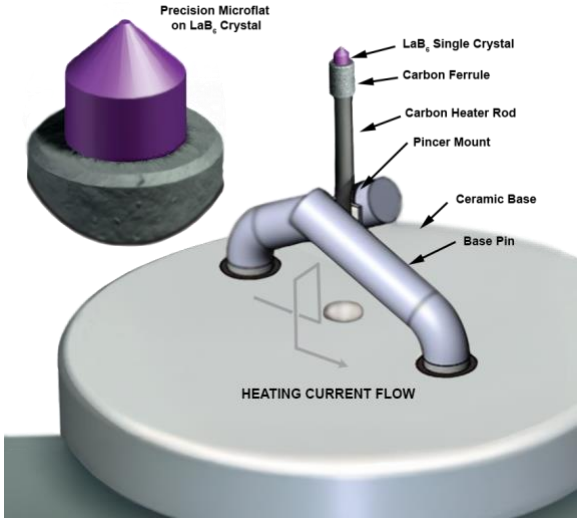
ES-462 (Pincer Mount) High Performance LaB_6 Cathode

FOR USE IN:

- Scanning Electron Microscopes
- Transmission Electron Microscopes
- Electron Lithography Systems
- Electron Accelerators
- X-ray Sources
- Free Electron Lasers
- Custom Applications

FEATURES / OPTIONS:

- **Exceptional Stability**
  - Robust electrical connections and improved heat-sinking
  - Low mechanical motion
  - High over-temperature tolerance
- **High Brightness / Low Energy Spread**
  - <100> oriented single crystal
  - Best quality / high purity material
- **No Magnetic Materials**
- **Extended Lifetime**
  - Thousands of hours in clean vacuum
  - Guaranteed against structural mounting failure
  - Precision machined carbon mounting



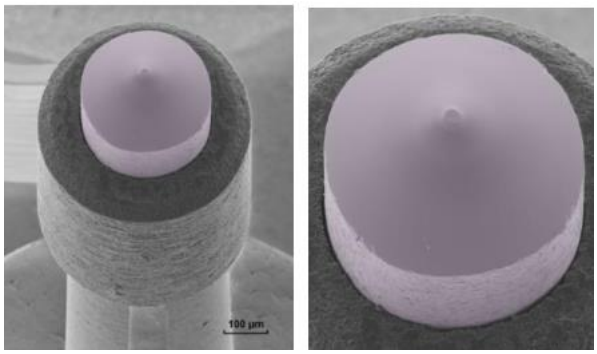
LaB_6 single microflat crystal with "pincer mount" mechanism, with two molybdenum pins firmly clamping the slotted precision single carbon rod heater on a rigid ceramic AEI base, to provide excellent functional stability.

- **Accurate Microflats**
  - Superior Optics
  - Controlled source size
  - Wide range of diameters

The Kimball Physics ES-462 (pincer mount) lanthanum hexaboride cathode is a high performance, resistively heated thermionic electron source. It builds off the long-time success of our ES-423E cathodes, utilizing the same well-proven heater structure and achieving the same extended lifetimes.

Like its predecessor, the ES-462 is ideal for use in many brightness-limited electron optical systems, including SEMs, TEMs, probes, and electron lithography tools. However, the ES-462 brings a significant *improvement in operating stability* that makes it the preferred choice for demanding applications in which constant beam current is important.

Our patented ES-462 cathodes incorporate improved heat-sinking and robust electrical



The ES-462 shares the same LaB6 single crystal and carbon heater of its predecessor, the ES-423E. These SEM views show the crystal mounted on the precision machined carbon heater rod. This cathode has a 15 micron microflat at the <100> apex of the LaB6 crystal.

connections to produce a LaB_6 emitter with unrivaled *electrical and positional stability*.

The "pincer mount" mechanism, found in the ES-462 LaB_6 cathodes, uses two molybdenum pins to directly and firmly clamp the carbon heater. Pincer mount cathodes consistently display minimal resistance fluctuations, even at high operating temperatures of 1800 K or greater . They retain extreme stability after over 10,000 temperature cycles from room temperature to 1800K and back, and after more than 100 days of continuous operation. *Stable resistance equates to stable operating temperatures, which in turn improves the stability of the cathode's emission*.

