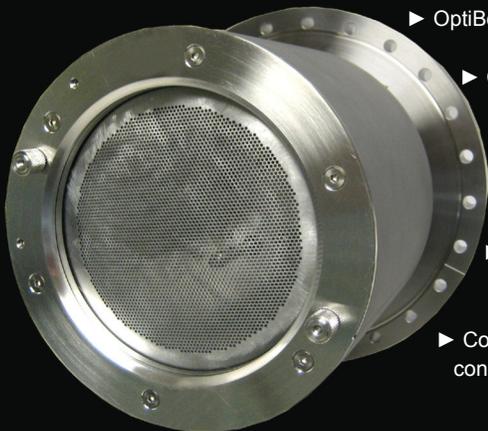
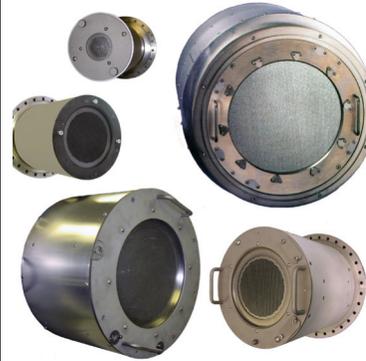


伯東國際通商
美國 KRI 考夫曼離子源臺灣總代理

Gridded Ion Beam Sources

Gridded Ion Sources

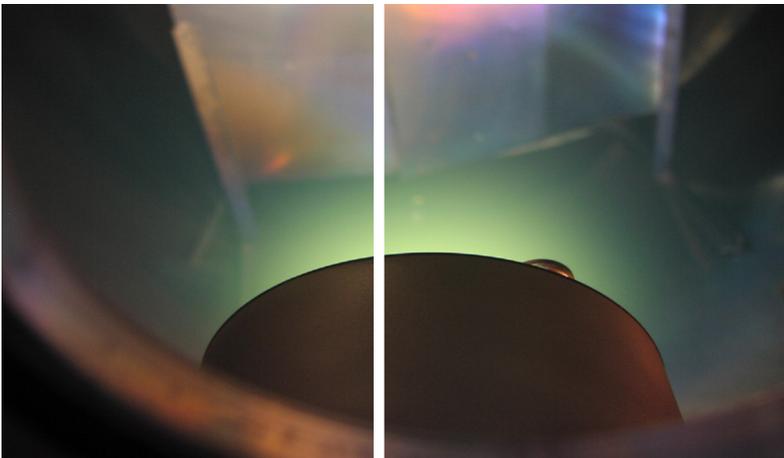
- ▶ OptiBeam™ self-aligning optics
- ▶ Controlled neutralization
- ▶ Plasma discharge
- ▶ Modular architecture
- ▶ Inert, reactive and organic gases
- ▶ Collimated, divergent, and convergent beams

KRI Gridded Products

- RFICP40
- RFICP100
- RFICP140
- RFICP220
- KDC 10
- KDC 40
- KDC 75
- KDC 100
- KDC 160

- Ion Beam Assisted Deposition
- In-situ Substrate Pre-cleaning
- Ion Beam Sputter Deposition
- Surface Modification
- Ion Beam Etching
- Ion Beam Figuring
- Surface Polishing & Smoothing
- Ion Beam Trimming and Tuning



Mean free path, $T_{target} = T_{incident}$

$$\lambda = 1/\sqrt{2} nQ$$

Mean free path, $T_{target} = 0$

$$\lambda = 1/nQ$$

Distribution of path lengths

$$I = I_0 \exp(-x/\lambda)$$

Debye length

$$\lambda_D = \sqrt{\epsilon_0 k T_e / n_e e^2}$$

Boltzmann equation

$$n_e = n_{e0} \exp(V_p / k T_e)$$

Child's law

$$j = (4\epsilon_0/9) \sqrt{2e/m} (V^{3/2}/x^2)$$

Bohm conductivity $\perp B$

$$\sigma_B \approx en_e/16$$

Temperature-energy equivalence

$$1 \text{ ev} = 11,600 \text{ K}$$

Mean Maxwellian speed

$$\bar{v} = \sqrt{8kT/\pi m}$$





- Credibility
- Innovative
- Quality

Applications

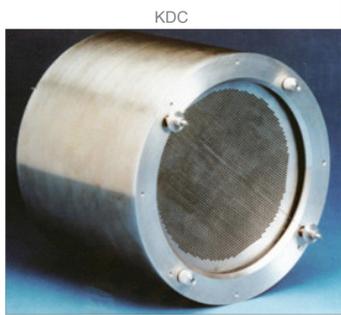
- Adhesion
- Film Densification
- Chemical Conversion
- Texturing
- Pinhole Free Films
- Ultra Thin Film Precision
- Microstructure Control
- Nanostructured Surface
- Anisotropic Etching

