Evaporation Sources

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➤ Evaporation Sources & Heating Methods

Introduction to Evaporation Sources

Evaporation occurs when the atoms/molecules of the evaporant (the material being evaporated) achieve sufficient energy to overcome the solid/liquid binding forces and enter the gas phase. To increase the evaporation rate, the average energy is increased by raising the evaporant's temperature. Expressed another way, raising its temperature increases an evaporant's vapor pressure (VP).

It's a common misconception that a solid has no VP, but as it melts, vapor suddenly appears. Melting has nothing to do with vapor pressure! For all materials (that do not decompose) VP versus temperature is a smooth curve—with the material's melting point being at just one point on that curve. Honig and Kramer's *Vapor Pressure Data for the Liquid and Solid Elements* (RCA 1969) clearly shows the non-relationship between VP and melting point.

The most striking examples are two pairs of metals: gallium/gadolinium and magnesium/aluminum. The first pair have melting points of 29.76° C (Ga) and 1312° C (Gd). Yet their VPs are within a factor of 10 from 10^{-11} Torr to 760 Torr. The second pair's melting points are 650° C (Mg) and 660.32° C (Al). However, Mg's VP is 10^{7} higher than Al's VP at any temperature.

The strict relationship between VP and temperature for each evaporant has at least one important consequence when evaporating alloys or mixtures. Except in rare circumstances, it's impossible to evaporate an alloy and make a film of identical stoichiometry. For example, evaporating 20/80 Sn/Pb solder gives, initially, a film of almost pure Pb since its VP is 10^{6} times higher than Sn's. (*Dilution* and *activity coefficient* affect the vapor composition too, but these issues are beyond this simple introduction.)

When evaporating compounds, there are few general rules. Some compounds (e.g., MgF_2 and KI) evaporate as molecules and the film's stoichiometry is identical to the compound's. Oxides may: dissociate completely, evaporate as lower oxides, evaporate as non-stoichiometric oxides, or give films with compositions identical to the evaporant. Compound semiconductor materials, the so-called III-V, II-VI materials, present a complex mix of results. Individual components may evaporate as dimers or tetramers, depending on the temperature (again, concepts beyond this simple introduction).

Heating Methods

Four heating techniques are commonly used to evaporate materials for thin film deposition. Different names may be applied but generally they are known as:

- Direct resistive heating
- Indirect resistive heating
- E-beam evaporation
- Pulse laser deposition (or ablation)

Direct Resistive Heating Thermal Sources

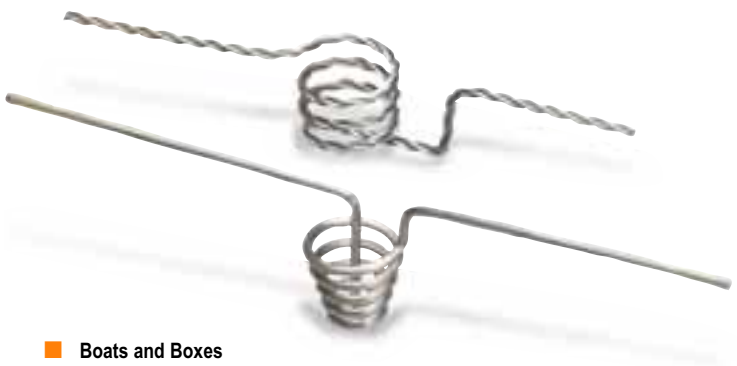
The evaporant is placed on/in a refractory metal source through which a high electrical current flows. The method's low equipment costs are balanced by the difficulty of maintaining a constant evaporation rate (when compared with other techniques) and possible reactions between evaporant and boat material. These devices are often called *thermal sources* and are essentially open heaters frequently without thermal radiation shielding, insulation, or any tricks to reduce thermal gradients.

Filaments

Single- or multiple-strand tungsten wire is bent into a shape (loop, point, coil) that suits a particular mounting or the required evaporation pattern. Evaporant is deposited on the wire by dipping into a melt, into a solution of a thermally degradable salt, or physically capturing pieces. The material's evaporation rate is varied by changing the current. If the material wets or alloys with the heater, non-reproducible or continuously changing evaporation rates may occur. Since this source is inexpensive, it is often used once and discarded.

Basket Heaters

If a refractory metal wire is shaped into an inverted conical basket, larger "pieces" of material can be inserted into the cone. These are also used to heat small crucibles.



Boats and Boxes

Thin, flat tungsten, tantalum, or molybdenum sheets are formed into shapes with creases, dimples, folds, bends, etc., to hold evaporant. The complexity ranges from a dimple in a strip to multichamber baffled boxes with sideways-pointing vapor chimneys. The "baffle" in a baffle box prevents a line-of-sight between evaporant and substrate. This type of source is used where the evaporant is known to "spit" (crepitate).

