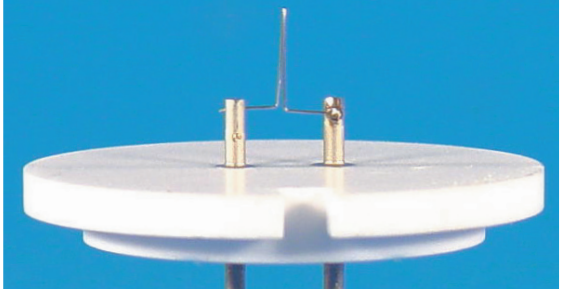
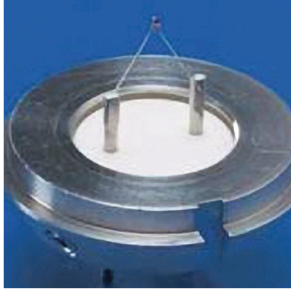
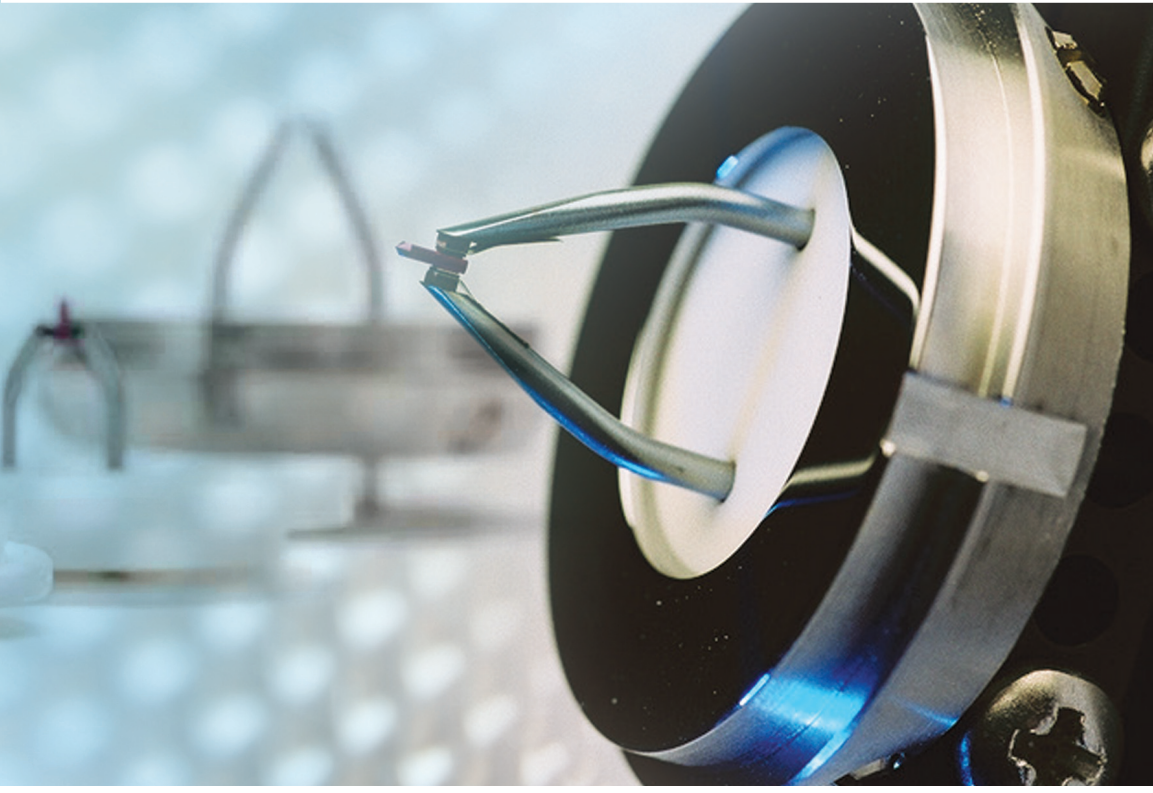




EDITION 3

Cathodes & Filaments for Electron Microscopes



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Electron Microscopy Sciences