Gridded Beam Sources

- Low Cost
- Industrial
- Remote Plasma
- Directed Beam
- Beam Shaping
- Precision Control
 - Ion Current
 - Ion Energy

Design Features

- Self-aligned Ion Optics
- Inert & Reactive Gases
- Large Ion Energy Range
- High Ion Current Densities
- Collimated, Divergent and Focused Beams

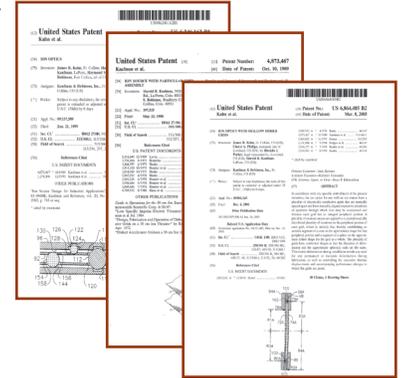


The Ion Beam Authority

Kaufman & Robinson offers gridded Ion Beam Products. Our products include broad-beam Gridded Ion Sources and automated power supplies controllers. All designs are straightforward which easily retrofit into existing vacuum systems, or easily integrate into new OEM systems.

Since 1978, Kaufman & Robinson (KRI), Inc. has designed and built broad-beam ion sources for the vacuum processing community including both manufacturers and researchers. The designs of the gridded ion beam products were developed with our world-recognized expertise in plasma physics, ion source design, and power control engineering.

Currently, KRI holds more than 20 active patents in ion beam and plasma technology, including its innovative designs in multi-aperture ion optics technology.



Meeting Your Application Needs

KRI's knowledge in material applications is captured in our product relevance. Our products are proven process tools which are connected to real results. For example: These products output a stable regulated beam ideally suited for dry plasma etching, surface treatment and thin film growth applications which include:

- Ion Beam Assisted Deposition
- In-situ Substrate Precleaning
- Ion Beam Figuring
- Ion Beam Etching
- Surface Modification
- Ion Beam Sputter Deposition

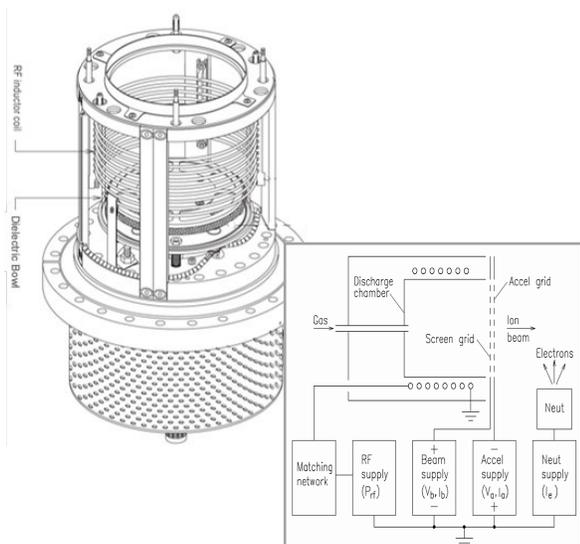


Gridded Series of Broad Beam Ion Sources

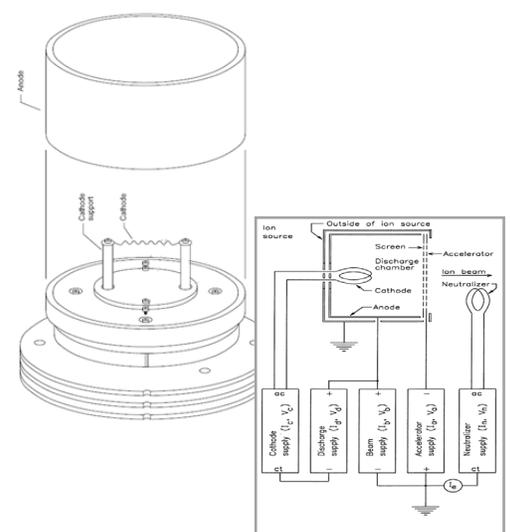
The versatile gridded series of broad beam ion sources are available in different sizes which covers both R&D and high yield production requirements. Large ion beam sources meet critical output performance for uniform coverage over wide process zones. The large ion energy range permits low energy operation to minimize bombardment damage and heat on sensitive substrates while high energy operation enables high rate sputtering processes.