Coated Boats

A variant of the normal boat, a coated boat has a thin coherent layer of aluminum oxide covering the dimple. These boats are sometimes recommended for applications where the hot evaporant reacts with refractory metals.

Rods & Screens

For very specific applications, thick tungsten rods and fine meshes/screens are recommended. Chromium evaporation is one common example. The thick rod has lower resistance than a filament, making it easier to control lower evaporating temperatures. Meshes are sometimes used to extend the coverage area without moving the substrate.

Indirect Resistive Heating Thermal Sources

With indirect resistive heating, a crucible holds the evaporant in isolation from the heater filament. The increased thermal mass and the evaporant/heater separation stabilizes the evaporation rate. Various iterations of these indirectly heated devices are called Knudsen cells, K-cells, effusion sources, diffusion cells, evaporation cells, etc. But distinctions between these names are blurring as manufacturers explore designs that use features from several devices.

Knudsen Cells

Where repeatable, constant evaporation rates are required, Knudsen cells are chosen. The classic Knudsen cell is a large-mass, small-volume tungsten container with a close-fitting thick lid where an inverted conical-shaped aperture is bored. The container is mounted on tungsten needle points to reduce thermal losses and surrounded by tungsten heater filaments and diffusers to ensure a uniform temperature. Outside the heaters, several layers of reflective radiation shielding further reduce thermal gradients in the cell.

With the cell maintained at a uniform, constant, and known temperature, the evaporant's equilibrium vapor pressure is known. The aperture is small so the vapor lost through it does not significantly affect the cell's internal pressure, and the evaporant's effusion rate is constant. In addition, the small aperture means the vapor emerges in a cosine distribution (the flux issuing at any given angle to the cell lid's normal is proportional to the cosine of that angle). The maximum temperature for the classic Knudsen cell is around 2000K to 2100K.

Evaporation Cells

Evaporation cells are based on the Knudsen cell design but are/have:

- Less mechanically complex
- Easier to fill
- Larger capacities
- Larger orifice diameters to increase material flux
- Lids or vapor shutters
- Less stringent thermal gradient specifications
- Higher deposition rates

These devices are known as K-cells, effusion cells, evaporation sources, or thermal sources. Although the vapor plume does not have a cosine distribution, these source have many thin film applications, including molecular-beam epitaxy, low temperature evaporation (100–500º C) for organic compounds, and high temperature evaporation (1500º C) for metals and inorganic compounds.

Some heaters are flat ribbons arranged parallel to the crucible's long axis. This helps reduce temperature gradients in the important central zone. In other designs, the heater wires are more closely spaced at the crucible's ends to combat thermal end-effects.

The crucible is typically a pure alumina cylinder closed at one end with a wide bore to increase the vapor flux. This source is well-suited to conventional evaporation but some low thermal mass versions are used as flash evaporators.

Thermal Sources

Some thermal sources described in *Direct Resistance Heating* can be constructed to accommodate crucibles and, therefore, fit in this section. In particular, refractory metal wire baskets or refractory metal boxes can be shaped into truncated cones of appropriate depth and slope to suit a given crucible. While such heaters lack the refinements and end-effect correction found in the evaporation cells, they provide inexpensive approaches to film deposition of materials that can't be in direct contact with a refractory metal.

E-Beam Sources

The electron-beam (e-beam) source's high deposition rates and large evaporant capacity make it convenient for production-scale coating machines. Solid evaporant such as powder, granules, lumps, or shaped starter sources, is placed in the source's copper hearth or in a crucible liner. A high electron flux generated by a hot filament placed below the source is electrostatically and magnetically focused on the top of the evaporant. The electron beam's energy raises the evaporant's surface temperature. Often the beam is rastered to increase the evaporation area. Since the evaporation area is surrounded by cooler (often solid) evaporant, unlike other thermal sources, the e-beam source's vapor plume is largely uncontaminated by crucible liner material.

Production scale e-beam sources are usually single pocket (one hearth). Multipocket sources (4 or 6 hearths) are available for R&D applications. A cover plate obscures the pockets "not-in-use" to prevent vapor *cross-contamination*. Multipocket sources are particularly convenient when depositing multilayer films on a single substrate.

The drawbacks of e-beam evaporation are similar to those of thermal evaporation, but they are more apparent in the e-beam source—the source must be mounted upright (to prevent the evaporant spilling), evaporants often "spit" and must be heated in a series of *ramp/soak* steps to evaporation temperature, and the melt presents a high-temperature source that thermally radiates the substrate.