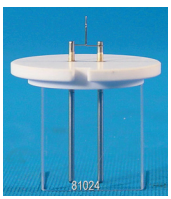
Standard Loop Filaments

- A rigid attachment of the filament wire to the post — no possibility of waving.
- Minimum tip radius for coherent beam.
- Polished post ends.
- Precise dimensioning.
- Bases can be cleaned and rebuilt many times.
- Better long-term economy.

for: AEI, Cambridge S Series, Novascan, Semco, and Nanolab

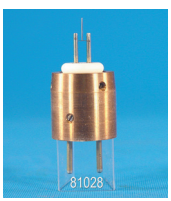
Cat. #	Description	Qty.
81020	New Filament	10/box
*81020-R	Rebuilt Filament	each

for: All Amray instruments (except Amray 1200 Series)



Cat. #	Description	Qty.
81024	New Filament	10/box
*81024R	Rebuilt Filament	each

for: Amray 1200 Series, Balscan, Camscan, Siemens, Cambridge (S-410, Mark II)

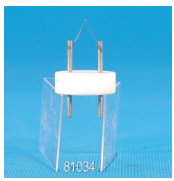


Cat. #	Description	Qty.
81028	New Filament	10/box
*81028R	Rebuilt Filament	each

for: ARL Instruments

Cat. #	Description	Qty.
81030	New Filament, 4 mil wire	10/box
81032	New Filament, 5 mil wire	10/box
*81030R	Rebuilt Filament, 4 mil wire	each
*81032R	Rebuilt Filament, 5 mil wire	each

for: ETEC instruments

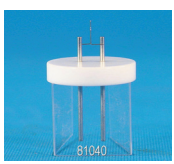


Cat. #	Description	Qty.
81034	New Filament	10/box
*81034R	Rebuilt Filament	each

for: ISI, ABT, Topcon instruments

Cat. #	Description	Qty.
81036	New Filament, 2-prong	10/box
81038	New Filament, 3-prong	10/box
*81036R	Rebuilt Filament, 2-prong	each
*81038R	Rebuilt Filament, 3-prong	each

for: Zeiss Instruments and Tescan and LEO



Cat. #	Description	Qty.
81040	New Filament	10/box
*81040-R	Rebuilt Filament	each

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Rebuilding Services

The base assembly of all of our new filaments are guaranteed to be rebuildable for the lifetime of the electron beam instrument. All of our filaments, new or rebuilt, are inspected for consistent quality and performance before being shipped to you. Return the base and we will rebuild it to meet its original specifications.

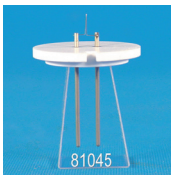
Filament Rebuilding Services Include...

- Reconditioning of the base
- Cleaning and/or replacement of necessary parts
- New standard loop or special filament tip installation
- Pre-centering
- Vacuum normalizing
- Microscopic inspection.

for: JEOL K-Type

Cat. #	Description	Qty.
81041	New Filament	10/box
81041-R	Rebuilt Filament	each

for: Philips Pointed S-Type



Cat. #	Description	Qty.
81045	New Filament	10/box
***81045R**	Rebuilt Filament	each

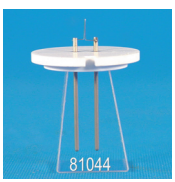
for: Jeol (JSM 35 series)

Cat. #	Description	Qty.
81042	New Filaments	10/box
***81042R**	Rebuilt Filament	each

for: Hitachi S-Type HOC

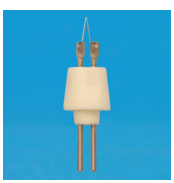
Cat. #	Description	Qty.
81046	New Filament	10/box
***81046-R**	Rebuilt Filament	each

for: Philips, FEI



Cat. #	Description	Qty.
81044	New Filament	10/box
***81044R**	Rebuilt Filament	each

for: Hitachi S-Type



Cat. #	Description	Qty.
81022	New Filament	10/box
***81022-R**	Rebuilt Filament	each

Denka Model 3s LaB_6 Cathodes

Lanthanum Hexaboride is the optimum cathode material for use in:

- **SEM**
- **TEM**
- **X-Ray Microanalysis**
- **Electron Beam Lithography**

Features

- Low potential barrier (work function)
- High melting point and stability at high temperatures
- Low vapor pressure – reduces evaporation lost
- Chemical stability
- **High brightness:** LaB_6 beam is ten times brighter than tungsten, has superior resolution – wide range of acceleration voltages. It provides sharp and clear pictures even to the smallest details. The initial brightness of a Denka Model 3 cathode (1×10^6 A/cm^2.Str) is substantially better than that of competing mini-vogel type cathodes (typically 5×10^5 A/cm^2.Str)
- **Long life:** Heat and vacuum are the final determinants of any cathode tip's life, but at 1550°C and a vacuum of 10^{-7} Torr, a service life of about 500 hours can be achieved.
- **Stability:** Every Denka Model 3 cathode offers a stability of better than 3% per hour at 1550°C
- **Interchangeability:** Denka Model3 LaB_6 cathodes are designed as direct replacement for tungsten filaments.

Tip Selection

Standard (Round) Tips

Provided with a 90° cone and 15µ radius round tip.

Flat (Truncated) Tips

Flat tips are recommended for applications where stability and long lifetime are the prime considerations, and where some degree of brightness can be sacrificed. Flat tips are available in eight configurations:

90° Cone Angle	60° Cone Angle
20µ radius	20µ radius
40µ radius	40µ radius
60µ radius	60µ radius
100µ radius	100µ radius

Sharp Tips

Sharp tips are recommended for applications where initial brightness is the foremost consideration and where shorter lifetime can be accepted. Sharp tips are available in two configurations.

60° Cone Angle	60° Cone Angle
5µ radius	10µ radius

Specifications	Flat Tip	Standard (Round) Tip	Sharp Tip
Brightness	About 5 times that of tungsten, 2-5 x 10^5 A/cm^2· Str	About 10 times that of tungsten, 1x10^6 A/cm^2· Str	Twice as bright as standard tips, 2 x 10^6 A/cm^2· Str
Saturation	Mono spot at about 1,400°C	Mono spot at about 1,500°C.	Almost the same as standard tips
Crossover	Large (11-13µ)	Small (7-10µ)	Small (7-10µ)
Angular distribution	Broad, 3.3-4.2 x 10^{-2} rad	Sharp, 1.6 x 10^{-2} rad	Sharp, 1.6 x 10^{-2} rad
Used Temperature	Low temperature	Low temperature	High temperature.
Lifetime	Long life, usable at low temperatures and crystallized end changes slowly.	Long life but shorter than flat tips.	Short
Operation	Easy, thanks to its large spot size and broad adjusting range.	Not so difficult.	Difficult; Point adjustment needed!
Stability	High, vulnerable to thermal expansion or vibration.	High	Middle, vulnerable to the thermal expansion or vibration. Adjustment is sometimes necessary.
Technology Needed	Ordinary	High	Very high

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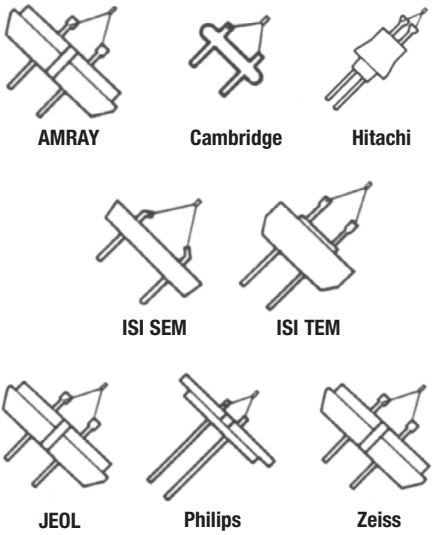
Denka Model 3 LaB_6 Cathodes (continued)

Ordering Information

All standard Denka M-3 LaB_6 Cathodes are provided with a 90° cone angle and a 15µm radius round tip. These are just the standard Denka LaB_6 Cathodes that are in stock.

For all other LaB_6 filaments in Flat Tip and Sharp tip just tell us what you require and we shall price it for you. The complete line of Denka Lab_6 filaments is available through us.