All gridded models feature patented self-aligned ion optics, electron source neutralizer and either a DC or RF discharge chamber. Our gridded products are fit into two categories: Kaufman DC (KDC) Style or RF Inductive Coupled Plasma (RFICP) Style.

RFICP Discharge Configuration



KDC Discharge Configuration



Electron Source Neutralizers



Non-immersed
(outside of beam)
Neutralizer



Immersed (in beam)
Filament Neutralizer

The gridded source can be configured with different neutralizers. The available neutralizer options include simple filaments or non-immersed electron sources. These neutralizers allow stable processing on dielectric materials, eliminating charge build-up effects.

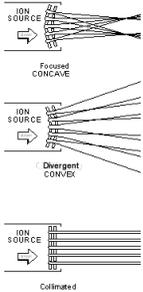
All electron sources tightly control the electron emission current whether it is inexpensive filament designs or non-immersed models used for extended run time and low temperature requirements.

- LFN2000 for up to 2 A emission current
- SHC1000 for up to 5 A emission current
- MHC1000 for up to 10 A emission current



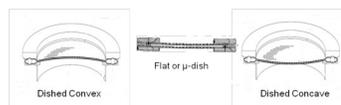
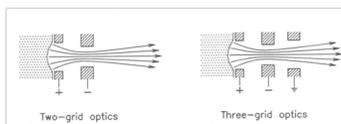
Electron Source Neutralizers

OptiBeam™ Ion Optics



Our ion optics assemblies come in a variety of configurations, sizes and outputs. The multi-aperture grids which seat in the ion optics assemblies are made from thermally stable materials such as Molybdenum and Pyrolytic Graphite. The grid sizes range from 1cm to 38cm diameters and they can be fabricated into flat or dished shapes. The ion optics designs can produce beams which diverge, focus or collimate from the ion source. Two grid ion optic assemblies are standard, while three grid ion optic assemblies are employed in specialized applications.

One of the core benefits in our gridded ion beam products is self-aligning ion optics technology. This technology eliminates the traditional grid alignment procedure. Consequently, the result is consistent and precise aperture position which ensures repeatable and optimized beam characteristics.



Product Options

All models can be equipped with optional hardware to tailor the product to the customer's process and installation.



- **Mounting Options**
 - Extended Mount Vacuum Feedthrough
 - Remote Vacuum Feedthrough
 - Direct Mount Vacuum Feedthrough
- **Angular Mounting Bracket**

- **Mass Flow Controllers**
- **In-vacuum Cables**
- **Ion Source Switchbox**



KDC 75 w/ O₂ Beam

Electron Sources

- Neutralization
- Beam Divergence
- Plasma Stabilization
- Low Energy
- ESD Control
- Dielectric Substrates

Ion Optics

- 1 to 38cm Φ size
- No Alignment Procedure
- Extended Grid Lifetime
- Optimize Divergence
- Minimizes Maintenance
- Maximizes Beam Current
- Reproducible Beam

Optional Accessories

- Lower MTBM
- Low Voltage Operation
- Installation Flexibility
- Process Optimization
- Long Filament Lifetime

Collimated Ar Beam



RFICP

Features

- Switch Mode
- Digital Control
- Low Stored Energy
- MFC Gas Control
- Single Button Enable
- Integrated Control
- Remote Interfaces
- Recipe Storage
- RF Automatching

Power Supplies

All KRI power supplies feature advanced primary switched power modules with output control to protect power supply and load. Upgrades from basic configurations to advanced configuration are easily achieved by replacing or adding modules. Depending upon the model, the power supplies deliver either AC, DC or RF signals with output powers ranging from 100 to 2000W.

