response gas and vapour analysis of thin film deposition and etching processes: CVD, ALD, MOCVD and RIE for example.



HPR-30



HPR-30 data on TiN deposition



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**

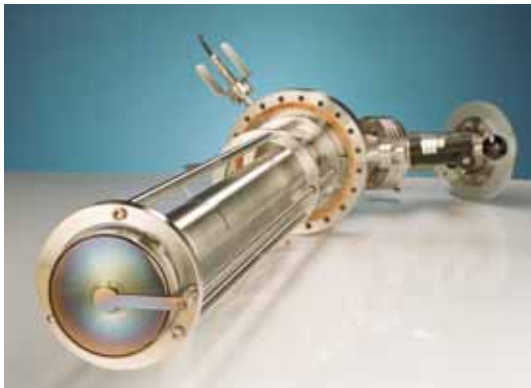
**high sensitivity RGA for UHV quality chamber base pressure measurements and leak detection**

**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 & 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.

Hidden 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.

### FEATURES/OPTIONS:

**mass and energy analysis of positive and negative ions**

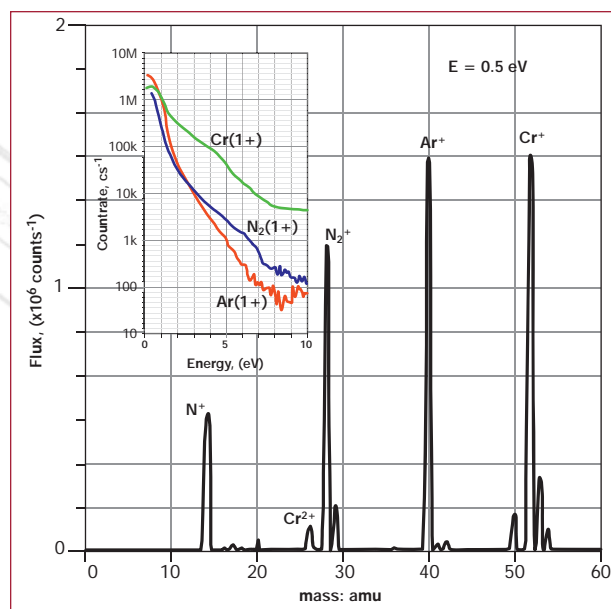
**neutrals and neutral radical analysis**

**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**



Example EQP data



# ESPion LANGMUIR PROBE

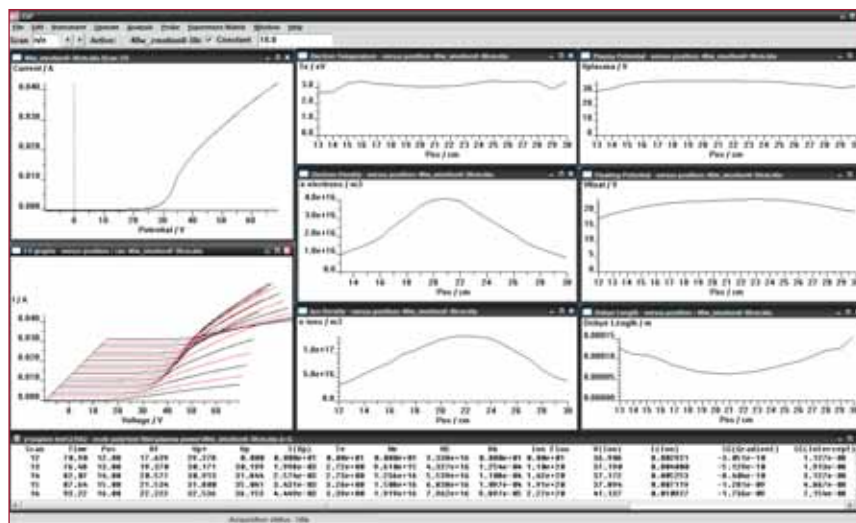
## for Measurement of Plasma Properties

The ESPion 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**



ESPion with 300 mm automatic Z-drive



ESPion data

Routine monitoring of the I-V plasma characteristic by the Hiden ESPion 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 ESPion 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.