AMRAY

Cat. #	Description	Qty.
80904	Standard	each
80904-5	KF Sharp 60-5 µm	each
80904-10	KF Sharp 60-10 µm	each
80904-20	KF Flat 60-20 µm	each
80904-40	KF Flat 60-40 µm	each
80904-60	KF Flat 60-60 µm	each
80904-80	KF Flat 60-80 µm	each
80904-100	KF Flat 60-100 µm	each
80904-21	KF Flat 90-20 µm	each
80904-41	KF Flat 90-40 µm	each
80904-61	KF Flat 90-60 µm	each
80904-81	KF Flat 90-80	each
80904-101	KF Flat 90-100	each

Cambridge

Cat. #	Description	Qty.
80906-5	60-5 µm	each
80906-10	60-10 µm	each
80906-20	60-20 µm	each
80906-40	60-40 µm	each
80906-60	60-60 µm	each
80906-80	60-80 µm	each
80906-100	60-100µm	each
80906-11	90-20 µm	each
80906-21	90-40 µm	each
80906-41	90-60 µm	each
80906-61	90-80 µm	each
80906-81	90-100 µm	each

Hitachi

Cat. #	Description	Qty.
80908-5	60-5 µm	each
80908-10	60-10 µm	each
80908-20	60-20 µm	each
80908-40	60-40 µm	each
80908-60	60-60 µm	each
80908-80	60-80 µm	each
80908-100	60-100 µm	each
80908-11	90-20 µm	each
80908-21	90-40 µm	each
80908-41	90-60 µm	each
80908-61	90-80 µm	each
80908-81	90-100	each

ISI SEM

Cat. #	Description	Qty.
80910	Standard	each

ISI TEM

Cat. #	Description	Qty.
80912	Standard	each

JEOL

Cat. #	Description	Qty.
80900	Standard	each
80900-5	60-5 µm	each
80900-10	60-10 µm	each
80900-20	60-20 µm	each
80900-40	60-40 µm	each
80900-60	60-60 µm	each
80900-80	60-80 µm	each
80900-100	60-100 µm	each
80900-11	90-20 µm	each
80900-21	90-40 µm	each
80900-41	90-60 µm	each
80900-61	90-80 µm	each
80900-101	90-100 µm	each

Philips

Cat. #	Description	Qty.
80902	Standard	each

Zeiss

Cat. #	Description	Qty.
80914	90-15 Round	each
80914-20	90-20 Flat	each

Applied Physics Technologies LaB_6 and CeB_6 Cathodes

Building the World's Best Cathodes

LaB_6 and CeB_6 cathodes are ideal for many small spot size applications such as SEM, TEM, surface analysis and metrology, and for high current applications such as microwave tubes, lithography, electron-beam welders, X-ray sources and free electron lasers.

Applied Physics Technologies has decades of experience in research, development, and manufacturing of LaB_6 and CeB_6 cathodes.

We can provide the cathodes you need for replacement, OEM, and custom applications.

Lanthanum Hexaboride (LaB_6) and Cerium Hexaboride (CeB_6) Cathodes

The unique properties of hexaboride crystals provide stable electron-emitting media with work functions near 2.65 eV. The low work function yields higher currents at lower cathode temperatures than tungsten, which means greater brightness (or current at the beam focus) and longer cathode life. Typically, these cathodes exhibit 10 times the brightness and more than 10 times the service life of tungsten cathodes. In electron microscope applications, these characteristics translate to more beam current in a smaller spot at the sample, improved resolution, and less frequent cathode replacement.

For applications with large beam spot sizes, where large total current and current density are required, large, flat crystal faces of LaB_6 or CeB_6 can be the cathodes of choice. This regime is unsuitable for point sources such as field emitters, which are unable to provide sufficient total current, and has been thought of as the realm of the dispenser cathode. However, LaB_6 and CeB_6 may be more suitable, being particularly robust and resistant to chemical poisoning. They have modest vacuum requirements and long shelf life, and need only be brought up to operating temperature to provide emission, eliminating the activation procedure required of dispenser cathodes. They can provide long-term, stable operation at current densities up to 50 A/cm^2, and may be fabricated in a variety of shapes and with many different heating and mounting configurations.

LaB_6 and CeB_6 are the materials of choice for high current cathodes in a variety of advanced and custom applications.

