IONOPTIKA
ion beam technology

Complete Ion Beam Systems

for all Applications

www.ionoptika.com

Overview

Since 1994, Ionoptika has gained an international reputation as a leading provider of high-performance ion beam technologies. From the development of the first carbon fullerene (C60) ion source, widely recognised as an excellent analytical sputter tool, to developing the first gold cluster ion source for secondary ion mass spectrometry (SIMS), we have always been pioneers in the field.

Today, we are a global leader in the field, producing the most advanced ion beams for TOF SIMS on the market, from our new Xe plasma beam to the unique water cluster ion beam. These remarkable tools are helping scientists around the world deliver cutting-edge research, from materials science to forensics to cancer diagnosis. We are incredibly proud to be a part of that.

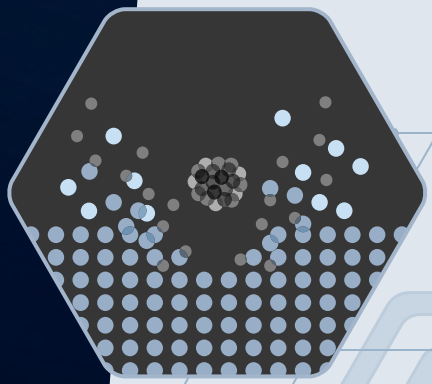
Choosing the Best Ion Beam System

Ionoptika's range of ion beams can be split into two groups based on their applications or purpose: sputter beams, and analytical beams.

Sputter Beams

Whilst all ion beams will sputter, or etch, a surface, some of our systems have been designed specifically for efficient and fast sputtering. Sputter beams have three characteristic features: high current, large spot size, and a wide field of view. This combination of features means they can deliver a large dose of ions over a wide area as quickly as possible to optimize etch rates.

Sputter beams are often used to remove material prior to analysis by a separate analytical technique, e.g., SIMS, XPS, SEM, TEM, or Auger. This can be for cleaning purposes or used as a means of depth profiling through the sample. The best ion beam for your application will depend on the type of material being sputtered; gas clusters are ideal for removing organic material, whilst a low energy oxygen beam would be best suited to depth profiling through hard, inorganic material.



Analytical Beams

The primary use of an analytical beam is for secondary ion mass spectrometry (SIMS), whereby the ion beam impinges a surface causing the ejection of secondary ions, which are then separated and analysed in a mass spectrometer.

SIMS is a powerful analytical technique that can generate incredibly complex chemical maps of a target in three dimensions. Traditionally, it has been used to study hard materials such as semiconductors and metals. However, the scope of the technique has recently expanded into biological and medical research, in part due to the introduction of Gas Cluster Ion Beams (GCIBs) for SIMS by Ionoptika.

Ionoptika offers a range of analytical ion beam systems, many of which can be fast pulsed and can therefore be used in third-party SIMS instruments.

Analytical beams have three characteristic features: wide energy range, small spot size, and variable current control. This allows fine control over the beam characteristics, enabling optimisation of the experiment.

C60 Ion Beam Systems
Overview

C60 ion beams are an extremely versatile tool, having a combination of features that make them ideal for many different applications.

Composed of sixty carbon atoms arranged into the shape of a soccer ball, the impact of a C60 ion on a surface is quite different from that of a monoatomic ion.

As the C60 molecule is larger (approx. 7 Å) than the lattice constant for most materials, it does not experience channelling the way smaller ions do. As such, C60 beams exhibit incredibly uniform sputter rates across a wide range of materials, including challenging poly-crystalline materials.

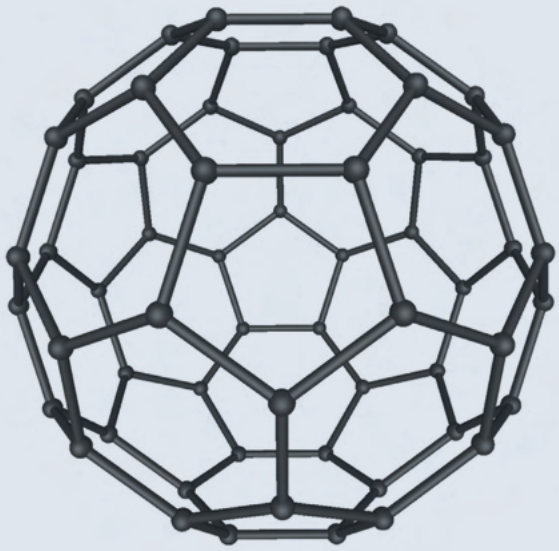
As the momentum of each individual carbon atom is extremely low, the large molecule is unable to penetrate deep into the sample and the energy of the ion is transferred to the top few atomic layers only. This results in high sputter yields, high yields of molecular ions, and low damage to the newly created surface.

C60 Sample Types

The combination of high sputter rates and low damage make C60 ion beams an extremely flexible tool and can be used for a wide range of materials including both organic and inorganic materials, semiconductors, and metals.

C60 Ion Beam Systems

The properties of C60 make it suitable for both sputtering and analysis. Ionoptika offers three C60 ion beams systems: a broad-beam sputter system – the C60-20S, and two small-spot analytical systems – the C60-20, and C60-40.



C60 Ion Beam Systems
General Information

Operation

All C60 ion beam systems operate with a similar principle. A small charge of C60 powder at the rear of the source is heated to produce C60 vapour, which then passes into the centre of an electron bombardment chamber.

The positively charged ions, which can be singly or multiply charged, are extracted, and accelerated to full voltage as they enter the column. A Wien filter separates the different ions present in the beam, and a gate valve allows the source to be vented for servicing without venting the main chamber.

Installation

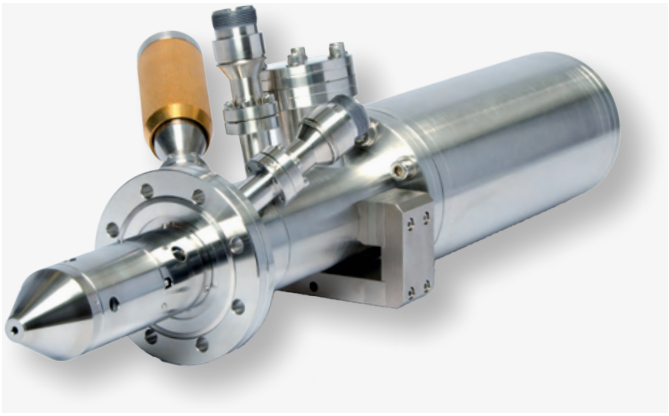
The ion beam is enclosed in a vacuum assembly which includes a gate valve for vacuum isolation of the source chamber. The C60-20 and C60-40 (but not C60-20S) also include a steering bellows for accurate alignment of the beam, and a port for differential pumping. All systems are suitable for use on ultra-high vacuum (UHV) chambers and are bakeable to 150°C.

Product and Integration Information	C60-20S	C60-20	C60-40
Principle application	**Sputtering**	**Analysis**	**Analysis**
Spot size	100 µm	2 µm	300 nm
Max scan field	4 x 4 mm	1.3 x 1.3 mm	1 x 1 mm
Energy range	5 – 20 kV	5 – 20 kV	10 – 40 kV
Max beam current	50 nA	2 nA	1 nA
Flange to nose length	142 mm	179 ± 5 mm	168 ± 5 mm
Recommended working distance	50 mm	22 ± 2 mm	22 ± 2 mm
Power supply unit	3U x 19" rack mountable unit	3U x 19" rack mountable unit	6U x 19" rack mountable unit
Electrical requirements	110-240VAC 13A 50/60Hz		
Software requirements	PC running Windows 10 or later		
Flange required for integration	DN 63 CF		

Pumping requirements

- All C60 ion beam systems are offered with an optional pumping kit comprising turbo molecular pump, dry scroll backing pump, and vacuum gauge.
- If the chamber vacuum is greater than $1x10^{-6}$ mbar additional pumping may be needed.

C60-20S



Overview

The C60-20S is a high-performance ion beam designed for sputtering surfaces with minimal damage and reduced preferential sputtering effects.

Operating at voltages up to 20 kV, the C60-20S effectively sputters material with minimal damage without redeposition of carbon.

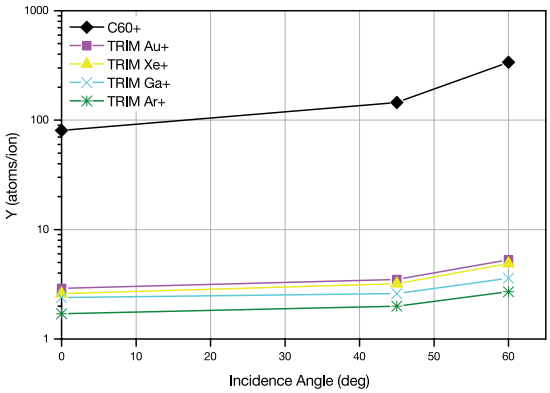
Ideal as an upgrade component for XPS, AES, and SIMS, C60 provides uniform sputtering across a wide range of materials.

Applications

High speed, low chemical damage etching of polymers.

C60 ions sputter up to 50 times faster than monatomic beams, including argon, and xenon, while causing much less damage to the underlying material. The figure below compares 15 keV C60 sputter yields against TRIM data for 15 keV gold, xenon, gallium, and argon.