Pulse Laser Deposition (PLD) Sources

PLD uses repetitive pulses from a laser of appropriate power density, angle of incidence, and wavelength to ablate a localized area of evaporant into a vapor plume. The wavelength is important to maximize photon absorption rather than reflection. The *flash* evaporation nature of this technique, at least in the small volume in which the laser pulse's energy is dumped, is advantageous when evaporating alloys or mixtures. The vapor plume tends to be stoichiometrically similar to the bulk; however, the PLD vapor plume is not particularly convenient because its flux distribution is closer to $\cos^6$ to the evaporant's surface normal.

Crucible and Liners

The crucible and liners are used to (A) keep the e-beam hearth free of evaporants or (B) to act as the evaporant container for basket or foil thermal sources. For an e-beam source, a liner provides an often unrecognized benefit—an efficient thermal barrier. The same deposition rate requires only 1/4 the power needed if a liner is not used. This reduces operating costs and lowers the system's thermal burden; however, any liner must be electrically conductive to dissipate the electron charge. For a thermal source, the crucible thermal resistance is a serious but unavoidable disadvantage. The heater is usually much hotter than the evaporant's average temperature.

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Crucible Liners for E-Beam Sources

Reference Table: Hearth & Crucibles Listed by Manufacturer

Original Manufacturer	Source Model	Pocket Size	Hearth Pockets	KJLC® Crucible Model
Balzers	ESQ-110	7cc	4	EVCEB-4
	ESQ-113	30cc	4	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
FerroTec	EVM-1	8cc	1	EVCEB-4
	EVM-1	40cc	1	EVCEB-6
	EVM-1	100cc	1	Call
	EVM-6	2cc	8	Call
	EVM-6	4cc	6	EVCEB-22
	EVM-6	8cc	4	EVCEB-4
	EVM-8	12cc	8	Call
	EVM-8	20cc	6	EVCEB-29
	EVM-8	35cc	4	EVCEB-32
KJLC	KL-1	8cc	1	EVCEB-4
	KL-1	40cc	1	EVCEB-6
	KL-1	100cc	1	Call
	KL-6	2cc	8	Call
	KL-6	4cc	6	EVCEB-22
	KL-6	8cc	4	EVCEB-4
	KL-8	12cc	8	Call
	KL-8	20cc	6	EVCEB-29
	KL-8	35cc	4	EVCEB-32
Temescal	SFIH-270-1	7cc	—	EVCEB-4
	SFIH-270-1	7cc	—	EVCEB-4
	SFIH-270-1CK	7cc	—	EVCEB-4
	SFIH-270-2	7cc	—	EVCEB-4
	SFIH-270-2CK	7cc	—	EVCEB-4
	SFIH-270-2	15cc	—	EVCEB-13 or EVCEB-13M
	SFIH-270-2CK	15cc	—	EVCEB-13 or EVCEB-13M
	Germini®	15cc	—	EVCEB-13 or EVCEB-13M
	Trigon®	15cc	—	EVCEB-13 or EVCEB-13M
	SFIH-270-2	25cc	—	EVCEB-16
	SFIH-270-2CK	25cc	—	EVCEB-16
	SFIH-270-3CK	25cc	—	EVCEB-25 or EVCEB-25M
	SFIH-270-2	40cc	—	EVCEB-6 or EVCEB-6M
	SFIH-270-3CK	40cc	—	EVCEB-6 or EVCEB-6M
	SFIH-270-3	156cc	—	EVCEB-12M
BOC Edwards	EB3	4cc	—	EVCEB-30
MDC	e-Vap® 3000	2cc	1	EVCEB-20
	e-Vap® Mighty Source	2cc	4	EVCEB-20