The performance and lifetime of the hexaboride cathode are determined by several factors: vacuum level, cathode temperature, impurity level, crystal orientation, tip shape, and mount design. Vacuum requirements are more stringent for hexaboride emitters than for tungsten in order to minimize carbon contamination. In laboratory tests, CeB_6 has proven to be more resistant to the negative impact of carbon contamination than LaB_6, which gives it an edge in potential cathode lifetime.

Excessive operating temperatures accelerate evaporation, thus decreasing the life of the cathode. Care must be taken to properly optimize cathode temperature to obtain the required emission without overheating the crystal.

CeB_6 has another advantage over LaB_6 relating to lifetime: its evaporation rate at normal operating temperatures near 1800 K is lower than that of LaB_6. So long as care is taken to operate the cathode below 1850 K, CeB_6 should maintain an optimum tip shape longer, and therefore last longer.

A comparison of electron emission characteristics of LaB_6, CeB_6 and Tungsten at typical operating temperatures

	CeB_6 <100>	LaB_6 <100>	Tungsten Filament
Brightness (A/cm^2-sr)	107	107	106
Short-Term Beam Current Stability % RMS	<1	<1	<1
Typical Service Life (hr)	1,500+	1000+	30-100
Operating Vacuum (torr)	10^{-7}	10^{-7}	10^{-5}
Work Function (eV)	~2.65	~2.70	4.5
Evaporation Rate (g/cm^2-sec)	1.6 x 10^{-9}	2.2 x 10^{-9}	NA

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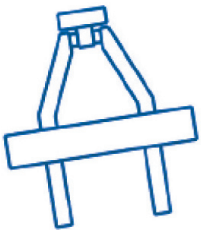
Crystal Growth

Impurities in the crystal will reduce both brightness and lifetime of the emitter because impurities increase both work function and volatility. We grow and fabricate our own high quality, single-crystal materials using a well-defined process called Inert Gas Arc Float Zone Refining. An electric arc melts a pressed-powder stick of LaB_6 or CeB_6 in a controlled atmosphere of inert gas, allowing the liquid-phase zone to freeze onto a selected orientation seed crystal as the arc is moved along the stick. The finished crystal assumes the desired orientation of the seed with less than 30 parts per million by weight metal impurities. Correct melt zone temperature and process speed minimize excessive boron evaporation to achieve the optimum ratio of metal to boron atoms in the grown crystal.

Crystal Orientation

Crystal orientation can be selected to match the cathode design or application. For electron microscopy, the <100> orientation is most desirable due to its brightness and crystal plane symmetry about the optical axis. As the cathode ages, the plane symmetry ensures an even evaporation rate relative to the axis, maintaining a centered, flat emitting surface (see figure). Also, the emission patterns from the symmetric crystal planes will remain consistent as they become more exposed by evaporation, contributing to a brighter beam spot.

Cathode Tip Design



The "tophat" design provides a large area crystal face electron source for maximum total current.

The design of the cathode tip is critical for maximum lifetime and optimum performance. Tip design must also match the specific application's requirements for beam current, spot size, and brightness. For electron microscopy, a conical tip with a flat emitting surface at the apex has proven to be the optimum design. With the flat-tipped cone design, changes in both cone angle and flat diameter affect emission characteristics. In general, the small cone angle (60°) results in higher brightness, but a larger angle (90°) provides longer life and easier alignment. Small flat diameters also result in higher brightness plus a smaller source size, but larger flats provide longer lifetimes and more beam current.

These trends allow us to tailor our cathodes to the requirements of practically all thermionic cathode applications. For example, SEM and most transmission electron microscope (TEM) applications are best served by a 90° cone angle and a 16 mm flat tip. This combination provides high brightness, a moderate source size, and very good lifetime. High resolution TEMs require a 60° cone and a 5 mm flat tip for very high brightness and a small source size.

In applications requiring high total current in a large beam spot, a <310> oriented crystal in a "top hat" configuration may be preferred, providing a slightly lower work function and large emitting surface. We excel at developing specialized cathodes for custom applications and research purposes. Contact us for your custom cathode needs.