The same robust mounting scheme that gives excellent resistance stability also produces a cathode with excellent *spatial stability*, with minimal off-axis thermal motions upon heating. This allows pincer mount cathodes to remain in optimal alignment with other elements in the electron optical system when heated from room temperture to operating temperature.

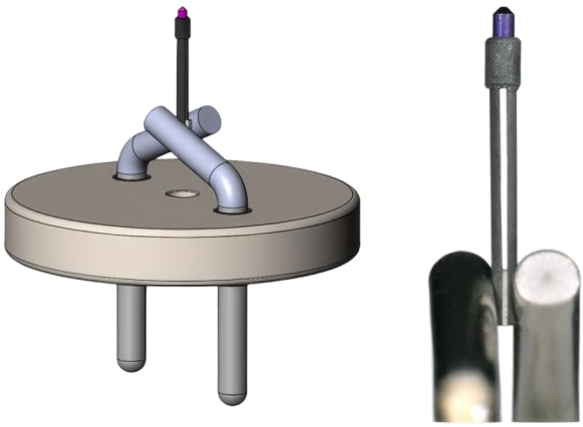
The ES-462 maintains these high stability features throughout the same extended lifetime enjoyed by users of our previous generation ES-423E cathodes. Many instruments can achieve thousands of hours of stable cathode operation at 1800 K with vacuum pressure in the range of 10^{-8} to 10^{-7} Torr. In commercial SEM instruments, our LaB_6 cathodes may achieve lifetimes of 3000-4000 hours at operating temperatures of 1850 K (with material surface loss rates in the 0.025 micron/hour range), or longer at slightly lower operating temperatures, such as are required by typical TEM instruments. The ES-462 carbon mounting structure is extremely robust and will outlast the usable life of the LaB_6 crystal: the heater will continue its stable operation long after the LaB_6 has completely evaporated away.

ES-462 cathodes are available with microflat diameters ranging from 6 to 330 microns. (Larger diameters up to 2 mm are available as part of our ES-466 pincer cathode series).

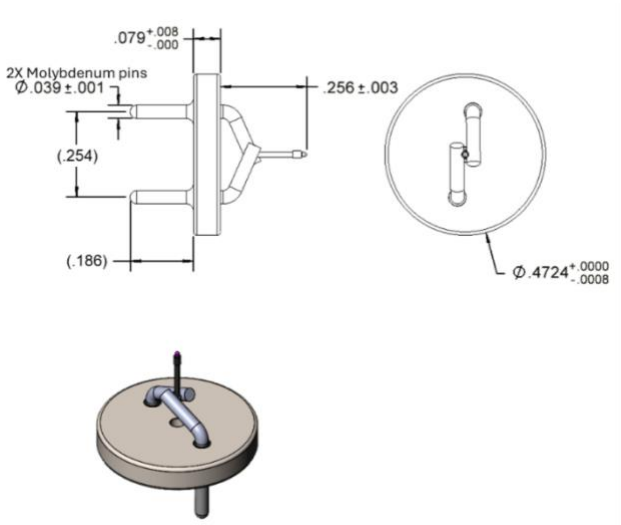
Each cathode contains a <100> oriented single crystal of LaB_6 (or CeB_6 upon request). The crystal is mounted onto the end of a single-piece carbon heater rod, which has been precision-machined with an axial slot. Heating current goes up one side of the rod and down the other, forming a minimal current loop that minimizes magnetic fields.

The optimized geometry of the carbon rod and its interface with the LaB_6 crystal enables the carbon to heat the crystal with no heating-current passing through the crystal itself. There is no high-temperature current-carrying joint, which significantly improves the stablilty and reliablity of the cathode.