	EV-4000-66	6cc	4	EVCEB-5
	EV-4000-66UHV	6cc	4	EVCEB-5
	EV-FMP-10HUHV	6cc	4	EVCEB-5
	EV-10RHUHV	6cc	4	EVCEB-5
	EV-1000-67-HF	7cc	1	EVCEB-23
	EV-FMP-8H	7cc	1	EVCEB-23
	EV-FMP-8RH	7cc	1	EVCEB-23
	EV-FMP-10H	7cc	1	EVCEB-23
	EV-FMP-10RH	7cc	1	EVCEB-23
	EV-FMP-10V	7cc	1	EVCEB-23
	EV-FMP-10RV	7cc	1	EVCEB-23
	EV-6000-1012-HF	12cc	6	EVCEB-31
	EV-1000-1015-HF	15cc	1	EVCEB-13 or EVCEB-13M
	EV-4000-1015	15cc	4	EVCEB-13 or EVCEB-13M
	EV-4000-1015UHV-HF	15cc	4	EVCEB-13 or EVCEB-13M
	EV-4000-6151-HF	15cc	4	EVCEB-13 or EVCEB-13M
	EV-1000-1025-HF	25cc	1	EVCEB-25
	EV-4000-1025	25cc	4	EVCEB-25
	EV-4000-6251-HF	25cc	4	EVCEB-25
	EV-6000-1525-HF	25cc	6	EVCEB-25
	EV-4000-1030-HF	30cc	4	EVCEB-9 or EVCEB-9M
	EV-4000-6031-HF	30cc	4	EVCEB-9 or EVCEB-9M
	EV-1000-1540-HF	40cc	1	EVCEB-8 or EVCEB-8M
	EV-4000-1540-HF	40cc	4	EVCEB-8 or EVCEB-8M
	EV-6000-1540I-HF	40cc	6	EVCEB-8 or EVCEB-8M
	EV-6000-1540-HF	40cc	6	EVCEB-8 or EVCEB-8M
	EV-1000-15100-HF	100cc	1	EVCEB-27
Telemark	211-0042-2	1.5cc	1	EVCEB-20
	211-0048-2	4cc	1	EVCEB-22
	211-0050-2	7cc	1	EVCEB-23
	211-0051-2	12cc	1	EVCEB-24
	211-0053-2	15cc	1	EVCEB-13 or EVCEB-13M
	211-0251-3	1.5cc	4	EVCEB-20
	231-0240-3	4cc	4	EVCEB-22
	241-0240-1	4cc	4	EVCEB-23
	241-0245-1	7cc	4	EVCEB-23
	241-0281-1	4cc	6	EVCEB-23
	265-0245-3	7cc	4	EVCEB-23
	265-0265-3	15cc	14	EVCEB-13 or EVCEB-13M
	265-0220-3	25cc	4	EVCEB-16 or EVCEB-16M
	265-0281-3	4cc	6	EVCEB-23
	265-0282-3	7cc	6	EVCEB-23
	265-0255-3	15cc	6	EVCEB-13 or EVCEB-13M
	265-0260-3	7cc	8	EVCEB-23
	290-0227-1	40cc	6	EVCEB-6 or EVCEB-6M
	251-0031-1	7cc	1	EVCEB-23
	251-0033-1	12cc	1	EVCEB-24
	251-0034-1	15cc	1	EVCEB-13 or EVCEB-13M
	251-0038-1	25cc	1	EVCEB-16 or EVCEB-16M
	251-0040-1	30cc	1	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
	251-0043-1	40cc	6	EVCEB-6 or EVCEB-6M
	251-0049-1	100cc	1	EVCEB-27
	294-0225-3	25cc	6	EVCEB-25 or EVCEB-25M
	294-0230-3	30cc	6	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
	294-0215-3	40cc	4	EVCEB-6 or EVCEB-6M
	294-0260-3	7cc	12	EVCEB-23
	294-0240-3	15cc	8	EVCEB-13 or EVCEB-13M
	294-0245-3	25cc	8	EVCEB-25 or EVCEB-25M
	294-0235-3	40cc	6	EVCEB-6 or EVCEB-6M
	295-0205-1	100cc	6	EVCEB-27
	295-0232-1	40cc	10	EVCEB-6 or EVCEB-6M
	295-0250-1	100cc	6	EVCEB-27
	271-0209-1	7cc	4	EVCEB-23
	271-0217-1	12cc	4	EVCEB-24
	271-0210-1	15cc	4	EVCEB-13 or EVCEB-13M
	271-0220-1	25cc	4	EVCEB-16 or EVCEB-16M
	271-0221-1	30cc w/ web	4	EVCEB-26
	271-0225-1	30cc w/o web	4	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
	271-0245-1	7cc	6	EVCEB-23
	271-0255-1	15cc	6	EVCEB-13 or EVCEB-13M
	271-0257-1	25cc	6	EVCEB-25 or EVCEB-25M
	271-0227-1	40cc	4	EVCEB-6 or EVCEB-6M
	271-0227-3	40cc	4	EVCEB-6 or EVCEB-6M
	271-0235-1	15cc & 25cc	2 & 2	EVCEB-13 or EVCEB-13M & EVCEB-16 or EVCEB-16M