- Powers and controls plasma discharge, ion beam and neutralizer parameters
- Feedback control stabilizes beam output for precision process control
- Short and arc management through protection circuits
- Constant and stable ion beam parameter control over complete operating range
- Selection of operational modes to fit application



Kaufman Source Power Supply Controller



Ion Optics Controller (Screen + Accelerator Grid)



LFN Neutralizer Controller



RFICP Source Power Supply Controller (RF Auto Matching)



Auto Controller: Gas Control, Recipe Storage, Operational Modes

Ion Beam Sources

- Standard configurations
- Optimized configurations
- Application specific
- Controlled ion energy
- Controlled current density
- Controlled beam shape

Nominal Specifications

Product	RFICP40	RFICP100	RFICP140	RFICP220
Discharge	RFICP	RFICP	RFICP	RFICP
Ion Beam Current (I_B)*	>100mA	>350mA	>600mA	>800mA
Ion Beam Energy (V_B)	100-1200V	100-1200V	100-1200V	100-1200V
Beam Size @ grid	4cm Φ	10cm Φ	14cm Φ	20cm Φ
Beam Type	Collimated, Convergent, Divergent			
Typical flow	3-10sccm	5-30sccm	5-30sccm	10-40sccm
Gases	Ar, Kr, Xe, O ₂ , N ₂ , H ₂ , others			
Typical Pressure	<0.5mTorr	<0.5mTorr	<0.5mTorr	<0.5mTorr
Length	5.0" (12.7cm)	9.25" (23.5cm)	9.7" (24.6cm)	11.8" (30cm)
Diameter	5.3" (13.5cm)	7.52" (19.1cm)	9.7" (24.6cm)	16.1" (41cm)
Neutralizer**	LFN 2000			

Product	KDC 10	KDC 40	KDC 75	KDC 100	KDC 160
Discharge	DC Thermionic	DC Thermionic	DC Thermionic	DC Thermionic	DC Thermionic
Ion Beam Current (I_B)*	>10mA	>100mA	>250mA	>400mA	>650mA
Ion Beam Energy (V_B)	100-1200V	100-1200V	100-1200V	100-1200V	100-1200V
Beam Size @ grid	1cm Φ	4cm Φ	7.5cm Φ	12cm Φ	16cm Φ
Beam Type	Collimated, Convergent, Divergent				
Typical flow	1-5sccm	2-10sccm	2-15sccm	2-20sccm	2-30sccm
Gases	Ar, Kr, Xe, O ₂ , N ₂ , H ₂ , others				
Typical Pressure	<0.5mTorr	<0.5mTorr	<0.5mTorr	<0.5mTorr	<0.5mTorr
Length	4.5" (11.5cm)	6.75" (17.1cm)	7.9" (20.1cm)	9.25" (23.5cm)	9.92" (25.2cm)
Diameter	1.52" (4cm)	3.5" (9cm)	5.5" (14cm)	7.6" (19.4cm)	9.1" (23.2cm)
Neutralizer**	All Sources offer Immersed Filament				