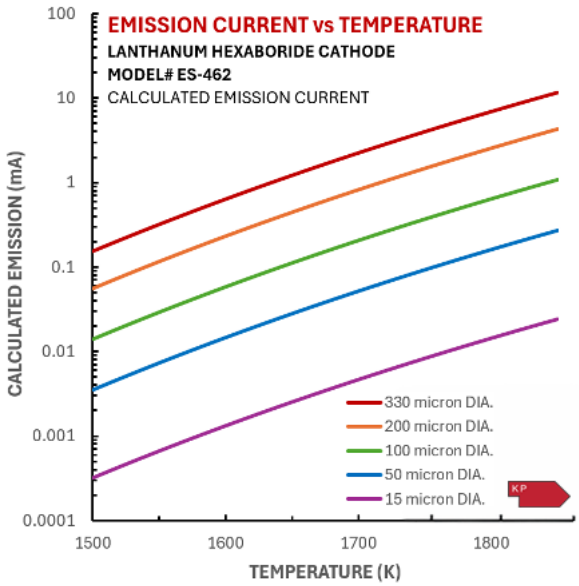
All ES-462 cathodes are mounted onto a ceramic AEI base with non-magnetic molybdenum pins.



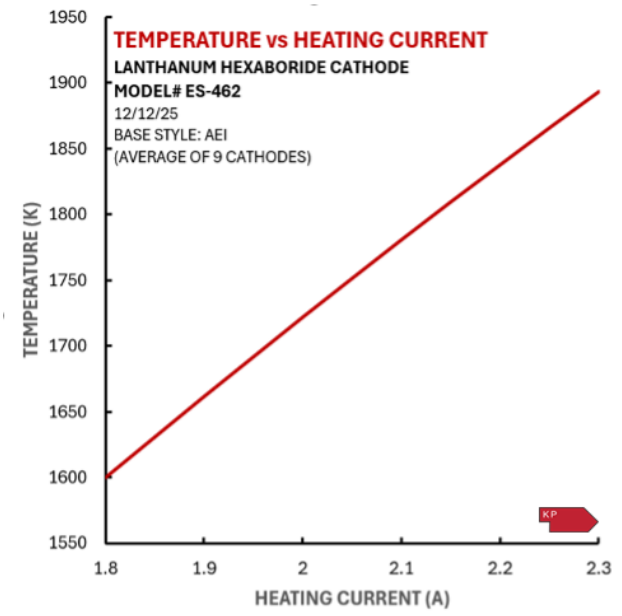
ES-462 cathodes are available on AEI base. Heating current passes through a precision machined carbon rod held firmly in place by the pincer mount using two adjacent non-magnetic molybdenum pins. The cathode image to the right has a 100 micron microflat. (U.S. Patent No. 12027340B2)



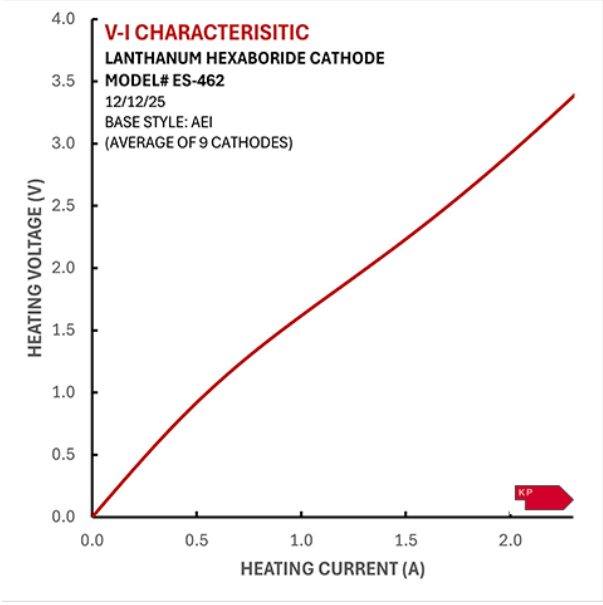
ES-462 single crystal LaB6 cathode on AEI base. All dimensions are in inches.



Calculated emission vs temperature, using a Richardson constant of 80 $A/cm^2 \cdot K^2$. The calculations assume temperature-limited emission. Actual emission will most likely be slightly lower.