➤ Crucibles Liners for E-Beam Sources

Original Manufacturer	Source Model	Pocket Size	Hearth Pockets	KJLC® Crucible Model
	271-0241-1	15cc & 30cc w/ web	3 & 1	EVCEB-13 or EVCEB-13M
	271-0260-1	7cc	8	EVCEB-23
	271-0259-1	15cc & 25cc	3 & 3	EVCEB-13 or EVCEB-13M & EVCEB-16 or EVCEB-16M
	271-0263-1	7cc & 12cc	4 & 4	EVCEB-23 & EVCEB-24
CHA Industries	SmartSource®	7cc	4 or 6	EVCEB-23
	SmartSource®	15cc	4 or 6	EVCEB-13 or EVCEB13M
	SmartSource®	25cc	4	EVCEB-16 or EVCEB-16M
	SmartSource®	25cc	6	EVCEB-25 or EVCEB-25M
	SmartSource®	30cc	4 or 6	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
	Dual EB	7cc	6 or 8	EVCEB-23
	Dual EB	15cc	4 or 6	EVCEB-13 or EVCEB-13M
	Dual EB	25cc	4	EVCEB-16 or EVCEB-16M
	Dual EB	30cc	4	EVCEB-9 or EVCEB-9M+ or EVCEB-9M
Thermionics	HFC1007	7cc	1	EVCEB-4
	HFC1015	15cc	1	EVCEB-13 or EVCEB-13M
	HFC1025	25cc	1	EVCEB-16 or EVCEB-16M
	HFC1040	40cc	1	EVCEB-8 or EVCEB-8M
	HRC0607-4-SD	7cc	4	EVCEB-4
	HRC0607-4-BD	7cc	4	EVCEB-4
	HRC1015-4-SD	15cc	4	EVCEB-13 or EVCEB-13M
	HRC1015-4-BD	15cc	4	EVCEB-13 or EVCEB-13M
	HRC1025-4-SD	25cc	4	EVCEB-16 or EVCEB-16M
	HRC1025-4-BD	25cc	4	EVCEB-16 or EVCEB-16M
	HRC1040-4-SD	40cc	4	EVCEB-8 or EVCEB-8M
	HRC1040-4-BD	40cc	4	EVCEB-8 or EVCEB-8M
	HRC0607-6-SD	7cc	6	EVCEB-4
	HRC0607-6-BD	7cc	6	EVCEB-4
	HRC1015-6-SD	15cc	6	EVCEB-13 or EVCEB-13M
	HRC1015-6-BD	15cc	6	EVCEB-13 or EVCEB-13M
	HRC1025-6-SD	25cc	6	EVCEB-16 or EVCEB-16M
	HRC1025-6-SD	25cc	6	EVCEB-16 or EVCEB-16M
	HRC0607-8-SD	7cc	8	EVCEB-4
	HRC0607-8-BD	7cc	8	EVCEB-4

Original Manufacturer	Source Model	Pocket Size	Hearth Pockets	KJLC Crucible Model
	HCL0607-4	7cc	4	EVCEB-4
	HCL0607-5	7cc	5	EVCEB-4
	HCL0615-4	15cc	4	EVCEB-13 or EVCEB-13M
	HCL0615-5	15cc	5	EVCEB-13 or EVCEB-13M
	HCL0625-4	25cc	4	EVCEB-16 or EVCEB-16M
	HLC1040-4	40cc	4	EVCEB-8 or EVCEB-8M
	HLC1040-5	40cc	4	EVCEB-8 or EVCEB-8M
	HM2 0607	7cc	1	EVCEB-4
	HM2 0610	10cc	1	Call
	HM2 1010	10cc	1	Call
	HM2 1015	15cc	1	EVCEB-13 or EVCEB-13M
	HM2 1540	40cc	1	EVCEB-8 or EVCEB-8M
	HM2 1575	75cc	1	Call
	HM2 151000	100cc	1	EVCEB-27
	HM2 R0607-4	7cc	4	EVCEB-4
	HM2 R0610-4	10cc	4	Call
	HM2 R0615-4	15cc	4	EVCEB-13 or EVCEB-13M
	HM2 R1010-4	10cc	4	Call
	HM2 R1015-4	15cc	4	EVCEB-13 or EVCEB-13M
	HM2 R1025-4	25cc	4	EVCEB-16 or EVCEB-16M
Varian	980-0001	1cc	1	EVCEB-1
	980-0003	1cc	3	EVCEB-1
	980-0005	1cc	5	EVCEB-1
	980-1105	10cc	1 or 4	EVCEB-2

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Crucible Liners for E-Beam Sources

Graphite Crucibles

- The crucible forms a thermal barrier between melt and water-cooled hearth so efficient that deposition rates at the same power can increase by 400%. At the same deposition rate, power may be cut to 25% of its bare hearth value
- Each graphite crucible undergoes high purification before it reaches the customer
- Major contaminants (Fe, Si, Al, and Mg) measure less than 5 ppm, while there are no detectable levels of 16 other common metals (including Na, K, and Pb)
- Withstands as many as 400 evaporation cycles

Materials evaporated from graphite crucibles:

- Al-Ge alloys, Al-Si alloys, B, Be, Bi, CdS, CeO_2, Cr, Cu, Ge, In, Mg, Mo, Na_3AlF_6, Pd, Pt, Sb, SiO, SiO_2, Sr, Ta, Ti, Y_2O_3, Zn
- Choose the correct size for your furnace. Taller models hold more material, but cannot work if put in a multi-hearth furnace not designed for tall crucibles
- Model EVCEB-2 has the same dimensions as EVCEB-4 but includes a top lip

NOTE: Do not confuse this ultra-fine-grain, high-density graphite with "glassy" (or vitreous) carbon which typically cracks after one run.