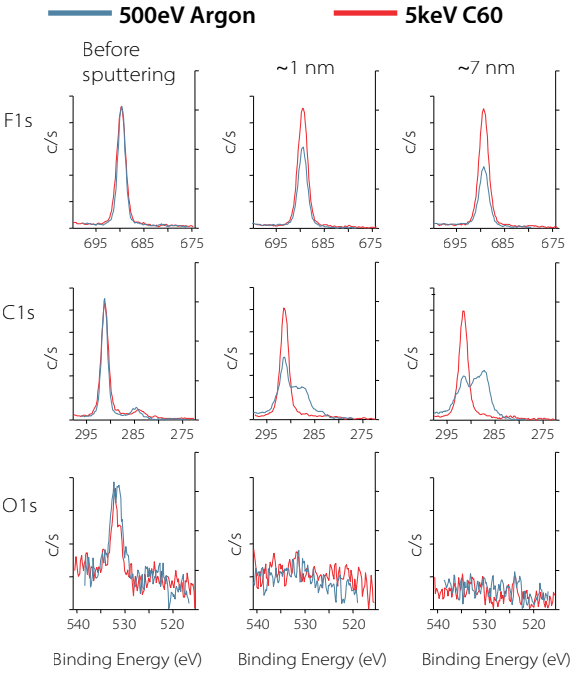
In the example shown opposite, a PTFE film is sputter-cleaned with both C60 and monatomic Ar ion beams. While both ion beams removed the surface contamination, only the C60 beam left the surface chemistry virtually unchanged.



Sputter yields of 15 keV $C60^+$ and TRIM data for 15 keV Au^+, Xe^+, Ga^+, and Ar^+.

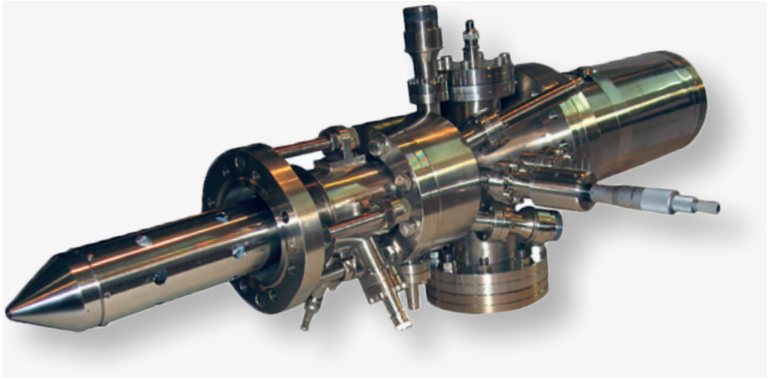
Features of the C60-20S

- High current density for faster etching.
- Reduced chemical damage over monatomic beams.
- Uniform sputter rates across different materials and crystal orientations.
- Gate valve for quick and easy servicing.
- Long lifetime source.
- Compatible with many different instruments.



Comparison of $C60^+$ and Ar^+ ion beam sputtering of PTFE.

C60-20



Overview

Ionoptika's C60-20 is a high-performance 20 kV ion beam system for SIMS analysis of samples with a high degree of chemical complexity.

The C60-20 is a powerful, cost-effective analytical ion beam system to get the most out of your SIMS analysis. With a small spot size down to 2 µm, it is suitable for a range of advanced applications.

The C60-20 is fitted with a Wien filter for mass filtering during both DC and pulsed operation. This filter allows choice of single, double, or triple charged species, giving beam energies up to 60 keV.

Features of the C60-20

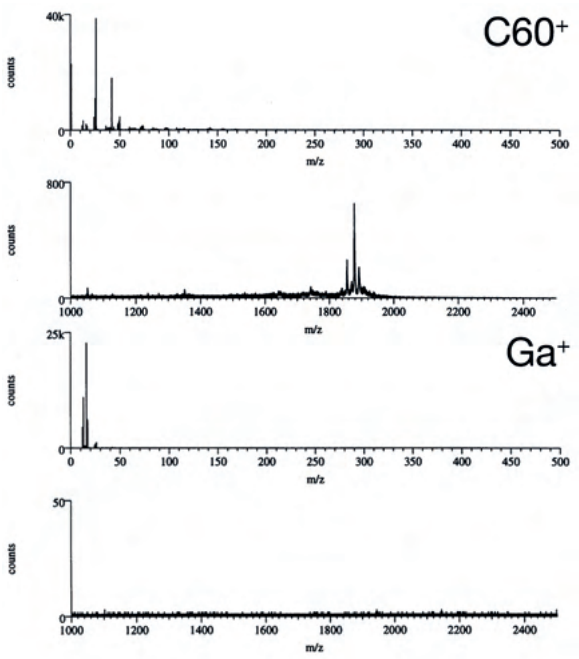
- Spot size down to 2 µm.
- High current beam up to 2 nA.
- Wien filter for mass filtering during both DC and pulsed operation.
- Provision for fast pulsing, pulse bunching, rastering, and secondary electron detection.
- Gate valve for quick and easy servicing.

Applications

The use of C60 in analysis of surfaces with large organic molecules provides high mass ion yields ranging from 20 to several thousand times the yields achieved with atomic ion beams such as Ga^+, Bi^+, or Au^+.

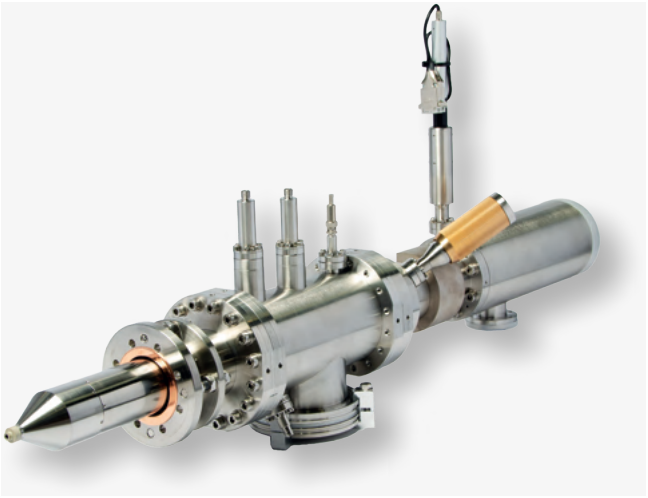
The figure opposite is a negative ToF-SIMS spectrum of Gramicidin D, a high-molecular weight peptide, using 15 kV $C60^+$ and Ga^+ ions. The ion yield with the C60 beam is enhanced by several orders of magnitude compared to Ga, even though the ion dose for C60 was 10x less than that of Ga.

The increase in signal can be seen across the full spectrum but is especially strong at higher mass where the molecular ion is observed with C60, but not for Ga.



Negative SIMS spectra of Gramicidin D under $C60^+$ and Ga^+ bombardment. Ga dose is 10x $C60^+$ dose. Data courtesy of SARC, University of Manchester.

C60-40



Overview

The C60-40 is the highest-performing C60 beam available, featuring a 300 nm spot size and beam currents of up to 1 nA.

From bio-medical applications to polymer science and metallurgy, the C60-40 can do it all. Benefiting from the same uniform sputtering as our other C60 ion beams, but with an incredibly fine spot and higher etch rates thanks to the higher beam energy, the C60-40 is an extremely powerful analysis tool for a wide range of applications.

The C60-40 is an excellent all-rounder demonstrated by the fact it is included on every J105 SIMS instrument sold by Ionoptika.

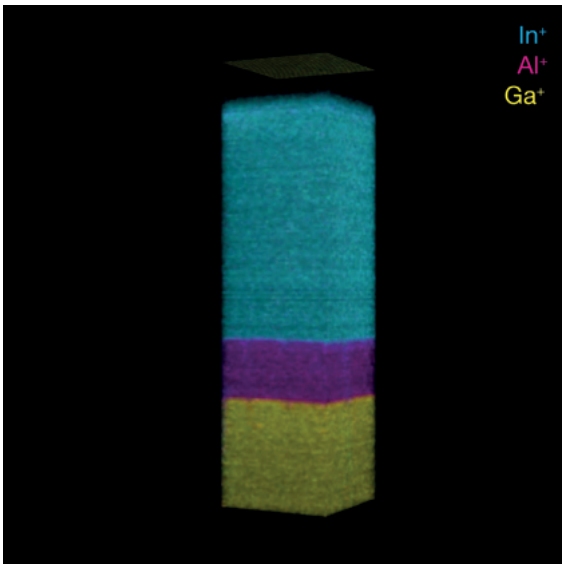
Applications

The figure opposite shows a 3D SIMS image of a semiconductor stack acquired with the C60-40 in positive ion mode. The sample consists of layers of InSb, Al, and GaAs, covered in a protective photoresist layer.

This combination of soft organic, inorganic, and hard metallic layers would prove extremely difficult for most other ion beams. The C60-40 is ideal for this tricky application due to its consistent sputter rates across different materials. Combined with a 300 nm spot size, the C60-40 is a powerful beam for delivering maximum resolution in 2D and 3D, no matter what type of sample you have.

Features of the C60-40

- Excellent all-round ion beam for SIMS analysis.
- Small spot size down to 300 nm.
- High current up to 1 nA.
- Wien filter for mass filtering during both DC and pulsed operation.
- Provision for fast pulsing, pulse bunching, rastering, and secondary electron detection.
- Gate valve for quick and easy servicing.