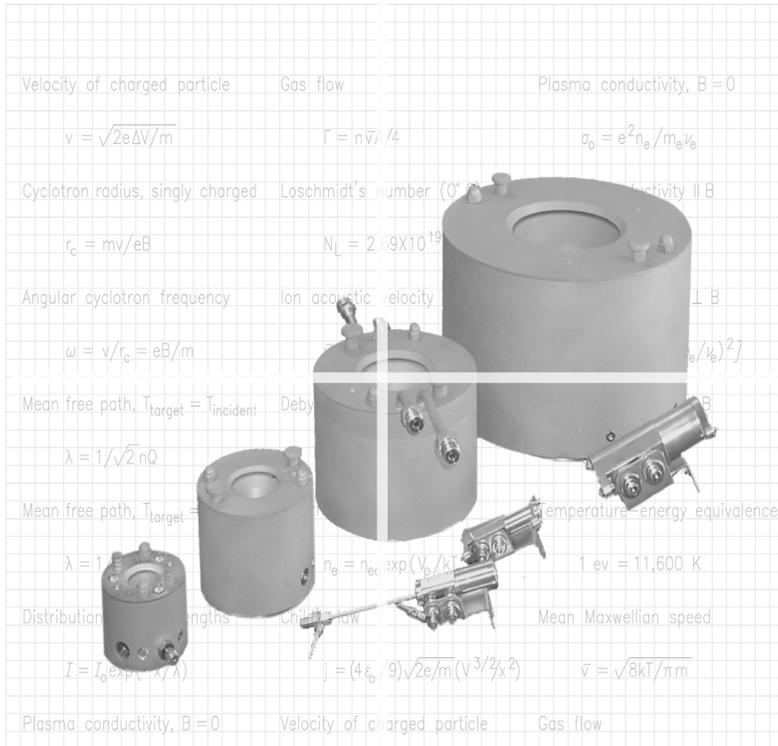
* Can Depend On Ion Optics

** Other Neutralizers are Available



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Gridless Ion & Plasma Sources



Velocity of charged particle: $v = \sqrt{2e\Delta V/m}$

Gas flow: $\Gamma = n\bar{v}/4$

Plasma conductivity, $B=0$: $\sigma_0 = e^2 n_e / m_e \nu_e$

Cyclotron radius, singly charged: $r_c = mv/eB$

Loschmidt's number ($0^\circ C$): $N_L = 2.69 \times 10^{19}$

Angular cyclotron frequency: $\omega = v/r_c = eB/m$

Mean free path, $T_{target} = T_{incident}$: $\lambda = 1/\sqrt{2}nQ$

Mean free path, $T_{target} = 0$: $\lambda = 1/nQ$

Distribution of path lengths: $I = I_0 \exp(-x/\lambda)$

Plasma conductivity, $B=0$: $\sigma_B = en_e \nu_e / (1 + \nu_e^2/\omega^2)$

Velocity of charged particle: $j = (4\epsilon_0/9)\sqrt{2e/m}(V^{3/2}/x^2)$

Gas flow: $\bar{v} = \sqrt{8kT/\pi m}$

Bohm conductivity $\perp B$: $\sigma_B \approx en_e/16$

Temperature-energy equivalence: $1 \text{ eV} = 11,600 \text{ K}$

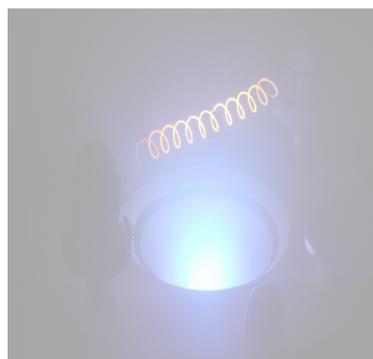
Mean Maxwellian speed: $\bar{v} = \sqrt{8kT/\pi m}$



- Ion Beam Assisted Deposition
- In-situ Substrate Precleaning
- Direct Deposition Coating
- Surface Modifications

KRI Gridless Products

- eH200
- eH400
- eH1000
- eH2000
- eH3000
- eH Linear



Mean free path, $T_{target} = T_{incident}$

$$\lambda = 1/\sqrt{2}nQ$$

Mean free path, $T_{target} = 0$

$$\lambda = 1/nQ$$

Distribution of path lengths

$$I = I_0 \exp(-x/\lambda)$$

Debye length

$$\lambda_D = \sqrt{\epsilon_0 kT_e / n_e e^2}$$

Boltzmann equation

$$n_e = n_{e0} \exp(V_p / kT_e)$$

Child's law

$$j = (4\epsilon_0/9)\sqrt{2e/m}(V^{3/2}/x^2)$$

Bohm conductivity $\perp B$

$$\sigma_B \approx en_e/16$$

Temperature-energy equivalence

$$1 \text{ eV} = 11,600 \text{ K}$$

Mean Maxwellian speed

$$\bar{v} = \sqrt{8kT/\pi m}$$





- Credibility
- Innovative
- Quality

Applications

- Adhesion
- Film Densification
- Chemical Conversion
- Smoothing
- LTCVD

End-Hall (eH) Ion / Plasma Beam Sources

- Low Cost
- Rugged
- Remote Plasma
- Directed Beam

Design Features

- Gridless
- Inert & Reactive Gases
- Optimized Configurations
- Modular Anode
- Low Energy Ions
- High Ion Currents
- Large Process Zone

EH1000

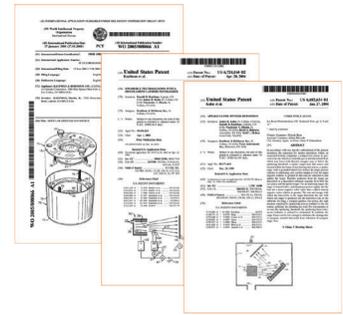


The Ion Beam Authority

Kaufman & Robinson offers gridless end-Hall “eH” Ion / Plasma Products. Our products include broad-beam End-Hall Ion Sources and automated power supplies controllers. All designs are straightforward which easily retrofit into existing vacuum systems, or easily integrate into new OEM systems.