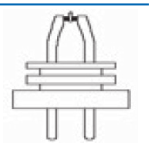
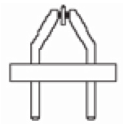
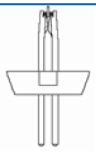
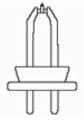
The cathode's mount design has a significant impact on performance.

The design must be simple, durable and precise. It must resist any movement of the crystal, despite the high operating temperatures, yet be easy to install and align. We feel we employ the best mount design in the industry, the Mini Vogel Mount.

In 1988, FEI of Hillsboro, Oregon introduced the Mini Vogel Mount (MVM) to provide the benefits of the original Vogel mount in a smaller, simpler, and more elegant design. Twin posts are rigidly fixed in a thick ceramic base, and bent towards the center in an inverted "V". The posts are made of a molybdenumrhenium alloy that maintains a high modulus of elasticity even at high temperatures. The posts are spread slightly during assembly to allow placement of small pyrolytic graphite blocks between the crystal and posts. The blocks act as resistive heaters, and help thermally isolate the hot crystal from the highly conductive posts. When the compressive force of the posts is released, the crystal is held with strength and precision. The clamping force of the posts will remain near 5,000 psi for the life of the cathode.

The structure of the MVM is amazingly robust, sustaining reasonable impact without deviating from structural specifications. Because the graphite pads shield evaporation of the crystal in the direction of the clamping force, the emitter crystal can be fully utilized without degradation of the mount. Structural failure of the MVM is not a concern when the cathode is operated within the correct temperature and pressure range. Typically, the beam stability of the Mini Vogel Mount cathode exceeds the specifications of the system in which it runs.

Applied Physics Technologies LaB_6 and CeB_6 Cathodes (continued)

Manufacturer	Equipment Type	Cat. #	Description	
AMRAY	SEM all LaB_6 models	**80920-L**	LaB_6 90/16	
		80920	CeBix 90/16	
CAMECA	EPMA SX50, SX100	**80921-L**	LaB_6 90/16 nonshunted	
		80921	CeBix 90/16 nonshunted	
CAMSCAN	SEM all LaB_6 models	**80922-20-L**	LaB_6 90/20 nonshunted	
		80922-20	CeBix 90/20 nonshunted	
		80922-16-L	LaB_6 90/16 nonshunted	
		80922-16	CeBix 90/16 nonshunted	
ELECTROSCAN/ PHILIPS	ESEM 2020, E-3, XL	**80923-L**	LaB_6 90/16	
		80923	CeBix 90/16	
ETEC	LITHOGRAPHY	**80919-L**	LaB_6 90/30 nonshunted	
		80919	LaB_6 90/30 nonshunted	
HITACHI	SEM	**80924-L-S**	LaB_6 90/16	
		80924-S	CeBix 90/16	
	TEM	**80924-L-T**	LaB_6 90/16	
		80924-T	CeBix 90/16	
	High Resolution TEM Recommended for 200 kV+	**80924-LHT**	LaB_6 90/5	
		80924-HT	CeBix 60/5	
ICT/ADVANTEST	SEM	**80925-L**	LaB_6 90/16 nonshunted	
		80925	CeBix 90/16 nonshunted	
ISI/TOPCON	DS-130, DS-150, SS, IC and WB/CL series, SEM	**80926-LS1**	LaB_6 90/16 nonshunted	
		80926-S1	CeBix 90/16 nonshunted	
	DS-701, SM-501, ABT series, SX,-40, CCCD	**80926-LS2**	LaB_6 90/16	
		80926-S2	CeBix 90/16	
	002B TEM	**80926-L-T**	LaB_6 60/5	
		80926-T	CeBix 60/5	
		80926-LT1	LaB_6 90/16	

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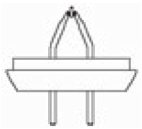
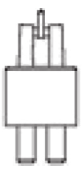
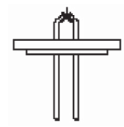
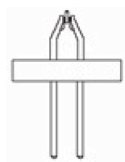
Applied Physics Technologies LaB_6 and CeB_6 Cathodes (continued)