Gas Cluster Ion Beams
Overview

At Ionoptika, we are proud to be considered global experts in the development of Gas Cluster Ion Beams (GCIB). GCIBs are incredibly versatile ion sources and are finding an increasing number of applications in SIMS, XPS, and SEM as well as other surface science applications. Ionoptika offer GCIBs for both sputtering and analysis, but all GCIBs share the same fundamental benefits.

As the name suggests, GCIBs are composed of ionised clusters of atoms or molecules formed from a gaseous source. The size of the cluster can range from just a few hundred constituent atoms to well over 30,000, and can be formed from many different gas sources, including both inert and reactive gases.

Such large clusters means that the energy of the ion is distributed across all atoms in the cluster. This results in a very gentle sputtering effect, and almost no damage to sub-surface layers. GCIBs are extremely effective primary ion beams for SIMS as this gentle sputtering tends to remove intact molecular ions from the surface rather than fragments.

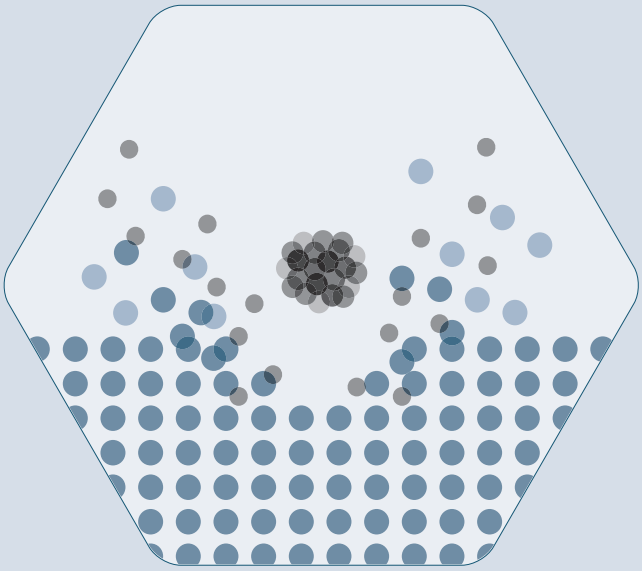
GCIBs are fast becoming a vital upgrade component for techniques such as XPS, SEM, and SIMS. Large cluster ions are most effective at sputtering soft materials such as organic tissue and polymers and provide very high-resolution depth profiles due to the lack of damage. They also etch harder materials much more slowly, which has led to their adoption as a tool for sample cleaning and removal of organic contamination prior to analysis.

GCIB Sample Types

Due to the low energy and gentle sputtering produced by GCIBs, they are perfect for soft, organic, and biological samples.

Gas Cluster Ion Beam Systems

Ionoptika produce three variants of GCIB: a broad beam sputtering system – the GCIB 10S, and two high energy analysis beams – the GCIB 40 and GCIB 70. A Water Source upgrade is also available for the GCIB 40/70.



Gas Cluster Ion Beams
General Information

Operation

Clusters are formed as high-pressure gas (~ 18 bar) expands into vacuum (~10^{-2} mbar) through a small nozzle, where it expands adiabatically, cools, and then condenses into clusters. A jet of neutral clusters is formed, which pass through a series of apertures into a region of high vacuum where they are ionised through electron bombardment.

The clusters formed will have a distribution of sizes, the average of which will depend on various parameters including the type of gas used, gas pressure, as well as ionisation conditions. The cluster distribution can be further controlled using the Wien filter.

A range of gases can be used in the GCIB, the most common of which are Ar, CO_2, and an Ar/CO_2 mix. A special water cluster source is also available as an upgrade for the GCIB 40 and GCIB 70 that allows H_2O vapour to be used.

Installation

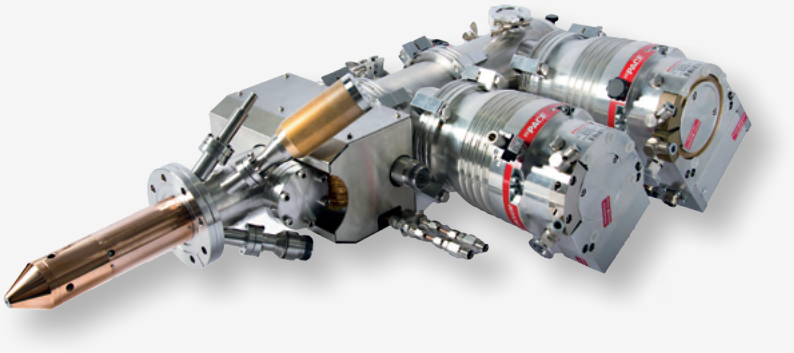
All GCIBs require a water chiller with > 50 l/hr flow rate, with cooling power of 500 W and 750 W for the GCIB 10S and GCIB 40/70 respectively. A 2-stage precision regulator up to 22 bar is required for input gas. Gas purity ~ 99% is recommended.

Product and Integration Information	GCIB 10S	GCIB 40	GCIB 70
Principle application	**Sputtering**	**Analysis**	**Analysis**
Spot size	250 µm	3 µm	1.5 µm
Max scan field	7.5 x 7.5 mm	0.9 x 0.9 mm	500 x 500 µm
Energy range	1 – 10 kV	10 – 40 kV	20 – 70 kV
Max beam current	60 nA	200 pA	300 pA
Flange to nose length	142 mm	168 ± 5 mm	157 ± 5 mm
Recommended working distance	50 mm	25 mm	25 mm
Power supply unit	3U x 19" rack mountable unit	6U x 19" rack mountable unit	9U x 19" rack mountable unit
Electrical requirements	110-240VAC 13A 50/60Hz		
Software requirements	PC running Windows 10 or later		
Flange required for integration	DN 63 CF		

Pumping requirements

- GCIBs require extensive pumping due to the high gas loads, particularly in the cluster formation region. As such, all GCIBs are supplied with a dedicated pumping kit including turbo molecular pumps, dry scroll backing pumps, and vacuum gauges.

GCIB 10S



Overview

The GCIB 10S is a high-performance 10 kV gas cluster ion beam for rapid, low-damage sputtering and superior quality surface analysis.

The GCIB 10S offers a host of useful features including real-time cluster size measurement and a built-in sample current imaging system, to help you get the most out your experiment.

With a complete pumping system and stand-alone software, the GCIB 10S is a bolt-on upgrade that brings the power of cluster beam sputtering to existing vacuum instrumentation such as XPS, SEM, and SIMS.

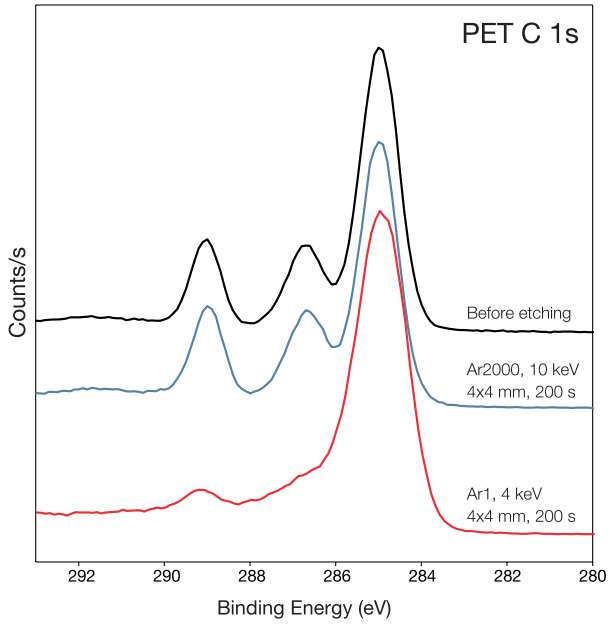
Applications

The GCIB 10S removes adventitious carbon and other surface contamination without damaging the substrate, while also providing damage-free depth profiling of soft materials such as organics and polymers.

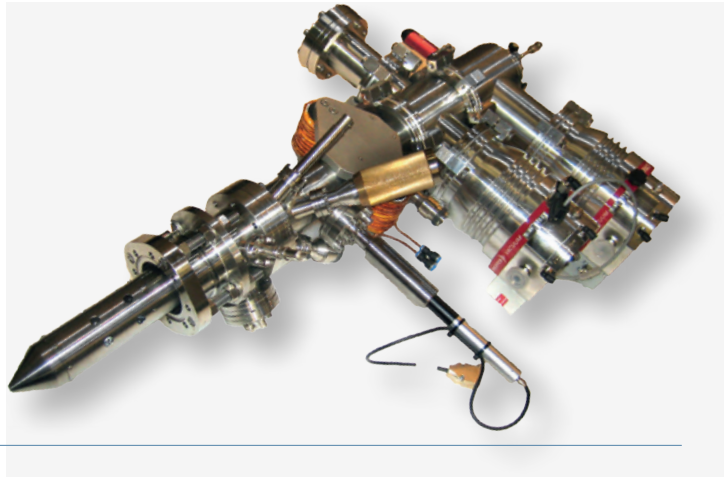
The figure opposite shows the C 1s peak before and after etching of a pristine PET surface with Ar1 and Ar2000 respectively. The data clearly shows chemical damage caused by the monatomic Ar beam (red), while the spectrum remains virtually unchanged after exposure to the Ar2000 beam (blue).