Since 1978, Kaufman & Robinson (KRI), Inc. has designed and built broad-beam ion sources for the vacuum processing community including both manufacturers and researchers. The designs of the eH ion/plasma beam products were developed with our world-recognized expertise in plasma physics, ion source design, and power control engineering.

Currently, KRI holds more than 20 active patents in ion beam and plasma technology, including its innovative designs in the gridless end-Hall technology.

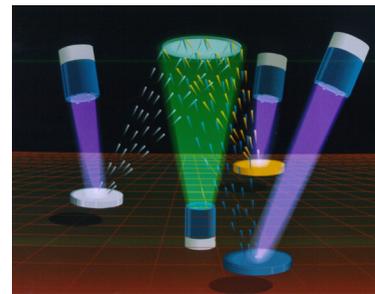


Meeting Your Application Needs

KRI’s knowledge in material applications is captured in our product relevance. Our products are proven process tools which are connected to real results. For example:

The eH products output a high current and low energy beam ideally suited for surface treatment and thin film growth applications which include:

- Ion Beam Assisted Deposition (IBAD)
- In-situ Substrate Precleaning
- Direct Deposition Coatings
- Low Energy Ion Beam Etching
- Surface Modification
- Biased Target Ion Beam Deposition



eH Series of Broad Beam Ion Sources

The compact low profile eH series of broad beam ion sources are available in different sizes which covers both R&D and high yield production requirements. Large ion beam currents meet critical arrival ratios for high deposition rate processes. Low energy ions minimize ion bombardment damage to surfaces and interfaces. The broad divergent beam improves throughput by uniformly covering a wide deposition zone.

All eH models feature the patented modular anode. The simple plug / unplug task makes it easy to maintain, assemble and disassemble, resulting in significant productivity benefits.

- Removable anode module for bench-top maintenance
- Self aligning anode module for simple reinstallation
- Double contoured anode for optimized plasma discharge
- Thermally decoupled magnet system
- Enhanced gas distribution for efficient gas management
- Shielded insulators for lower maintenance



- plug-in filament electron emitter
- hollow cathode system optional
- modular anode (patented) including anode and gas distribution
- main module including magnet system and electrical and gas inlets
- adjustable angular mounting bracket (optional)

Cathode / Neutralizer Options



Grooved Anode with O₂

The eH source can be configured with different cathode and anode module components. The available cathode / neutralizer options include simple filaments or filamentless hollow cathodes. The anode module options include optimized configurations for a low energy / high output, extra current output for O₂ gas, or improved stability in dielectric environments.



EH200F

EH400HC

Electron Sources

All electron sources tightly control the electron emission current whether it is inexpensive filament designs or hollow cathode models used for extended run time and low temperature requirements.

- LFN2000 for up to 2 A emission current
- SHC1000 for up to 5 A emission current
- MHC1000 for up to 10 A emission current
- LHC1000 for up to 20 A emission current
- DHC1000 disposable hollow cathodes
- eH Sidewinder for up to 10 A emission current



Electron Sources

Product Options

The eH models can be equipped with optional hardware to tailor the product to the customer's process and installation.



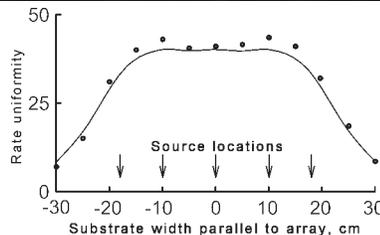
- Vacuum feedthroughs
- Grooved anode
- Water cooled anode
- Water cooled front plate
- Angular mounting bracket
- Ti, Ta, graphite or stainless steel gas reflectors
- Magnetic field options



eHL-X Linear Configurations

The linear eHL-X ion / plasma beam sources are suited for installation with linear movement substrates, such as in-line, web coating and rotary sputtering systems. Typical, applications are in-situ cleaning and ion assisted deposition where low energy & high currents are beneficial.

