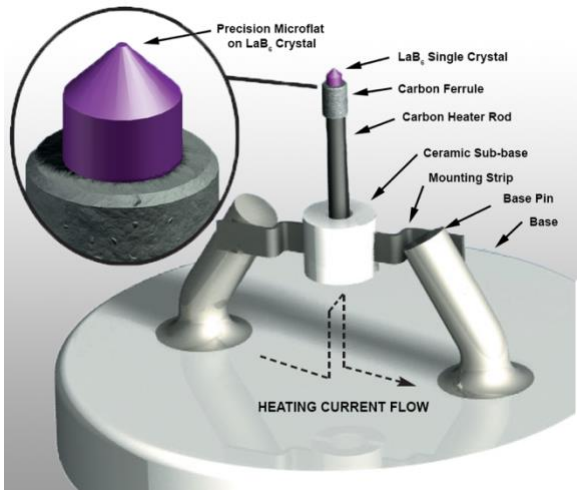
ES-423E (Extended Life) LaB_6 Crystal
User Information



LaB_6 single crystal cathode mounting: Heating current path through precision-machined, slotted single-piece carbon rod and with mounting strips; sub-base provides rigidity and easier mounting.

Introduction

The Kimball Physics ES-423E (Extended Life) Lanthanum Hexaboride LaB_6 Cathode is a high performance, resistively heated, thermionic electron source. It is currently employed in many brightness-limited electron optical systems: SEM's, TEM's, probes, electron lithography systems, etc. The emitter is a 15 µm diameter (standard) oriented-single-crystal, surface (standard) mounted on the end of a single-piece, stress-free carbon heater rod, held in place by a carbon ferrule.

The model ES-423 is available with the LaB6 crystal cut at a cone angle of 60º or 90º and a microflat size from 2 µm to 320 µm. These dimensions are included in the part number, the standard ES-423E style 90-15, having a 90º cone with a 15 µm microflat. The LaB_6 cathode is available mounted on a standard AEI base, a Kimball Physics CB-104 ceramic base, or on a variety of custom bases for particular SEM or TEM systems.

Handling

Cathodes are fragile and caution must be used in handling. Do not touch the cathode structure itself, only the cathode base.

The cathodes are shipped vacuum clean and ready to install. The use of clean room gloves is recommended to keep parts free of fingerprints and other contaminants.

Example of Cathode Transport Container.

To remove the cathode assembly from the purple shipping container:

a) Place the purple base on a level surface.
b) Holding onto the lower part (purple) of the shipping container, unscrew the upper cover (plexiglass) and remove it vertically to avoid hitting the cathode.
c) Loosen the Philips screws to release clamp on the cathode.
d) Carefully lift off the cathode assembly.

Example of cathode with AEI base secured in transport container base

Operating In Vacuum

A vacuum of $1x10^{-6}$ torr or better is required for proper operation of the cathode, but is not considered satisfactory for long life operation. A pressure of less than $5x10^{-7}$ torr (preferably $1x10^{-7}$ torr) is required for longer lifetimes. Cathode lifetime will increase as the vacuum is reduced to the 10^{-8} torr range. (Reference Kimball Physics Technical Bulletin #LaB6-02, "The Relationship Between LaB6 and Gun Vacuum" for additional information.)

Initial Run-Up

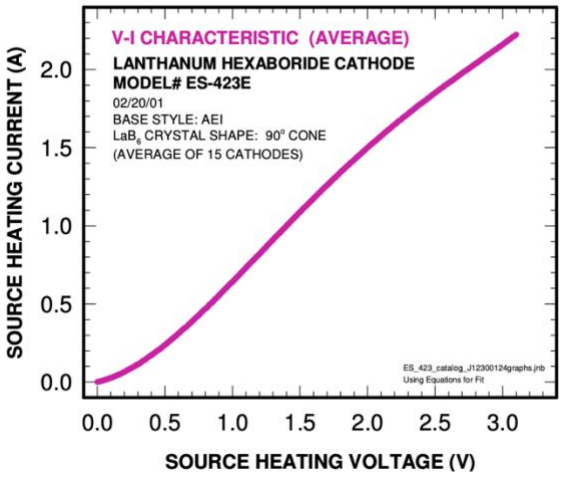
In commercial microscopes, follow the initial start–up procedure recommended by the manufacturer. This serves the purpose of outgassing water vapor form inside the Wehnelt cap (water vapor forms oxides on the LaB6 surface) and removes any oxides that have already formed on the LaB_6 surface. Alternatively, for outgassing, run the cathode at reduced power (about 1.9 V at 1.4 A) for 15 to 20 minutes. During this initial run-up, the pressure in the gun will increase and should not be allowed to exceed $1x10^{-6}$ torr. The temperature should be adjusted up to the normal operating temperature gradually so that pressures do not exceed $1x10^{-6}$ torr in the process. For operation, pressures of 10^{-7} torr are recommended. The ES-423E cathode is designed to resist thermal shock: after the initial run-up and outgassing of the Wehnelt, the cathode can be turned off and on to maximum current instantly.