Features of the GCIB 10S

- 10 kV argon cluster ion source with selectable clusters from Ar1 to > Ar3000.
- Real-time cluster measurement & adjustment.
- Sample current imaging.
- Large spot size and wide scan field for even removal of material.
- Easy installation on many high-vacuum instruments.
- Standalone software and web-socket based API for integration with third party software.



GCIB 40



Overview

The GCIB 40 is a 40 kV gas cluster ion beam producing a focused beam of cluster ions for analytical applications where sensitivity to molecular ions is required.

GCIBs are unrivalled in their ability to minimise fragmentation and remove intact molecules from a surface. The GCIB 40, operating at 40 kV delivers excellent ionisation yields, enhancing the molecular signal even further.

Featuring selectable cluster sizes from monomer to over 10,000, and a spot size down to 3 µm, the GCIB 40 is a powerful tool for analysing intact molecular ions with high spatial resolution.

Available on the J105 SIMS or as an upgrade to selected third-party instruments. Contact us for more information.

Applications

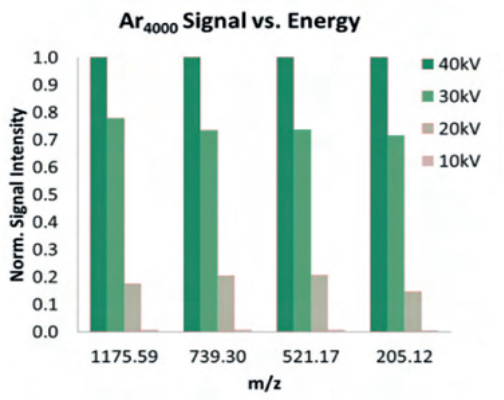
SIMS analysis of organic samples often results in fragmentation due to the ion beam and loss of molecular signal. With a GCIB, the damage is reduced so that the material can be analysed and depth profiled.

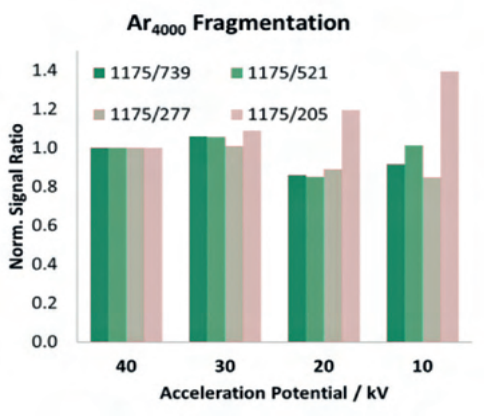
However, at lower beam energies (< 40 kV) the secondary ion yield of GCIBs can be low. Operating at higher energies results in a much higher yield of secondary ions, while still maintaining the low damage characteristic.

The figure opposite shows how the ion yield scales with beam energy when analysing an organic sample. Despite keeping the primary ion dose constant, the secondary ion signal from an Irganox 1010 thin film increases by more than five times going from 20 kV to 40 kV primary beam energy. Meanwhile the fragmentation remains virtually unchanged across all beam energies.

Features of the GCIB 40

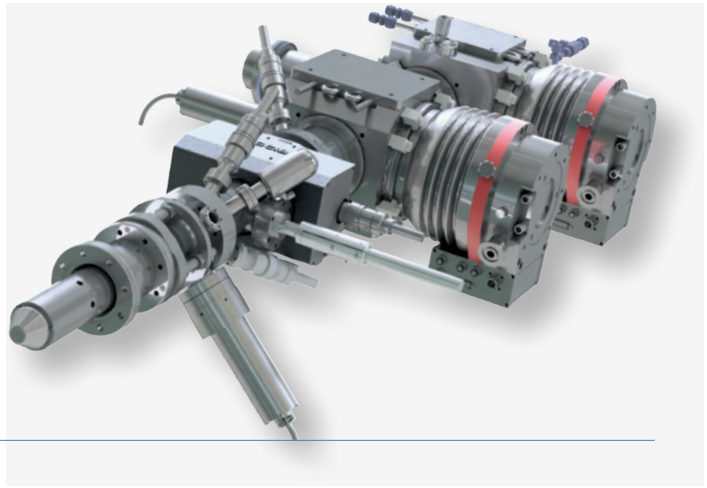
- 40 kV gas cluster ion beam with 3 µm spot size.
- Real-time cluster measurement & adjustment.
- Selectable clusters from monomer to > 10,000.
- Runs on a range of gases, including Ar, CO_2, Ar/CO_2 mix.
- Water source upgrade available.





Data courtesy of Prof. John Fletcher, University of Gothenburg

GCIB 70



Overview

The GCIB 70 is a 70 kV high-performance gas cluster ion beam producing a highly focused beam of cluster ions for high-resolution imaging SIMS with unrivalled sensitivity.

The benefits of gas cluster beams for use in SIMS are now well established; high-mass clusters are extremely efficient at sputtering organic, biological, and polymeric materials, producing high yields of intact molecular ions.

Until now, however, spatial resolution of these beams was limited to several microns. The GCIB 70 now delivers the highest resolution available with gas clusters, focusing a beam of cluster ions down to just 1.5 µm.

The GCIB 70 is available exclusively on the J105 SIMS from Ionoptika.

Features of the GCIB 70

- 70 kV gas cluster ion beam with 1.5 µm spot size.
- Selectable clusters from monomer to > 10,000.
- Runs on a range of gases, including Ar, CO_2 , Ar/CO_2 mix.
- Water source upgrade available.
- Available exclusively on the J105 SIMS.

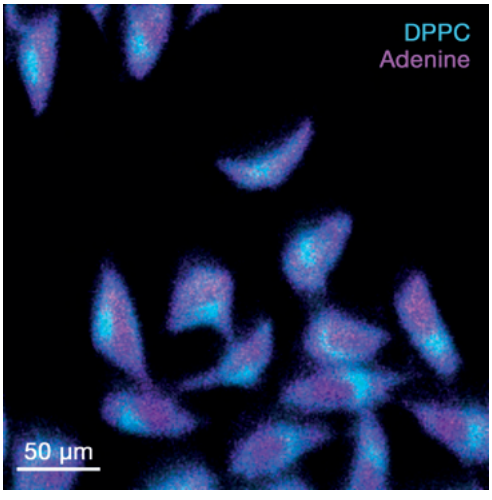
Applications

Single Cell Imaging SIMS with GCIB

High spatial resolution GCIB SIMS analysis enables subcellular imaging of intact molecules on a single cell level.

The figure opposite shows intact DPPC (cyan) and adenine (magenta) signals inside individual HeLa cells, taken at 1 µm per pixel with a 50 kV $(CO_2)_{5000^+}$ beam on the J105 SIMS.

This image was taken as part of a series during which the surface of the cells was gradually etched away, revealing the nuclear material within. This is only possible because of the powerful combination of high-sensitivity and low-damage nature of the GCIB.



Single cell imaging with the GCIB 70. Data courtesy of Dr Hua Tian, Pennsylvania State University.

Liquid Metal Ion Beams
Overview

Liquid metal ion sources (LMIS) are perhaps the best-known type of ion source, having been widely used in focused ion beam (FIB) columns for decades. LMIS produce beams of monatomic ions such as Au^+ and Ga^+, or small cluster ions such as Au_3^+. They are characterised by very small spot sizes (< 100 nm) and high beam currents. This makes them ideal for applications such as ToF SIMS and FIB micromachining.

The small, highly energetic ions can penetrate, or channel, far beneath the surface before dissipating their energy. This can be beneficial but does cause significant sub-surface damage, and as such depth profiling with these ion beams is generally not possible. It also results in significant fragmentation of molecules, which limits the application of liquid metal ion beams to the analysis of monatomic and small molecular ions in techniques such as SIMS.

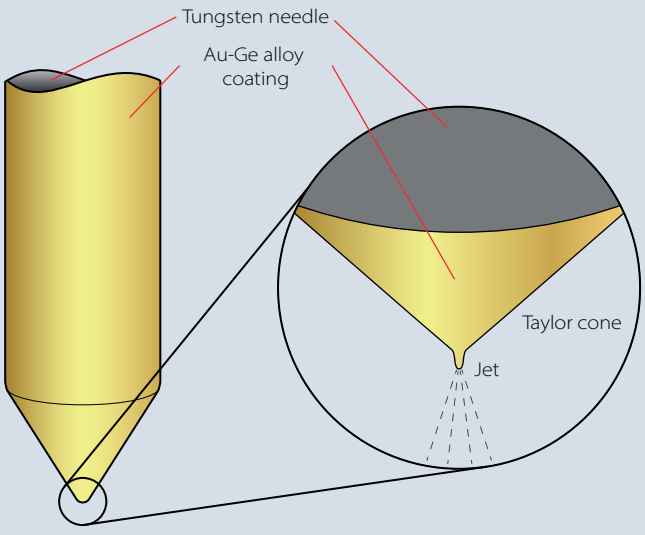
LMIS operate by a reservoir of liquid metal, or liquid metal alloy, feeding a blunt metal tip, from which ions are extracted by a strong electric field. The source design is elegant and reliable and has been used in FIB systems for decades.