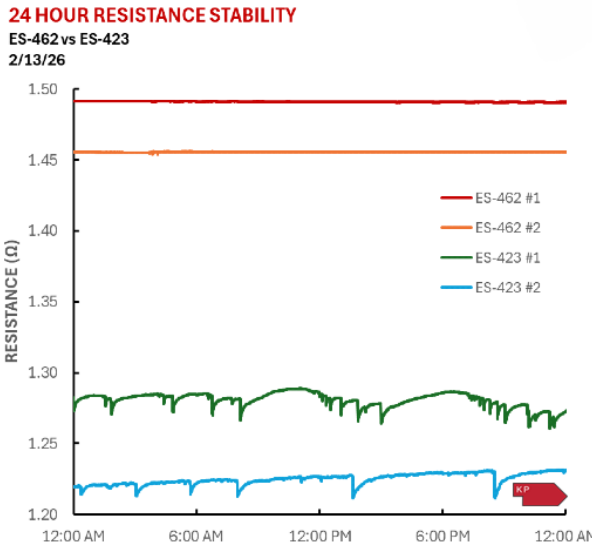
Average temperature vs heating current for 10 ES-462 cathodes running in a Kimball Physics test chamber. Heating current vs temperature varies depending on cathode mounting and heat sinking. In real-world systems, the heating current required to reach 1800 K may vary between ~1.7 A - 2.3 A.

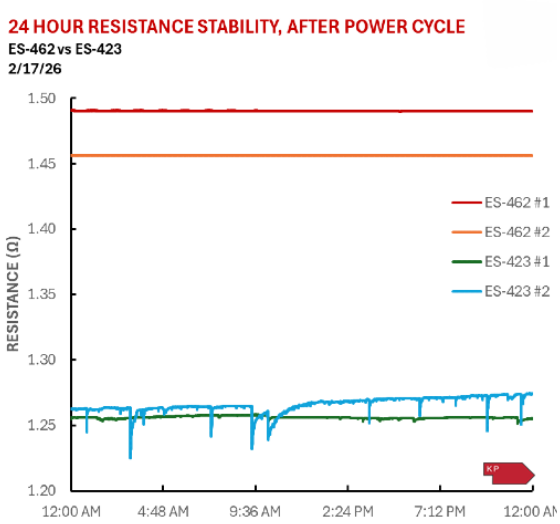


Average V-I relationship for 10 ES-462 cathodes running in a Kimball Physics test chamber. The required heating voltage will vary depending on the lengths of cables and types of electrical connections. The plotted voltage was measured directly at the cathode base pins.

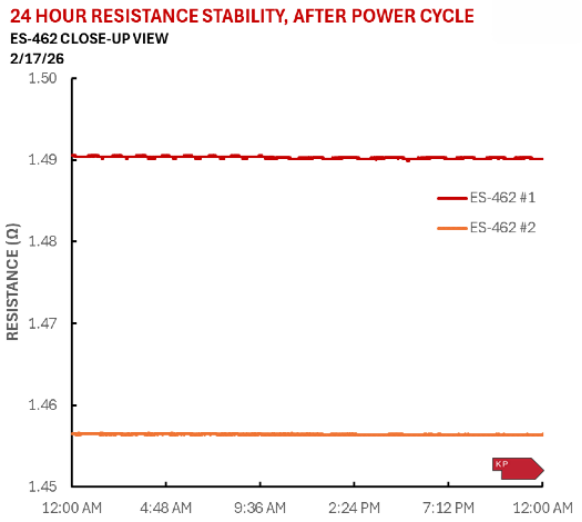
How do ES-462 cathodes compare to ES-423E cathodes?

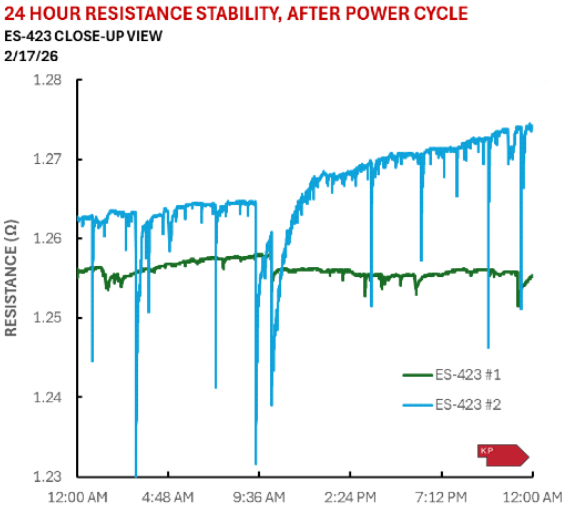
The ES-423E cathode has been an industry-leading design for decades, and it continues to work well for many applications. However, for demanding uses where beam stability is of the utmost importance, the ES-462 is a preferred choice.