Figure 1

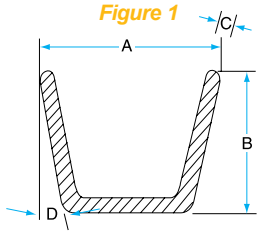


Figure 2 (EVCEB-1)

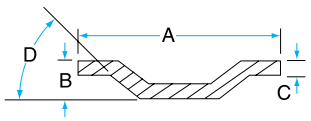
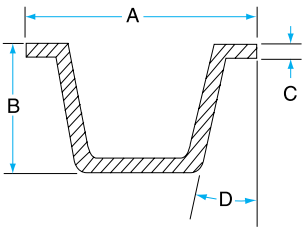
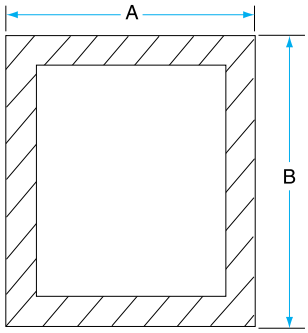


Figure 3 (EVCEB-2)

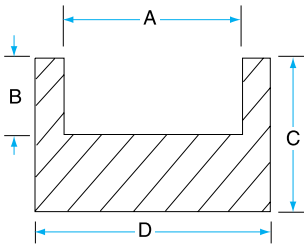




TOP VIEW

Figure 4 (EVCEB-10)

Figure 5 (EVCEB-11)



Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Figure	Part No.	Price
1	0.24	0.750	0.162	0.040	30°	2	EVCEB-1	Call
10	4.8	1.384	0.593	0.093	15°	3	EVCEB-2	Call
4	1.8	0.865	0.563	0.093	15°	1	EVCEB-3	Call
7	4.4	1.167	0.563	0.093	15°	1	EVCEB-4	Call
NA	2.4	0.936	0.593	0.093	15°	1	EVCEB-5	Call
40	30.4	2.030	1.020	0.093	15°	1	EVCEB-6	Call
40	17.0	2.030	1.020	0.250	15°	1	EVCEB-6M	Call
40	27	2.030	1.020	0.125	15°	1	EVCEB-6M+	Call
NA	126.0	2.960	1.562	0.093	7.5°	1	EVCEB-7	Call
40	30.2	2.000	1.062	0.093	15°	1	EVCEB-8	Call
40	16.9	2.000	1.062	0.250	15°	1	EVCEB-8M	Call
30	20.2	1.775	0.940	0.093	15°	1	EVCEB-9	Call
30	10.3	1.775	0.940	0.250	15°	1	EVCEB-9M	Call
30 (Without Web)	18.5	1.775	0.940	0.125	15°	1	EVCEB-9M+	Call
NA	2.8	0.781	0.437	0.062	14°	4	EVCEB-10	Call
NA	2.3	1.000	0.750	0.125	0°	5	EVCEB-11	Call
156	94.7	3.250	1.530	0.250	15°	1	EVCEB-12M	Call
15	8.2	1.480	0.670	0.125	15°	1	EVCEB-13	Call
15	3.9	1.480	0.670	0.250	15°	1	EVCEB-13M	Call
NA	27.1	2.390	1.000	0.250	15°	1	EVCEB-14M	Call
NA	16.2	1.890	0.700	0.125	15°	1	EVCEB-15	Call
25	17.1	1.850	0.680	0.093	15°	1	EVCEB-16	Call
25 (4 Pocket)	12.8	1.850	0.680	0.125	15°	1	EVCEB-16M	Call
62	47.6	2.212	1.400	0.093	15°	1	EVCEB-17	Call
15	14.7	1.640	0.970	0.125	15°	1	EVCEB-18	Call
1	0.32	0.560	0.384	0.093	15°	1	EVCEB-19	Call
2	0.84	0.706	0.465	0.093	15°	1	EVCEB-20	Call
3	1.44	0.805	0.545	0.093	15°	1	EVCEB-21	Call
4	2.1	0.885	0.595	0.093	15°	1	EVCEB-22	Call
7	3.7	1.125	0.520	0.093	15°	1	EVCEB-23	Call
12	8.3	1.280	0.940	0.093	15°	1	EVCEB-24	Call
25	16.3	1.633	0.940	0.093	15°	1	EVCEB-25	Call
25 (6 Pocket)	14	1.633	0.940	0.125	15°	1	EVCEB-25M	Call
30	21.9	1.920	0.810	0.093	15°	1	EVCEB-26	Call
100	82.7	2.700	1.490	0.093	15°	1	EVCEB-27	Call
20	14.6	1.673	0.768	0.093	15°	1	EVCEB-29	Call
4	**1.6**	**0.846**	**0.689**	**0.093**	15°	1	**EVCEB-30**	Call
12	**5.6**	**1.350**	**0.680**	**0.125**	15°	1	**EVCEB-31**	Call

➤ Crucible Liners for E-Beam Sources

FABMATE Crucibles

FABMATE® material = 99.9995% elemental carbon.