The modular linear configuration has unique optimization capabilities. It uses standard cylindrical end-Hall modules placed in a linear array. The spacing and number of the modules provides a strong benefit to the application. The modules can be spaced to optimize current density dose, uniformity and overall length. Since this configuration uses one electron source and a common power supply, the cost for the integrated modular linear package is minimized.



EH3000



Electron Sources

- Neutralization
- Ionization
- Plasma Stabilization
- Low Energy
- ESD Control
- Dielectric Substrates



EH1000F Sidewinder

Optional Accessories

- Temperature Management
- Lower MTBM
- Low Voltage Operation
- Installation Flexibility
- Process Optimization
- Long Filament Lifetime

Linear Sources

- Modular
- Optimize uniformity
- Optimize ion current dose
- Minimize lengths
- User adjustable
- Monolithic option

EHL200-3

Features

- Switch Mode
- Digital Control
- Low Stored Energy
- MFC Gas Control
- Discrete Modules
- Integrated Control
- Remote Control Interfaces
- Recipe Storage
- Dual Regulation



eH 400 with Filament and LHC

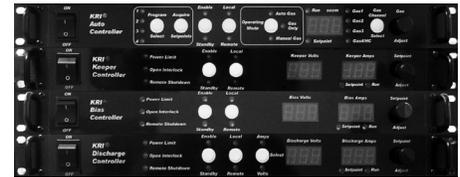
Power Supplies

All KRI power supplies feature advanced primary switched power modules with output control to protect power supply and load. Upgrades from basic configurations to advanced configuration are easily achieved by replacing or adding modules. Depending upon the model, the power supplies deliver either AC or DC signals with output powers ranging from 300 to 4000W.

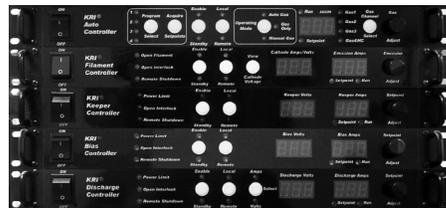
- Modular architecture with quick change power modules
- Reliable power modules, designed for industrial use
- Short and arc management through protection circuits
- Constant and stable ion beam parameter control over complete operating range
- Selection of operational modes to fit application



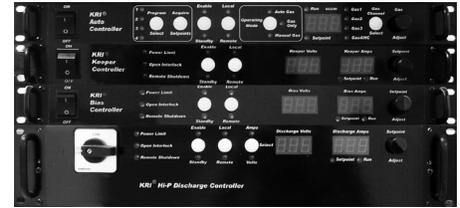
eH Filament Power Supply Controller



eH Hollow Cathode Power Supply Controller



eH Filament & Hollow Cathode Power Supply Controller



eH High Power Controller

eH Ion / Plasma Sources

- Standard configurations
- Optimized configurations
- Application specific
- Controlled ion energy
- Controlled current density

Nominal Specifications

KRI	eH200	eH400 eH400LE	eH1000 eH1000LE eH1000LO	eH1000xO ₂	eH2000 eH2000LE eH2000HO	eH3000 eH3000LO eH3000MO
Cathode/Neutralizer	F or HC	F or HC	F or HC	F or HC	F or HC HC HC	HC
Discharge Voltage (V _D)	30-300V	50-300V 30-150V	50-300V 30-150V 50-300V	100-300V	50-300V 30-150V 50-250V	50-250V 50-300V 50-250V
Discharge Current (I _{Dmax})	2A	5A 10A	10A 12A 5A	10A	10A 15A 15A	20A 10A 15A
Divergence (hwhm)	>45	>45	>45	>45	>45	>45
Gases	Ar, O ₂ , N ₂ , H ₂ , organic precursors, others					
Typical flows	1-15sccm	2-25sccm	2-50sccm	2-50sccm	2-75sccm	5-100sccm
Height	2.0"	3.0"	4.0"	4.0"	4.0"	6.0"
Diameter	2.5"	3.7"	5.7"	5.7"	5.7"	9.7"
Water cooled	no	optional	optional	optional	yes	optional

F = Filament; HC = Hollow Cathode; xO₂ = Optimized for O₂ current

 **Kaufman & ROBINSON**

 **伯東**

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