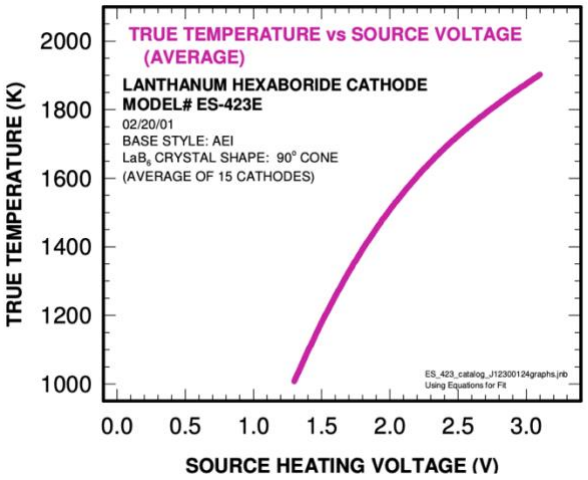
Operating Power

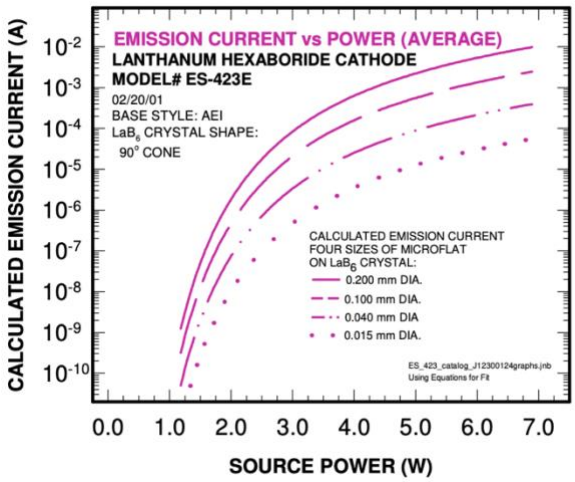
During typical operation, the temperature of the LaB_6 crystal is in the range of 1700 K (~1.73 A) to the maximum high brightness temperature of 1900 K (~2.12 A) (1425ºC to 1625ºC). Increasing the power gradually, in small increments, will enable the operator to stop at saturation. The cathode power at saturation will depend on the setting of the bias resistor value. (Reference Kimball Physics Technical Bulletin

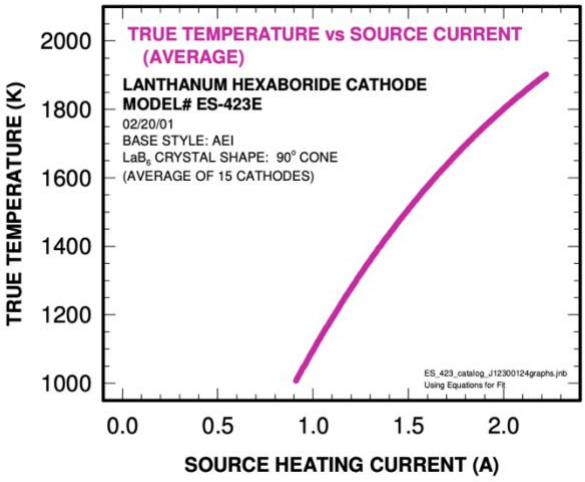
CATHODE ES-423E	
CATHODE MATERIAL	Lanthanum Hexaboride (LaB6) single crystal
CATHODE SHAPE	Cone with 60 or 90º sides and microflat tip
MICROFLAT SIZE	Standard: 0.015 mm dia., larger or smaller diameters available
HEATER	Single piece carbon rod
EMISSION AREA	$1.7x10^{-6}$ cm^2 standard microflat, excluding sides
EMISSION CURRENT	0.051 mA (standard microflat)
HEATING CURRENT	1.7A to 2.1A
CATHODE LOADING	20-30A/cm^2 recommended High loadings result in reduced lifetime
BRIGHTNESS	$>10^6$ A/cm^2/sr