LMIS Sample Types

Due to the high energy and small spot sizes, liquid metal ion beams are best suited to the analysis of hard surfaces such as metals, semiconductors, and inorganic materials.

LMIS Ion Beam Systems

Ionoptika offer a 25 kV LMIS ion beam system in two variants: the IOG 25Au gold-cluster system, and the IOG 25Ga gallium system, while new LMIS for a wider range of elements are also in development. Please contact us to discuss new source species that may be available.



Ion emission from a liquid metal ion source.

Liquid Metal Ion Beams
General Information

Operation

In liquid metal ion beams, a reservoir of liquified metal feeds a blunt tungsten needle creating a thin coating. An electric field then forms the liquid metal into a Taylor cone at the tip of the needle from which the ions are emitted. An LMIS ion beam system consists of the relevant liquid metal ion source and a high precision two-lens ion optics assembly.

A Wien filter, if available, allows selection from multiple ion species, including double and triple charged ions and clusters. The variable aperture allows control over current and spot size and is available in both manual and motorised versions.

The IOG 25 can be operated in either collimated mode or crossover mode, in which an intermediate field image is produced between the lenses. In this mode it can be set up for minimum motion blanking for TOF-SIMS. The crossover mode can also be used in DC operation as a variable probe current mode, controlling the beam current by moving the intermediate image along the optical axis.

Installation

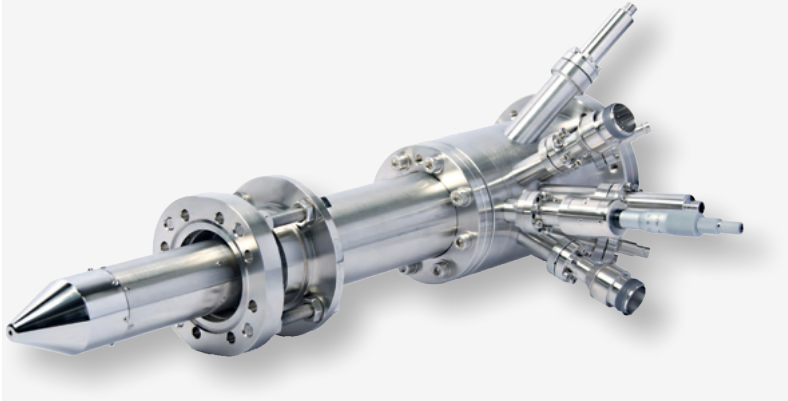
The IOG 25 has a compact design and is differentially pumped to facilitate installation on a range of instruments. Extension of the nose cone length as well as other modifications are available. Please contact sales@ionoptika.co.uk to discuss your requirements.

Product and Integration Information	IOG 25Au	IOG 25Ga
Principle application	**Analysis**	**Analysis**
Spot size	100 nm	50 nm
Max scan field	1 x 1 mm	1 x 1 mm
Energy range	5 – 25 kV	10 – 25 kV
Max beam current	10 nA	20 nA (option for 50 nA)
Flange to nose length	188 ± 7 mm	170 mm
Recommended working distance	25 mm	25 mm
Power supply unit	6U x 19" rack mountable unit	
Electrical requirements	110-240VAC 13A 50/60Hz	
Software requirements	PC running Windows 10 or later	
Flange required for integration	DN 63 CF	

Pumping requirements

- All LMIS ion beam systems are differentially pumped, and are offered with an optional pumping kit comprising turbo molecular pump, dry scroll backing pump, and vacuum gauge.

IOG 25Au



Overview

The IOG 25Au is a 25 kV high-performance liquid metal ion beam system that provides a focused beam of gold ions.

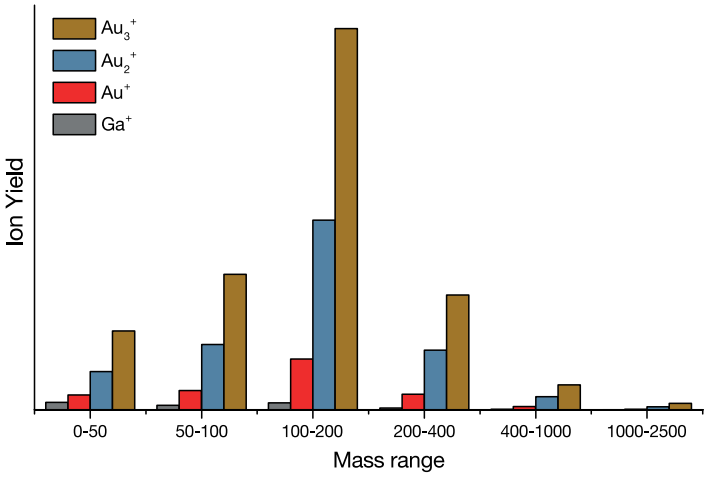
Fitted with a gold-germanium liquid metal alloy ion source, a range of ions can be selected using the built-in mass filter, including Au^+, Au^{++}, Au_2^+, and Au_3^+.

The IOG 25Au offers a wide current range with fine probe capability down to 100 nm, and can be operated in either DC or pulsed mode. It is also differentially pumped for use in a wide range of instruments and applications.

Applications

In static SIMS, a gold cluster ion beam significantly improves yields of secondary ions compared with lower mass primary ions such as gallium or argon.

The figure below demonstrates that gold and gold cluster beams show a progressive increase in ion yield with increasing mass of the ion – all of which are superior to a gallium primary beam. In the 1000-2500 mass range, Au_3^+ shows 75 times the yield achieved with gallium.

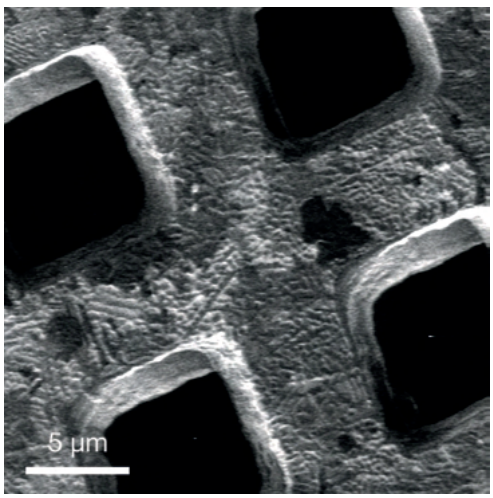


Comparison of ion yields from a thin film of low molecular weight polystyrene.

Features of the IOG 25Au

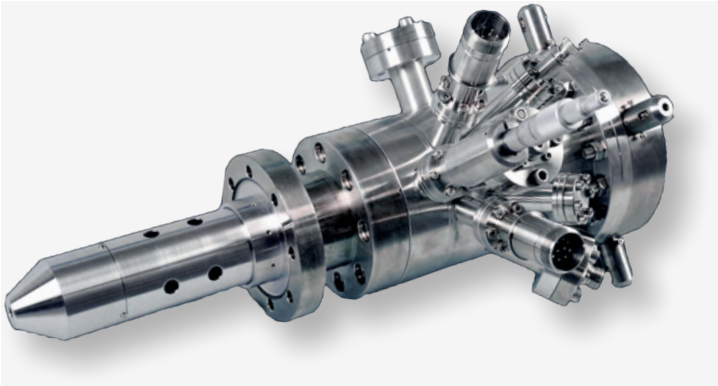
- Gold-germanium liquid metal alloy ion source.
- Spot size down to 100 nm.
- Wien filter for selection of different species.*
- Mass filtered beam available in both DC and pulsed mode.
- Variable aperture for current and spot size control.

**Species as % of beam current are Au^+ 58.9%, Au^{++} 16.2%, Au_2^+ 6.4%, Au_3^+ 4.3%, Au_3^{++} 1.4%*



Secondary electron image of a 12.5 µm pitch copper grid.

IOG 25Ga



Overview

The IOG 25Ga is a 25 kV high-performance liquid metal ion beam system that provides a highly focused beam of gallium ions.

A wide current range makes the IOG 25Ga ideal for a variety of applications, from high precision direct write and micromachining to large area quadrupole SIMS.

In the lower current range, beam spot sizes less than 50 nm are achievable.

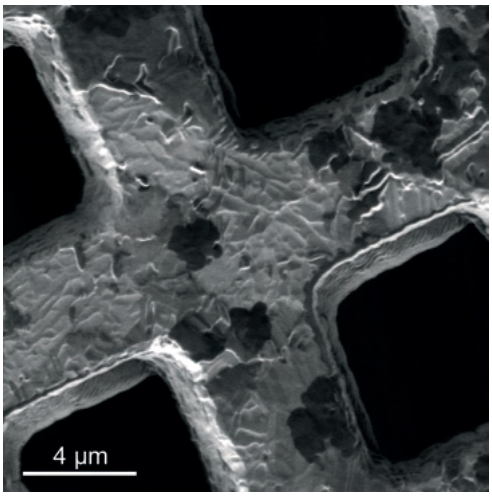
Applications

The IOG 25Ga gives excellent spatial resolution throughout its current range, from micron performance at over 10 nA of beam current to below 50 nm in low current mode. Note that small spot performance requires a stable instrument platform with suitable isolation from vibration.

The figure opposite is a secondary electron image of a 12.5 µm pitch copper grid, showing features below 50 nm across at a 25 mm working distance. A larger scan field can be achieved with a ± 200 V scan at greater working distances.