Manufacturer	Equipment Type	Cat. #	Description	
JEOL	SEM, TEM, JAMP30, JXA 8600 High Resolution TEM	**80927-L**	LaB_6 90/16	
		80927	CeBix 90/16	
		80927-LHT	LaB_6 60/5	
		80927-HT	CeBix 60/5	
LEICA/LEO (Cambridge SMVM base)	200, 400 Series SEM	**80928-L**	LaB_6 90/16	
		80928	CeBix 90/16	
	360 SEM	**80928-L-S**	LaB_6 90/16	
LEICA LITHOGRAPHY (Philips base)	EBPG, EBL, VB Series	**80929-L-P**	LaB_6 90/16	
		80929-P	CeBix 90/16	
(Cambridge MVM base)	EBMF series 1-10.5, EBML	**80929-LCM**	LaB_6 90/20 nonshunted	
		80929-CM	CeBix 90/20 nonshunted	
(Cambridge SMVM base)	EBMF constant voltage	**80929-L-20**	LaB_6 90/20	
		80929-20	CeBix 90/20	
		80929-L-20S	LaB_6 60/40	
		80929-20S	CeBix 60/40	
OMICRON	LEED	**80930-L**	LaB_6 90/100	
		80930	CeBix 90/100	
PHILIPS	SEM, TEM, EBPG	**80931-L**	LaB_6 90/16	
		80931	CeBix 90/16	
ZEISS/LEO	SEM, TEM	**80933-L**	LaB_6 90/16	
		80933	CeBix 90/16	

All Cathodes are shunted unless listed as non-shunted

L90/16: 90 = 90* cone angle 16 = 16 micron flat

Kimball Physics Lanthanum Hexaboride (LaB_6) Filaments/ Cathodes

Features

Extended Life – Thousands of hours in clean vacuum. Guaranteed life (measured in surface loss). Guaranteed against mounting structure failure.

Exceptional Stability – Thermal/Chemical/Electrical. Precision machined carbon mounting. High over-temperature tolerance.

High Brightness/Low Energy Spread – Oriented single crystal. Best-Quality/High-Purity material.

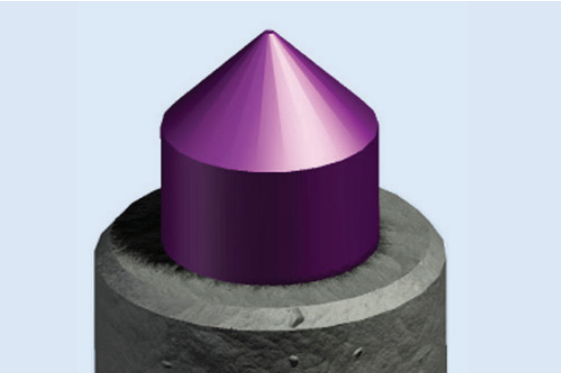
Accurate Microflats – Superior optics/controlled source size standard diameter available.

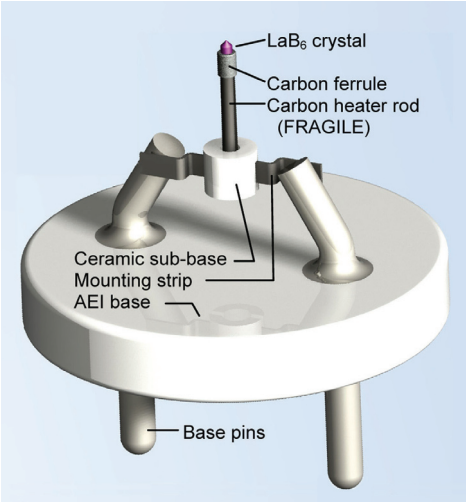
For Use in

- **Scanning Electron Microscopes**
- **Transmission Electron Microscopes**
- **Electronlithography Systems**
- **X-Ray Sources**

The new improved Kimball Physics Model ES-423E (Extended Life) LaB_6 Cathode is a high performance, resistively heated, thermionic electron source. The improvement stability of the LaB_6 crystal, results in less exposure of LaB_6, which reduces Wehnelt aperture contamination.

Its lifetime is in excess of 6 months with continuous operation. Continuous operation at the full operating temperature improves the thermal stability of the gun and hence beam current stability. It is no longer necessary to wait hours for stable beam conditions in order to perform quantitative EEL or EDX measurements.





