Cathode Source Materials ~ Borides, Carbides, Refractory Metals

Overview:

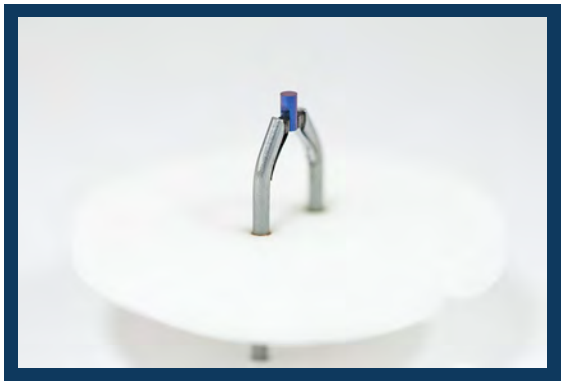
APTech is a specialty producer and supplier of CeBix® cathodes (cerium hexaboride), LaB_6 cathodes (lanthanum hexaboride), HfC cathodes (hafnium carbide), CFE and ESE sources. Our cathodes have been used in many different applications: microscopy, microanalysis, additive manufacturing, and many other industries applying electron emission to their work.

Applied Physics Technologies has decades of experience in research, development, and manufacturing various cathodes using different sources. We can provide the cathodes you need for replacement and various custom applications.

www.a-p-tech.com

1600 NE Miller Street • McMinnville, OR 97128 • P: 503.434.5550 • F: 503.434.1312 • E: APTsales@a-p-tech.com

Cerium Hexaborides (CeB_6) CeBix® Cathodes



The unique properties of CeBix® crystals provide stable electron emitting media with work functions less than 2.6 eV. The low work function yields higher currents at lower cathode temperatures, which means greater brightness, or current in the beam, and longer CeBix® cathode life.

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 CeBix® in a controlled atmosphere of inert gas, allowing 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.

CeBix® cathodes 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 20 A/cm², and may be fabricated in a variety of shapes and with many different heating and mounting configurations. CeBix® cathodes are the materials of choice for high current cathodes in a variety of advanced and custom applications. APTech is the only producer of CeBix® cathodes worldwide.

Performance & Lifetime

Vacuum requirements are more stringent for CeBix® cathodes than others in order to minimize contamination. CeBix® cathodes are proven to be more resistant to the negative impact of carbon contamination, adding to the lifetime of the cathode. CeBix® cathodes have an evaporation rate lower than LaB_6 cathodes when temperatures near 1800 K. As long as care is taken to operate the cathode below 1800 K, a CeBix® cathode should maintain an optimum tip shape longer, making it the longest lasting cathode available.

	CeB_6 <100>	LaB_6 <100>	Tungsten Filament
Brightness (A/cm^2-sr)	10^7	10^7	10^6
Short-term Beam Stability (% RMS)	<1	<1	<1
Typical Service Life (hr)	1500+	1000+	100
Operating Vacuum (torr)	10^{-7}	10^{-7}	10^{-6}
Effective Work Function (eV)	~2.65	~2.70	4.5
Evaporation Rate (g/cm^2-sec) @ 1800 K	1.7×10^{-9}	2.3×10^{-9}	N/A

Lanthanum Hexaborides (LaB_6) Cathodes

The rare earth hexaboride compounds exhibit an excellent combination of low work function and low volatility. In fact, LaB_6 is in wide-spread everyday use in a variety of fine-focused electron beam instruments. LaB_6 cathodes are ideal for many small spot size applications such as SEM, TEM, sterilization, surface analysis and metrology, and for high current applications such as lithography, x-ray sources, small space space-craft thrusters, and even electron-beam welders.

The unique properties of lanthanum hexaboride crystals provide stable electron emitting media with work functions near 2.70 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 LaB_6 cathode life. Typically, LaB_6 cathodes exhibit 10 times the brightness and 50 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.

We grow and fabricate our own high quality, LaB_6 single-crystal materials as well. Our floating zone refining technique has been perfected over the years to produce some of the purest material available. This coupled with our stringent and exacting composition requirements produces both the purest and the lowest work function LaB_6 available anywhere in the world.