[www.HidenAnalytical.com](http://www.HidenAnalytical.com)

### ESPION PROBES MEASURE:

**ion and electron density over the range  $10^{14} - 10^{19} \text{ m}^{-3}$**

**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.

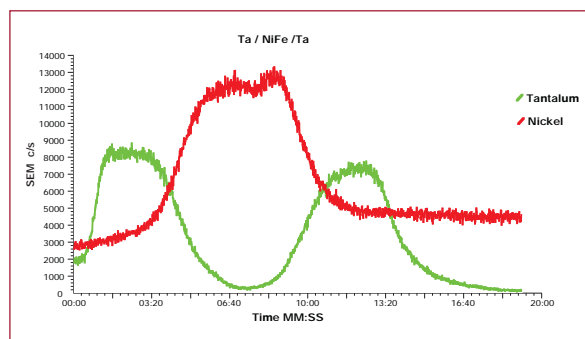
### End point controls:

Rising and falling edge algorithms

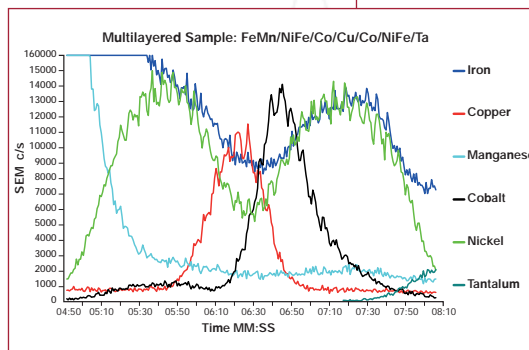
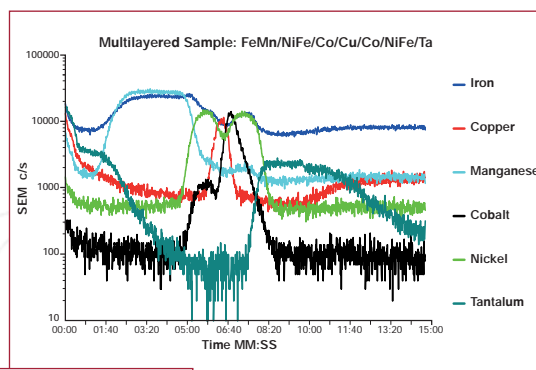
Layer counting for end point on a selected interface in a multilayered stack

Endpoint relative to a reference peak

Automatic signal correction due to wafer rotation



IMP data



### APPLICATIONS:

end point analysis

target impurity determination

quality control/SPC

residual gas analysis

leak detection

# XBS TRIPLE FILTER MS

## MBE Deposition Flux Rate Monitor

Electron beam (e-beam) sources require accurate control for reproducible production quality thin film growth.

Hidden's XBS system provides in-situ monitoring of multiple sources with real-time signal output for precise control of the deposition. The high sensitivity and fast data acquisition of the XBS system provide signals for control of growth rates from 0.01 Angstrom per second.