Features of the IOG 25Ga

- Sub 50 nm spot size.
- High current option up to 50 nA.
- High speed pulsing option.
- Pulse bunching option, for short intense pulses.
- Compact design to allow installation on a wide range of instruments.
- Available with both standard and monoisotopic gallium sources.



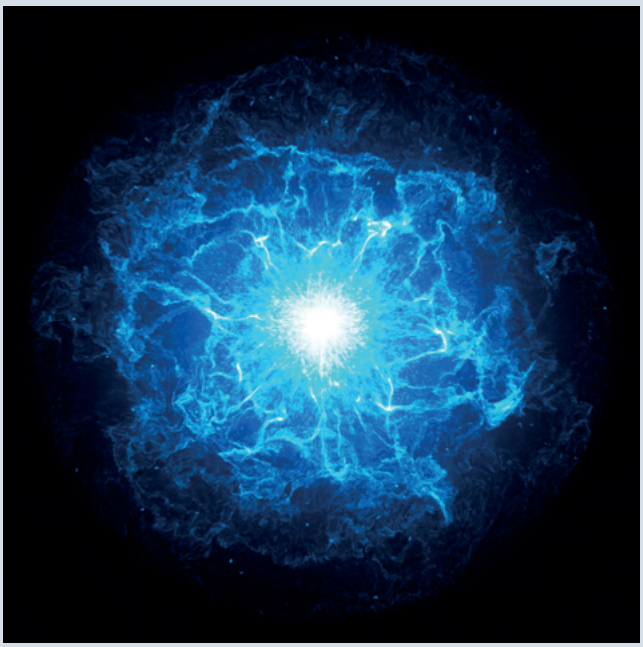
Secondary electron image of a 12.5 µm pitch copper grid.

Plasma Ion Beams Overview

Plasma ion sources are extremely bright ion sources, capable of delivering hundreds of nanoamps at the sample. This makes them ideal for etching/milling through material very quickly.

A single plasma source can run on a range of different gases without needing to change parts, as would be the case for other types of ion source. Gas sources available for our plasma ion beams include hydrogen, helium, oxygen, nitrogen, argon, and xenon.

Ionoptika offer two types of plasma ion beam system – Duoplasmatrons (comprising the IOG 30D and FLIG 5), and an Electron Cyclotron Resonance (ECR) source, the IOG 30ECR. The type of ion beam system advised will depend upon the application and the specifications required.



Duoplasmatron source

In a duoplasmatron source, ions are generated as gas is slowly fed into an arc chamber where it ignites as plasma. The plasma is then extracted and focused through the column. The nature of the source allows for many different source gases to be used.

Electron Cyclotron Resonance (ECR) source

An ECR source generates plasma by an RF field superimposed on a static magnetic field that ionises the gas molecules. ECR ion sources offer a low powered alternative to the duoplasmatron. They also have the distinct advantage of having no consumable or wearing parts, meaning that stable ion beams can be maintained for prolonged periods.

Plasma Ion Beam Sample Types

Plasma beams are an excellent choice for etching or milling through a wide range of materials. For analysis purposes, plasma beams are best suited for hard materials such as metals, semiconductors, and inorganics.

Plasma Ion Beam Systems

Ionoptika have three plasma ion beams available: an ultra-low energy beam – the FLIG 5; a 30 kV duoplasmatron beam – the IOG 30D, and a 30 kV ECR system – the IOG 30ECR.

Plasma Ion Beams
General Information

Operation

All systems use a two-lens ion optical column to produce a high-brightness, low-aberration spot. The FLIG 5 however utilises a floating column design to deliver high current densities at ultra-low impact energies.

All three systems will run on pure argon (or other noble gases), nitrogen, or oxygen, and a mass filter is included to separate beams of different mass/charge species.

Note that the IOG 30D and FLIG 5 are configured by default with electrodes suitable for use with oxygen.

Use of other gases will require different electrodes, so please discuss your anticipated use with us prior to purchase.

Installation

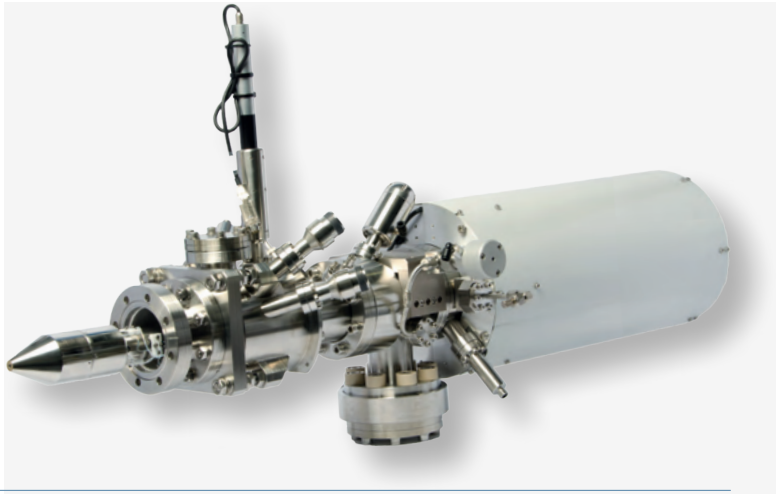
All systems include a 2° bend to reject neutrals in the beam. As such, the lower column projects into the instrument chamber off centre by ~ 6 mm. This should be considered when integrating the ion beam system. Gas purity of 99.999% is recommended.

Product and Integration Information	IOG 30D	FLIG® 5	IOG 30ECR
Principle application	**Analysis**	**Analysis**	**Analysis**
Spot size	500 nm	15 µm	300 nm
Max scan field	1 x 1 mm	1 x 1 mm	1 x 1 mm
Energy range	5 – 30 kV	0.2 – 5 kV	5 – 30 kV
Max beam current	500 nA	500 nA	200 nA
Flange to nose length	157 mm	188 mm	157 mm
Recommended working distance	22 ± 4 mm	18 mm	22 ± 4 mm
Power supply unit	6U x 19" rack mountable unit	3U x 19" rack mountable unit	6U x 19" rack mountable unit
Electrical requirements	110-240VAC 13A 50/60Hz		
Software requirements	PC running Windows 10 or later		
Flange required for integration	DN 63 CF		

Pumping requirements

- All Plasma ion beam systems require differential pumping and are offered with an optional pumping kit comprising turbo molecular pump, dry scroll backing pump, and vacuum gauge.

IOG 30D



Overview

The IOG 30D is a high-brightness focused ion beam system for contaminant free micro-machining and analysis of small areas. It uses a duoplasmatron ion source and two-lens optical column to produce a high-brightness, low-aberration spot.

The source may run on pure argon (or other noble gases), nitrogen, or oxygen, and a mass filter is included in the column to separate beams of different mass/charge species. A gate valve in the column allows the source to be serviced without venting of the whole column.

The system operates from 5 kV up to 30 kV, with a maximum beam current of more than 500 nA into a beam diameter less than 10 µm. A selection of five adjustable apertures allows control of beam current across a wide range.

Applications

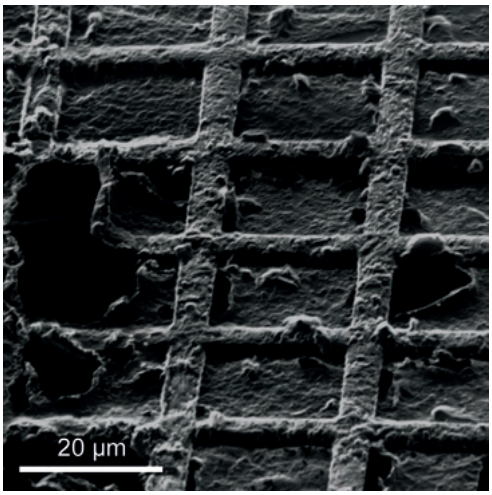
The IOG 30D is designed for retrofitting to vacuum chambers of electron microscopes or SIMS instruments. The high brightness source provides gallium free milling capabilities with a range of gas sources.

The figure opposite demonstrates SED imaging with a 30 kV He^+ beam, 50pA, achieving 100 nm spatial resolution.

The IOG 30D is especially useful for SIMS applications when running O_2, as the reactive ion species can strongly enhance positive secondary ion yields.

Features of the IOG 30D

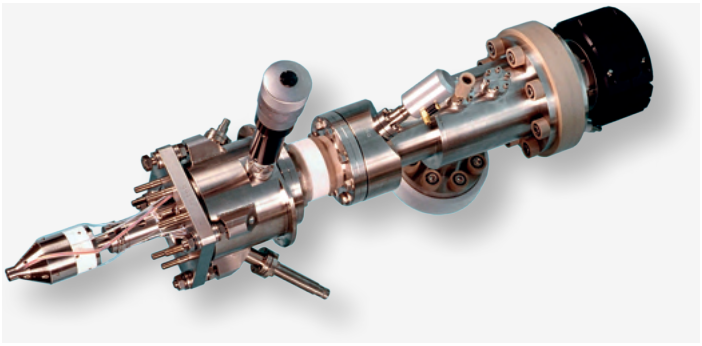
- 30 kV high brightness duoplasmatron source.
- 500 nA maximum current.
- 500 nm spot size.
- Integrated mass filter.
- Gate valve for safe venting of the source.
- Runs on H_2, He, O_2, N_2, & Ar.