- FABMATE shows a 0% erosion rate after (15) one-hour soak cycles in 10% hydrofluoric acid, and a 0% erosion rate after (20) one-hour soak cycles in a 70% combination nitric acid and hydrofluoric acid
- Alternative to troublesome materials such as quartz
- A high-strength graphite that has undergone purification, machining, and subjection to a proprietary carbon modification treatment from Poco Graphite, Inc.
- Has amorphous carbon in the first few layers of pores and an abrasion-resistant, virtually particle-free surface
- Acid resistant and exceptionally durable
- Remain thermally stable (up to 2500° C in inert atmospheres)

Materials that work with FABMATE:

- Materials demonstrating optimum performance with FABMATE crucibles include Ag, As, Au, Ga, GeO_2, Ni-Cr alloys, Pb, Se, Sn, Te, and TiO
- Material with which FABMATE demonstrates a prolonged crucible life: Al
- Materials requiring FABMATE, but good for only a single run: Fe, Ni, and Si
- FABMATE also works well with all materials listed under graphite crucibles

NOTE: We offer FABMATE in the same models/dimensions as the standard graphite crucibles.

Figure 1

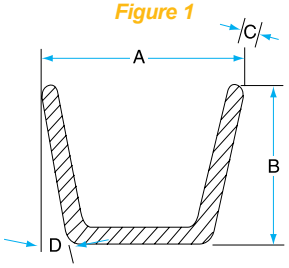


Figure 4 *(EVCFABEB-10)*

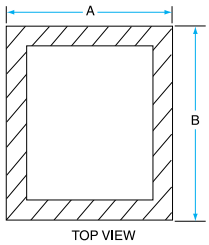


Figure 2 *(EVCFABEB-1)*

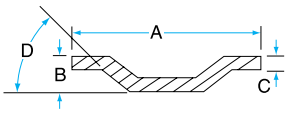


Figure 3 *(EVCFABEB-2)*

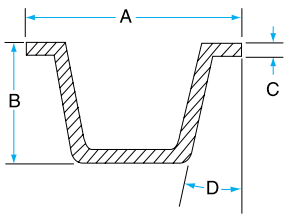
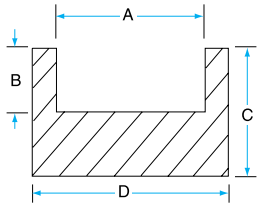