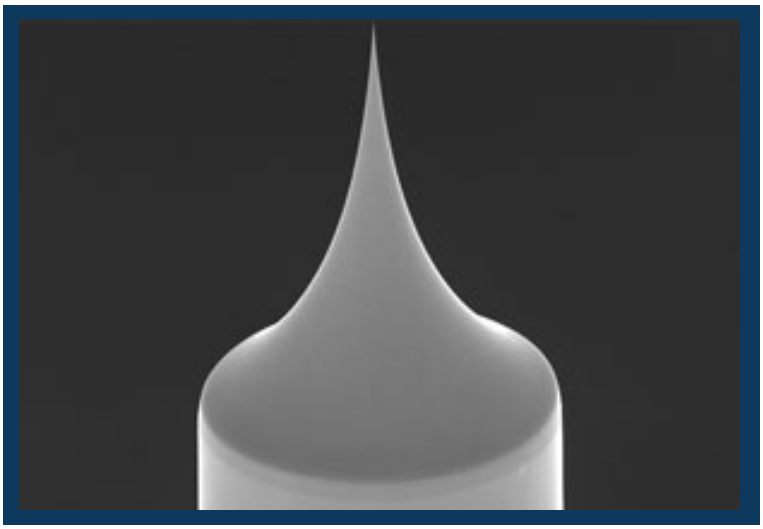
Transition Metal Carbides

Transition metal carbides are good candidates for durable electron sources that can perform well even in relatively poor vacuum environments. Carbides are characterized by very high melting points, extreme hardness, and relatively low work functions. Hafnium carbide has the highest melting point of any binary substance at 3890°C and has work functions in the 3.3 to 3.6eV range. In general, the transition metal carbides have unique properties that can make them well suited for use as thermionic emitters in areas where conventional cathodes would quickly fail. These uses could entail operation in residual oxygen, CO, CO_2 atmospheres.

APTech has developed zone refining techniques to obtain purified single crystal stock of specific orientations. This material has been used in plane-dependent work function and surface chemistry studies. We have performance studies of single crystal thermionic emitters and single crystal etched field emitters made from these carbides, which show their utility and robustness or electron sources. Stoichiometry is controlled through the addition of carbon to the starting sintered stock and in controlling the zone refining process. APTech is able to create single crystal HfC, ZrC, TiC, and NbC transition metal carbide material and others upon request.

Refractory Metals

Tungsten



Applied Physics Technologies offers both single crystal tungsten wire and single crystal tungsten rod. Diameters range from 0.12 mm (etched wire) to 2.5 mm (as-refined rods). Orientations offered include (100), (111), (210) and (310).

Single crystal tungsten wire is zone refined and axially oriented to the specified crystal plane within 2°. The refining process purifies and reduces impurities to less than 30 parts per million by weight. Standard wire sizes are centerless ground, electrochemically etched to the specified diameter, +/- .0003", and then cut to the specified length +/- 5%.

Other Refractory Metals

Many other refractory elements can be refined in our facilities. These are also purified during the refining process and oriented single crystal rods are produced. We have a ready supply of seed crystals of common orientation and can custom make virtually any orientation. Common metals include: Mo, Re, Ir, Ta, Hc, Pt, Ni, etc.

Custom Cathodes

Applied Physics Technologies is involved with the production and development of electron emitting materials and electron sources. Custom design and fabrication capabilities augment our standard catalog items to meet our customers' needs. Partnering is available for your more challenging product requirements, particularly for key component realization. Applied Physics Technologies maintains an active role in fundamental electron emission research and publication, striving to bring the newest ideas from the laboratory to the marketplace. Please visit our website: **www.a-p-tech.com** or call us at **503.434.5550** for more information.

APTECH
APPLIED PHYSICS TECHNOLOGIES

WWW.A-P-TECH.COM
1600 NE Miller Street
McMinnville, Oregon 97128
503.434.5550
APTsales@a-p-tech.com