Comparison of ES-423E and ES-462 cathodes running in the same chamber at 1800 K over two 24 hour periods, with a power cycle in between. Not only are the ES-462 cathodes significantly more stable, but their behavior is unchanged by the power cycle, unlike the ES-423.





A closer look at the second 24 hour period. The two plots have the same Y-axis range. The small fluctuations on the ES-462 plot are largely due to the resolution limit of the power supply. An additional plot of ES-462 resistance fluctuation (from different cathodes) over a weeklong period is shown at the end of this document.

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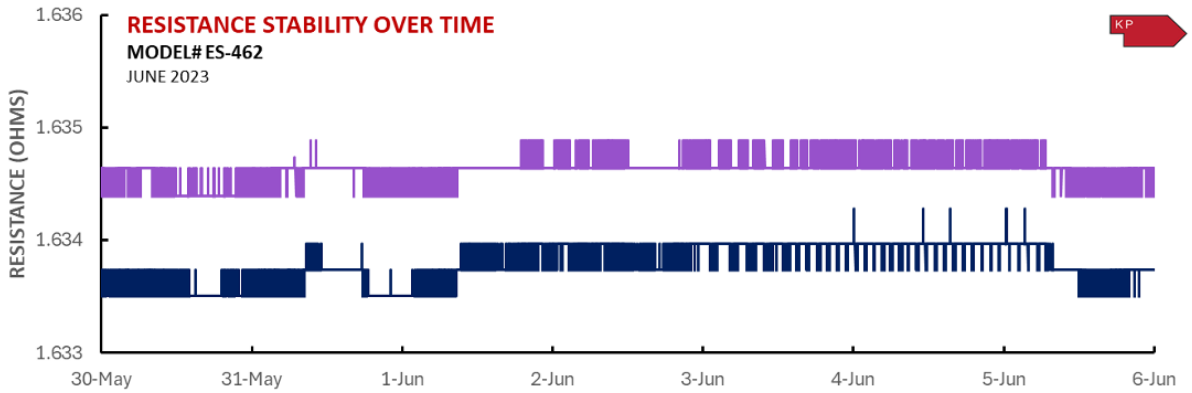

Resistance stability for additional two pincer cathodes over a weeklong period. Note that the Y-axis scale is much condensed relative to the previous plots.

CATHODE ES-462	
CATHODE MATERIAL	Lanthanum Hexaboride (LaB6) single crystal
MICROFLAT SIZE	6 microns to 330 microns
HEATER	Single piece carbon rod
HEATING CURRENT	1.7A to 2.3A (system dependent)
CATHODE LOADING	~15 A/cm^2 recommended High loadings result in reduced life
BRIGHTNESS	>10^6 A/cm^2/sr

CATHODE ES-462	
WORK FUNCTION	2.69 eV
OPERATING TEMP	~ 1700 - 1900 K
ENERGY SPREAD	~ 0.4 eV
LIFETIME	Thousand plus hours with medium currents, good vacuum
VACUUM LEVEL	1 x 10^{-8} to 5 x 10^{-7} Torr recommended
POWER SUPPLY CAPABILITY	Voltage regulated power supply recommended, 5V, 3A
BASES	AEI

CAUTION

Kimball Physics recommends that LaB6 cathodes be operated only in vacuum between **$1x10^{-8}$ and $5x10^{-7}$ Torr**, and at temperatures between **1650-1850 K**. **Poor vacuum or excessive temperatures will reduce cathode lifetime**. Extremely good vacuum or lower operating temperatures may cause temporary suppression of emission.

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

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. AM Calvey, 1/20/2026; AM Calvey, DE Altobelli 3/2/2026

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