**MBE monitoring and control**

**Molecular beam studies**

**Multiple beam source analysis**

**High performance RGA**

**Desorption / outgassing studies / bakeout cycles**

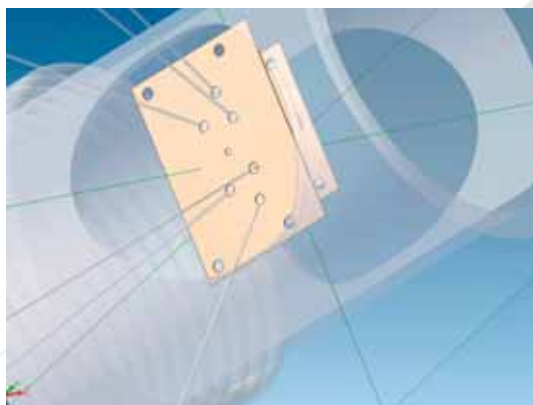
**Chamber / process gas contaminants**



*XBS probe*



*XBS probe with water-cooled shroud and z-drive*



*Integral water-cooled shroud*

### FEATURES:

**high sensitivity, enhanced detection from 100% to 5 ppb, mass range to 510 amu**

**enhanced long-term stability (less than  $\pm 0.5\%$  height variation over 24 h)**

**crossbeam ion source, beam acceptance through  $\pm 35^\circ$  to transverse axis**

**ion source control for soft ionisation and appearance potential mass spectrometry**

**enhanced sensitivity for high mass transmission**

**2 mm beam acceptance aperture – configured to specific user application**



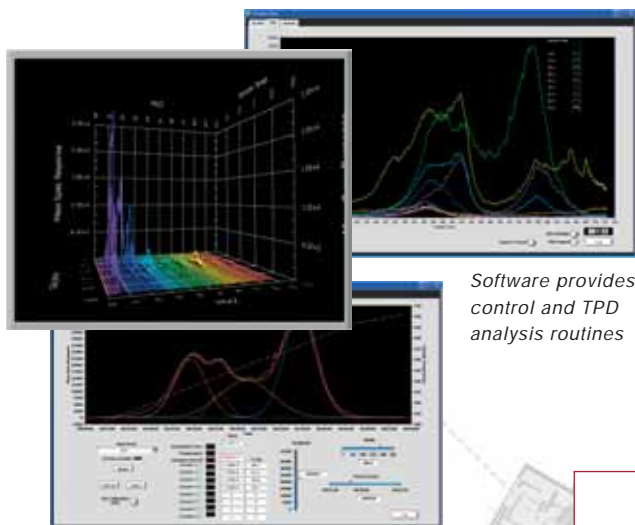
# TPD WORKSTATION

## for UHV Thermal Desorption Studies



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 liquid N<sub>2</sub> cooled shroud giving the analyser optimum sensitivity to desorption products from the sample. A fast sample load lock with sample transfer mechanism is included to provide for rapid sample change.



Software provides control and TPD analysis routines

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 etc) are also included in this package.

### 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)**

**linear 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**



TPD Workstation

# 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

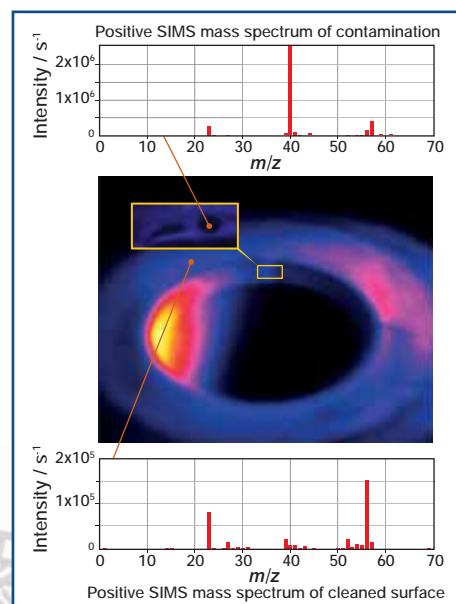


IG5C-caesium ion gun for high sensitivity negative ion SIMS analysis of electro-negative species.

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

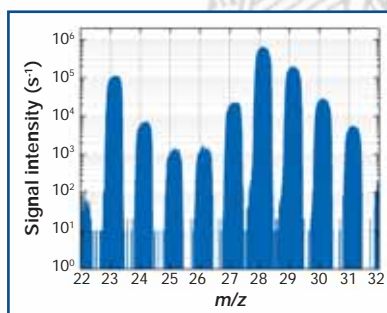
SNMS uniquely offers quantitative surface analysis (for example, dopant levels)



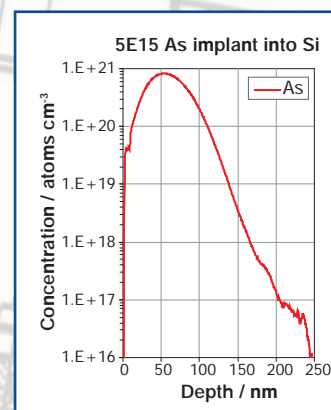
IG20 - general purpose argon/oxygen ion gun for depth profiling

IG5C - caesium ion gun for electro-negative 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<sup>+</sup> primary ions from the IG5C whilst collecting AsSi<sup>-</sup> secondary ions



Positive SIMS mass spectrum from Si target, 5 keV Ar<sup>+</sup> primary ions

## HIDEN APPLICATIONS

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

### Gas Analysis

dynamic measurement  
of reaction gas streams  
catalysis and thermal  
analysis  
molecular beam studies  
dissolved species  
probes  
fermentation,  
environmental and  
ecological studies

### Surface Science

UHV TPD  
SIMS  
end point detection in  
ion beam etch  
elemental imaging -  
surface mapping

### Plasma Diagnostics

plasma source  
characterisation  
etch and deposition  
process reaction kinetic  
studies  
analysis of neutral and  
radical species

### Vacuum Analysis

partial pressure  
measurement and  
control of process  
gases  
reactive sputter process  
control  
vacuum diagnostics  
vacuum coating  
process monitoring



quadrupoles for advanced science



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