Secondary electron image of a 25 µm pitch copper grid using a 30 kV He^+ beam, achieving a spatial resolution of 100 nm. Image courtesy of National Institute for Materials Science, Japan.

FLIG® 5

(Floating Low Energy Ion Gun)



Overview

The FLIG 5 is a unique ion beam that delivers extremely low energy operation down to 200 V, while still delivering high current, and is recommended for applications where ultimate depth resolution is required.

Unlike most ion beams which show poor performance at lower beam energies, the FLIG 5 has a floating column which transports ions at high energy prior to deceleration in the final lens. This enables it to deliver a probe of high current density at beam energies as low as 200 V.

Operating at such low impact energies greatly reduces the penetration depth of the beam and minimises the effects of beam induced atomic mixing, making the FLIG 5 one of the most powerful tools for ultra-high resolution depth profiling.

Applications

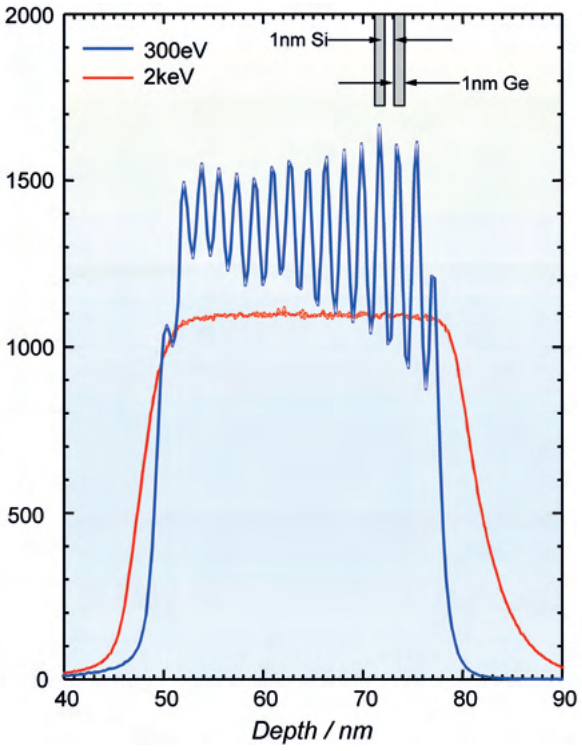
To achieve high depth resolution in dynamic SIMS without sacrificing erosion rate, the bottom of the analysis crater must remain flat throughout the profile. Reducing the extent of the crater curvature also allows the use of smaller scan fields and hence shorter analysis time.

The FLIG's floating column design reduces beam spread in the column and associated aberrations in the final probe, resulting in sub-nanometre depth resolution with high dynamic range.

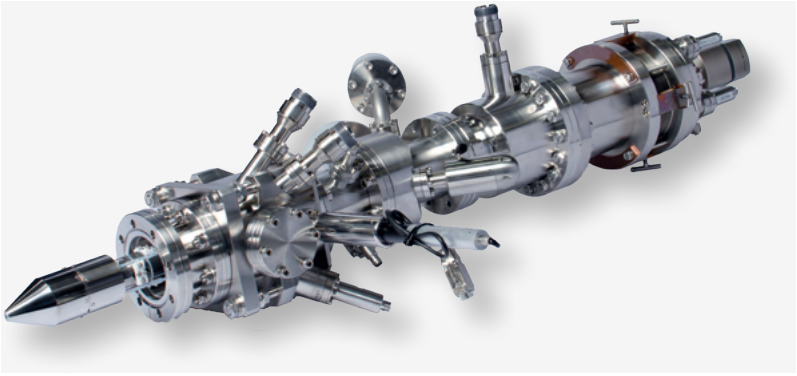
The depth resolution capability is demonstrated opposite with profiles of a Si-Ge superlattice. Grown by molecular beam epitaxy, this structure has alternating 1 nm layers of Si and Ge. The low energy profile shows a 45% valley between Ge peaks 14 and 15, showing the feature to be easily resolved.

Features of the FLIG 5

- 200 V – 5 kV beam energy range.
- High erosion rates even at low energy.
- Wien filter for mass selection.
- Gate valve for safe and easy venting of the source.
- Runs on H_2, He, O_2, N_2, & Ar.



IOG 30ECR



Overview

The IOG 30ECR is a low-power, high-performance plasma ion beam sytem for FIB and SIMS applications. The high brightness ion source produces a high current density beam for fast and efficient milling, without the need for water cooling.

The ECR source operates at powers as low as 1.5 watts, meaning minimal heat generation and a much smaller package.

The lack of consumable or wearing parts in the source mean that stable ion beams can be maintained for long periods.

The IOG 30ECR may run on pure argon (or other noble gases), nitrogen, or oxygen, and a mass filter is included in the column to separate beams of different mass/charge species. A selection of 5 apertures allows a wide current range.

Features of the IOG 30ECR

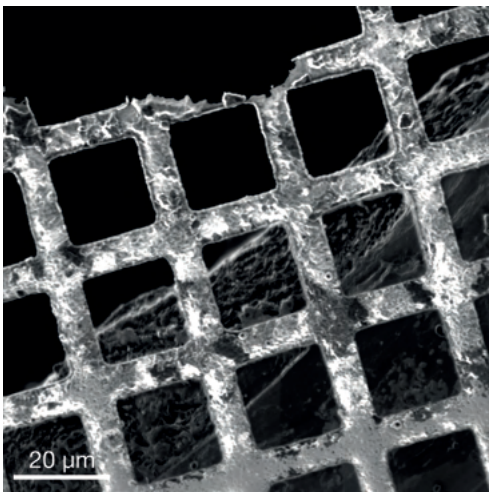
- 30 kV high-brightness ECR Source.
- 200 nA maximum current.
- 300 nm spot size.
- Low-power ion source – no need for water cooling.
- Integrated mass filter.
- Long service intervals and low maintenance.
- Runs on N_2, O_2, Ar, & Xe.

Applications

The IOG 30ECR is ideal for applications that require Ga free FIB milling and where high etch rates are required, such as large area milling and analysis applications such as SIMS.

Xenon beams have significantly higher sputter rates than lighter elements such as Ga. In addition, the high brightness of the ECR source allows much higher current densities to be used than would be possible with a LMIS, even at small spot sizes. This combination allows the IOG 30ECR to mill through material much faster than any traditional Ga FIB system.

The IOG 30ECR is suitable for retrofitting to vacuum chambers of electron microscopes or SIMS instruments.

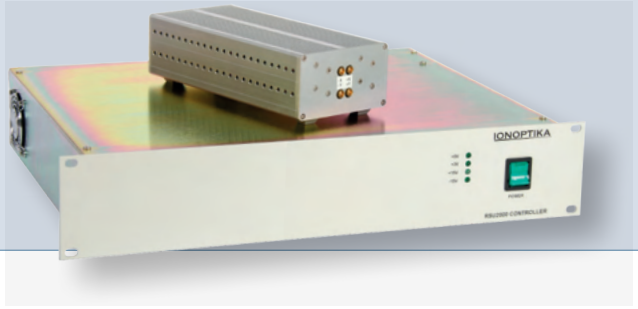


Secondary electron image of a 25 µm pitch copper grid using a 30 kV Xe^+ beam, achieving a spatial resolution of 160 nm.

IGM 300 Imaging System

The IGM 300 is a complete charged particle detection and imaging system. Featuring beam rastering, a high dynamic range secondary electron/ion detection system, and dedicated software with a range of advanced features, the IGM 300 is a must-have accessory to your ion beam system.

The IGM 300 comprises the RSU 2000 raster scanning system and SED03 secondary electron/ion detector, both of which may also be purchased separately.



RSU 2000

The RSU 2000 is a fully integrated beam scanning control package, designed for use in conjunction with ion or electron beam systems for imaging, micromachining, and lithography.

Key Features:

- Provides scan outputs with a wide range of frame rates and pixel densities.
- Drives up to 3 scan outputs with independent control over offset, gain, and rotation.
- Digital communication with a remote scan amplifier eliminates noise pick-up associated with analogue ramp outputs.
- Easily interfaces with third party equipment.

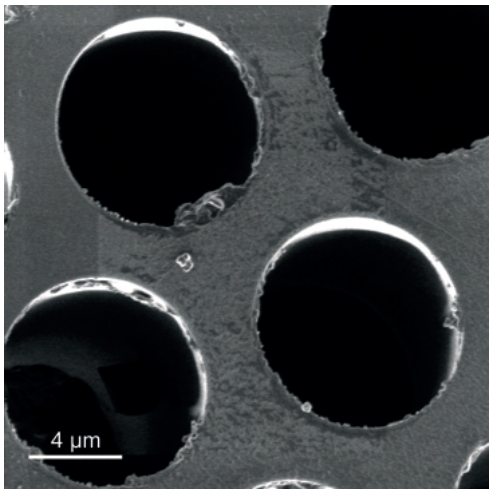
IGM 300 Specifications	RSU 2000
Communications	Connection to PC via USB
Power supply unit	2U x 19" rack-mountable chassis
Electrical requirements	110-240VAC 13A 50/60Hz
Software requirements	PC running Windows 10 or later

SED 03

The SED 03 is a high-gain channeltron-based system for the detection of secondary electrons or ions, providing an amplified signal suitable for feeding into an image display system. The system comprises an SED, pre-amplifier, power supply, and cables.