CATHODE ES-423E	
WORK FUNCTION	2.69 eV
OPERATING TEMP	Approx. 1700-1900K
ENERGY SPREAD	Approx. 0.4 eV
LIFETIME	Thousand plus hours with medium currents, good vacuum
VACUUM LEVEL	10^{-7} torr or better recommended
POWER SUPPLY CAPABILITY	Voltage regulated power supply recommended, 4V, 3A
BASES	AEI, CB-104, electron microscope bases, and other custom bases available









Typical Parameters of the ES-423E LaB_6 Cathode

CAUTION

Kimball Physics recommends that the LaB_6 cathode be operated only in a vacuum of **10^{-7} torr** or better and at currents less than **2.1 A**.
Poor vacuum or excessive current will reduce cathode lifetime.

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#LaB6-01, “General Guidelines for Operating ES-423E LaB6 Cathodes,” for further details.)

The onset of saturation should be observed with the aid of the cross-over image in TEM’s or the electron emission pattern (EMP) in SEM’s. Always run the cathode at the minimum power necessary for adequate emission at saturation. As with all cathodes, there is a compromise between operating lifetime and total emission current (brightness). See graphs for typical operating parameters of the cathode.

CAUTION: Operating the cathode above 2.1 A will limit the lifetime of the cathode to a few hundred hours.

Emission Instability

The surface of a truncated cathode is sensitive to gas evolution from the condenser lens liner tube during the initial stages of use. Gas pulses, due to electron desorption or heating, can result in emission current variations, which result in sudden changes in the appearance of the cross-over image or the EMP. These patterns will expand or contract symmetrically about their center. This effect can persist for a period of about one day in some instruments, while in others, the effect is small and frequently not noticed. Sudden sideways motions of the cross-over image or the emission pattern are most likely due to contamination of the Wehnelt aperture or the liner tube in the region of the condenser lenses. The above instabilities should not be attributed to the cathode, but to contamination of the surfaces within the instrument during loading of the cathode.

Service for Repair / Breakage

If a problem arises during initial installation, call Kimball Physics at for further assistance. Cathodes may be returned to Kimball Physics for evaluation and possible repair with a return authorization number. In case of breakage, handle the cathode assembly with tweezers, being careful to touch only the carbon mount or the base of the cathode (never the cone or the flat). If broken off prior to usage, place the cathode in a capsule or in tissue or secure with double-sided adhesive, and return to Kimball Physics along with the cathode base in the original shipping tube. Unused cathodes can often be repaired, provided the crystal is in good condition.

References

For more information on LaB_6 operations, you may download additional detailed technical bulletins from the website cathode resource page:

LaB_6-01 General Guidelines for Operating LaB6 Cathodes.
LaB_6-02 The Relationship Between LaB_6 and Cathode Life and Gun Vacuum
LaB_6-03 Emission Drift—LaB_6 and Gun Stability
LaB_6-04 Oxygen Activation of LaB_6 Cathodes—The Double Saturation Effect
LaB_6-05 Kimball Physics ES-423E LaB_6 Cathode Style 60-06 (60° Included Cone Angle, 6μm Diameter Flat)
LaB_6-06 Kimball Physics ES-423E LaB_6 Cathode Operating Instructions for LEICA/Cambridge
LaB_6-07 Recovery of Emission From ES-423E LaB_6 Cathodes Following a Vacuum Dump

LaB_6 ES423-E

LaB6 Cathode (ES-423E) - Cathodes / Emitters- Extended Life LaB6 Cathode- Description and Specifications
LaB6 Cathode (ES-423E) - Cathodes / Emitters- Extended Life LaB6 Cathode- User Information.

Notes:
1. Charts /graphs show typical performance, data is for guidance only
2. It is not necessarily possible to achieve all maximum specifications simultaneously.
3. Specifications Subject to Change Without Notice.
4. DE Altobelli, DT Taylor 01/12/2023

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