Specifications

The emitter is machined to 15+/-2µm diameter (standard), microflat alignment to the instrument base can be provided (on request), oriented-single-crystal, <100> surface.

Mounted on the end of a single-piece, stress-free, carbon heater rod, held in place by a carbon ferrule.

A high degree of axial symmetry provides great mechanical stability.

The rod has a 100µm slot along the axis, which allows the heating current to go up one side and down the other.

In SEM type instruments, its lifetime is up to 3000 - 4000 hours In TEM instruments the lifetime can be even longer.

Mounting structure will last more than 10,000 hours.

Chemical reactivity and mechanical drift problems have been eliminated.

Instrument Conditions

While the cathodes can be fitted to virtually any instrument, there are several requirements needed for achieving quality results.

The most important requirement is for clean vacuum, with partial pressures of oxidizing gases being kept below 10^{-7} torr in the electron gun. The condition of the cathode itself, along with that of the Wehnelt aperture, may often be used to verify the partial pressures in the gun.

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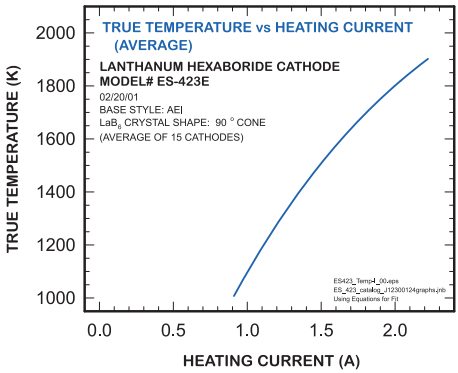
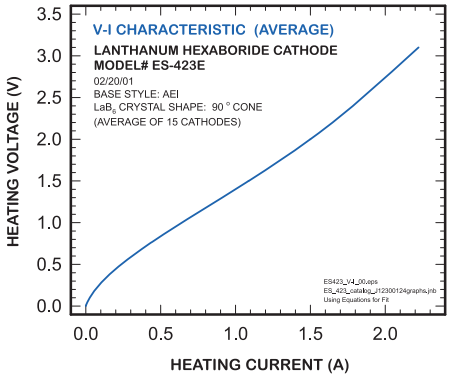
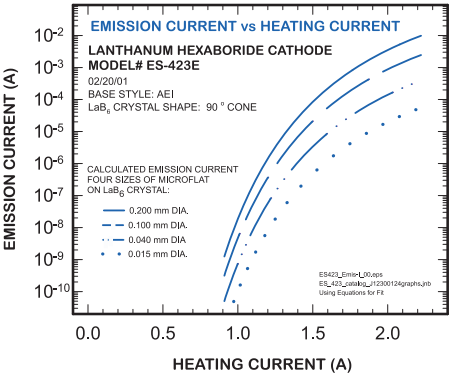
Kimball Physics Lanthanum Hexaboride (LaB_6) Filaments/Cathodes (continued)

The cathode must be accurately and correctly positioned behind the Wehnelt aperture.

There must be controllable bias resistors which can reach adequately high values; some instruments are limited by values which are to low.







Ordering Information

For most SEMs and TEMs, the standard Styles 90-15 (90° included angle with a 15*m flat) is recommended.

Style 90-15 (90° included angle with a 15*m flat) is recommended for Leica/Cambridge.

Style 90-06 (90° included angle with a 6*m flat) is for high resolution, and selective TEMs. This cathode provides higher brightness, but with some compromise in lifetime.

To order:

Specify Model: Model ES-423E & Style

i.e. Style 90-15 : Standard Microflat

Style 90-20 : Standard for Leica, Cambridge

Style 90-20 : 90° Angle w/non-standard microflat

Style 60-06 : 60° Angle w/non-standard microflat

Specify Instrument Manufacturer and Model No.

Specify Type of Instrument: SEM, TEM, STEM.

Cat. #	Description	Qty.
81080-15	1. Standard (90-15)	each
81080-20	2. Standard for Leica, Cambridge	each
81080-90	3. Non-Standard (90-20)	each
81080-60	4. Non-Standard Selective (60-06)	each

Example

Model ES-423E, Style 90-15 Standard for JEOL 820 TEM

Cat. # 81080-15

Electron Microscopy Sciences

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