Key Features:

- High gain, low noise electron multiplier.
- Slim detector assembly with customisable lengths.
- Electron & ion detection modes.
- Anti-aliasing filters, black level clamping, and auto gain control ensure a stable and optimised video signal.
- Current meter complete with auto ranging.



Secondary electron image of a 10 µm microchannel plate, acquired with the IGM 300 driving the IOG 25Ga.

IGM 300 Specifications	SED 03
Flange to nose length	148 ± 9 mm
Vacuum flange	DN 35 CF
Communications	Connection to PC via RS-232
Power supply unit	2U x 19" rack-mountable chassis
Electrical requirements	110-240VAC 13A 50/60Hz
Software requirements	PC running Windows 10 or later

IOE 10 Electron Beam

The IOE 10 is a low energy electron beam designed for charge neutralisation during analysis of insulating materials. It supplies a high current density beam of electrons over a wide range of beam energies, from 10 to 1000 eV.

The low energy range is suitable for reducing electron stimulated desorption (ESD) of ions from the surface, which is known to fall off as the energy drops below 40 eV. Use of low energy electrons also reduces localised heating of the sample surface.

Specifications	
Energy range	10 – 1000 V
Current density	0.2 mA cm^{-2} @ 10 V 500 mA cm^{-2} @ 1 kV
Communications	Connection to PC via RS-232
Power supply unit	1U x 19" rack-mountable chassis
Electrical requirements	110-240VAC 13A 50/60Hz
Software requirements	PC running Windows 10 or later
Vacuum flange	DN 35 CF

PUL 03 Pulser

The PUL 03 is a 10 nanosecond, 400 V pulser designed for quickly blanking / unblanking an ion beam system and is an essential accessory to any of our ion beams when fast pulsing is required.

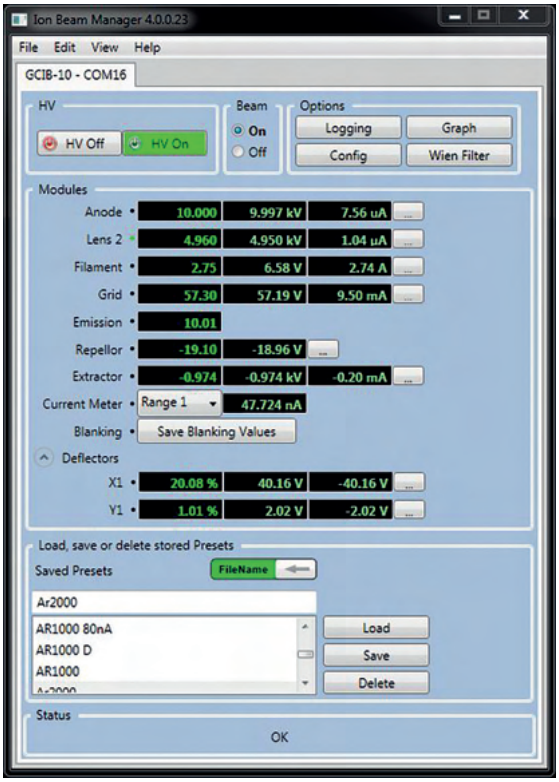
The unit comprises of an LCD display with touch pad controls, a 24 V DC power supply, and an amplifier that connects directly to the ion column. It is designed to drive an open circuit load of 4 to 10 pF, and is not intended to run into any resistive load or short circuit less than 10 MΩ.

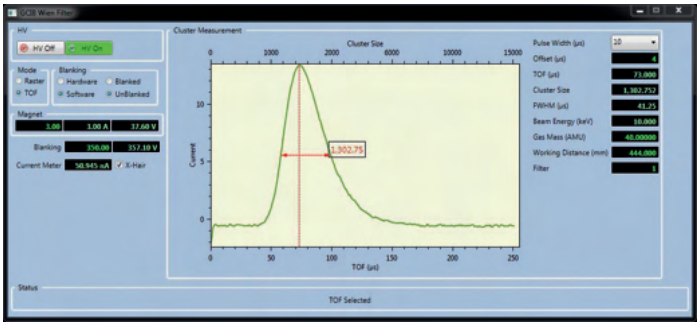
Specifications	
Voltage output	10 – 400 V
Set voltage	+10 – 400 V
Rise / Fall time	~8 ns to 90%
Frequency	DC to 10 kHz, BNC TTL trigger
Pulse width	Internal timer, 10 ns to 1 µs, or follow rise & fall of trigger pulse
Output	BNC
Power supply	24 VDC (universal mains adapter supplied)

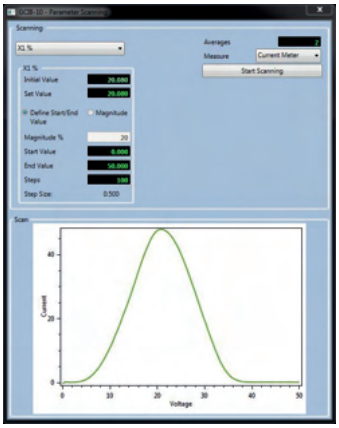
Software

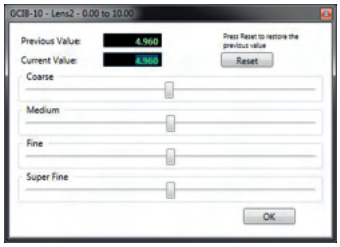
All ion beam systems from Ionoptika are supplied with dedicated control software, allowing users to control, configure, and monitor their ion beam system(s). In addition to being able to control all the operating parameters for each ion beam system, the software also offers the ability to:

- Monitor the status of the ion beam;
- Save configurations as presets, and rapidly switch between them;
- Provide system diagnostics and logging;
- Interface with Ionoptika's IoX API for integration with 3rd party software.









IOX

IOX is Ionoptika's websocket-based API that provides access for third-party / remote applications to IOX-enabled applications. IOX is compatible with any websocket-ready platform (JavaScript/C#/.NET/ Java) and enables Ionoptika applications to also be controlled via the web.

Product Comparison Table

Ion Beam	Species	Energy Range	Min Spot Size	Beam Current	Scan Field	Fast Pulsing	Application	Best For
C60 Ion Beams								
C60-20S	$C60^{+}$, $C60^{++}$, $C60^{+++}$	5 – 20 kV	100 µm	50 nA $C60^{+}$	4 × 4 mm	No	Sputter	Organic / bio, inorganics, metals
C60-20	$C60^{+}$, $C60^{++}$, $C60^{+++}$	5 – 20 kV	2 µm	2 nA $C60^{+}$	1.3 × 1.3 mm	Yes	Analytical	Organic / bio, inorganics, metals
C60-40	$C60^{+}$, $C60^{++}$, $C60^{+++}$	10 – 40 kV	300 nm	1 nA $C60^{+}$	1 × 1 mm	Yes	Analytical	Organic / bio, inorganics, metals
Gas Cluster Ion Beams								
GCIB 10S	Ar, CO_2, or Ar/CO_2 clusters	1 – 10 kV	250 µm	60 nA Ar_{1000}^{+}	7.5 × 7.5 mm	No	Sputter	Organic / bio, polymers
GCIB 40	Ar, CO_2, or Ar/CO_2 clusters	5 – 40 kV	4 µm	200 pA $(ArCO_2)_{2000}^{+}$	0.9 × 0.9 mm	No	Analytical	Organic / bio, polymers
GCIB 70	Ar, CO_2, or Ar/CO_2 clusters	10 – 70 kV	1.5 µm	300pA $(ArCO_2)_{3000}^{+}$	0.5 × 0.5 mm	No	Analytical	Organic / bio, polymers, inorganics
Liquid Metal Ion Beams								
IOG 25Au	Au^{+}, Au^{++}, Au_2^{+}, Au_3^{+}, Au_3^{++}	5 – 25 kV	100 nm	10 nA Au^{+}	1 × 1 mm	Yes	Analytical	Semiconductors, metals, inorganics
IOG 25Ga	Ga^{+}	10 – 25 kV	50 nm	20 nA Ga^{+}	1 × 1 mm	Yes	Analytical	Semiconductors, metals, inorganics
Plasma Source Ion Beams								
IOG 30D	H_2, He, O_2, N_2, Ar	5 – 30 kV	500 nm	500 nA O_2^{+}	1 × 1 mm	Yes	Analytical	Semiconductors, metals, inorganics
FLIG® 5	H_2, He, O_2, N_2, Ar	0.2 – 5 kV	15 µm	500 nA O_2^{+}	1 × 1 mm	No	Analytical	Semiconductors, depth profiling
IOG 30ECR	Ar, Xe, O_2, N_2	5 – 30 kV	300 nm	200 nA Xe^{+}	1 × 1 mm	Yes	Analytical	Semiconductors, metals, inorganics

IONOPTIKA
ion beam technology

We deliver our ion beam systems to universities, research institutes, and industries worldwide for a wide range of applications. We know that choosing the best ion beam for your application can be tricky. That is why our expert team is on hand to supply advice and suggestions, and we will work closely with you to help you make the final decision. Please don't hesitate to get in contact; we'd love to hear from you.

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