Figure 5 *(EVCFABEB-11)*

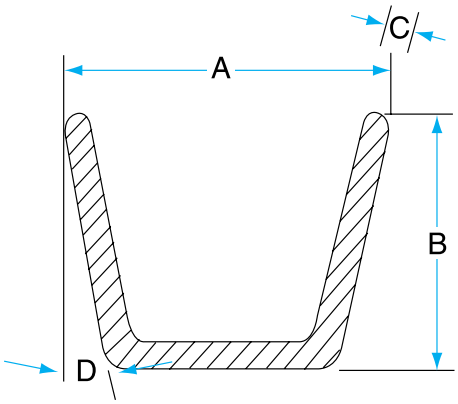


Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Figure	Part No.	Price
1	0.24	0.750	0.162	0.040	30°	2	EVCFABEB-1	Call
10	4.8	1.384	0.593	0.093	15°	3	EVCFABEB-2	Call
4	1.8	0.865	0.563	0.093	15°	1	EVCFABEB-3	Call
7	4.4	1.167	0.563	0.093	15°	1	EVCFABEB-4	Call
N/A	2.4	0.936	0.593	0.093	15°	1	EVCFABEB-5	Call
40	30.4	2.030	1.020	0.093	15°	1	EVCFABEB-6	Call
40	17.0	2.030	1.020	0.250	15°	1	EVCFABEB-6M	Call
N/A	126.0	2.960	1.562	0.093	7.5°	1	EVCFABEB-7	Call
40	30.2	2.000	1.062	0.093	15°	1	EVCFABEB-8	Call
40	16.9	2.000	1.062	0.250	15°	1	EVCFABEB-8M	Call
30	20.2	1.775	0.940	0.093	15°	1	EVCFABEB-9	Call
30	10.3	1.775	0.940	0.250	15°	1	EVCFABEB-9M	Call
N/A	2.8	0.781	0.437	0.062	14°	4	EVCFABEB-10	Call
N/A	2.3	1.000	0.750	0.125	0°	5	EVCFABEB-11	Call
156	94.7	3.250	1.530	0.250	15°	1	EVCFABEB-12M	Call
15	8.2	1.480	0.670	0.125	15°	1	EVCFABEB-13	Call
15	3.9	1.480	0.670	0.250	15°	1	EVCFABEB-13M	Call
N/A	27.1	2.390	1.000	0.250	15°	1	EVCFABEB-14M	Call
N/A	16.2	1.890	0.700	0.125	15°	1	EVCFABEB-15	Call
25	17.1	1.850	0.680	0.093	15°	1	EVCFABEB-16	Call
62	47.6	2.212	1.400	0.093	15°	1	EVCFABEB-17	Call
15	14.7	1.640	0.970	0.125	15°	1	EVCFABEB-18	Call
1	0.32	0.560	0.384	0.093	15°	1	EVCFABEB-19	Call
2	0.84	0.706	0.465	0.093	15°	1	EVCFABEB-20	Call
3	1.44	0.805	0.545	0.093	15°	1	EVCFABEB-21	Call
4	2.1	0.885	0.595	0.093	15°	1	EVCFABEB-22	Call
7	3.7	1.125	0.520	0.093	15°	1	EVCFABEB-23	Call
12	8.3	1.280	0.940	0.093	15°	1	EVCFABEB-24	Call
25	16.3	1.633	0.940	0.093	15°	1	EVCFABEB-25	Call
30	21.9	1.920	0.810	0.093	15°	1	EVCFABEB-26	Call
100	82.7	2.700	1.490	0.093	15°	1	EVCFABEB-27	Call
1.5	0.55	0.695	0.400	0.093	15°	1	EVCFABEB-28	Call
20	14.6	1.673	0.768	0.093	15°	1	EVCFABEB-29	Call
4	1.6	0.846	0.689	0.093	15°	1	EVCFABEB-30	Call
12	5.6	1.350	0.680	0.125	15°	1	EVCFABEB-31	Call
35	24.1	2.081	0.767	0.093	15°	1	EVCFABEB-32	Call

Kurt J. Lesker Company

Crucible Liners for E-Beam Sources

Intermetallic Crucibles ($BN\text{-}TiB_2$)



NOTE: Custom sizes available upon request.
NOTE: Recommended for aluminum evaporation.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
4	2.1	0.885	0.595	0.093	15°	EVCEB-22INT	Call
7	4.4	1.167	0.563	0.093	15°	EVCEB-4INT	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13INT	Call
25 (4 Pocket)	17.1	1.850	0.680	0.093	15°	EVCEB-16INT	Call
25 (6 Pocket)	16.3	1.633	0.940	0.093	15°	EVCEB-25INT	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26INT	Call
40	30.4	2.030	1.020	0.093	15°	EVCEB-6INT	Call

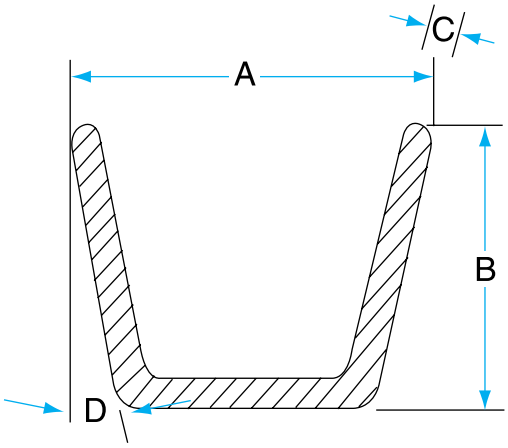
Aluminum Oxide Crucibles (Al_2O_3)

NOTE: Custom sizes available upon request.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
4	2.1	0.885	0.595	0.093	15°	EVCEB-22ALO	Call
7	4.4	1.167	0.563	0.093	15°	EVCEB-4ALO	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13ALO	Call
25 (4 Pocket)	17.1	1.850	0.680	0.093	15°	EVCEB-16ALO	Call
25 (6 Pocket)	16.3	1.633	0.940	0.093	15°	EVCEB-25ALO	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26ALO	Call
40	30.4	2.030	1.020	0.125	15°	EVCEB-6ALO	Call

Crucible Liners for E-Beam Sources

Molybdemum Crucibles (Mo)



NOTE: Custom sizes available upon request.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
4	2.1	0.885	0.595	0.093	15°	EVCEB-22MO	Call
7	4.4	1.167	0.563	0.093	15°	EVCEB-4MO	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13MO	Call
25 (4 Pocket)	12.8	1.850	0.680	0.125	15°	EVCEB-16MMO	Call
25 (6 Pocket)	14.0	1.633	0.940	0.125	15°	EVCEB-25MMO	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26MO	Call
30 (Without Web)	18.5	1.775	0.940	0.125	15°	EVCEB-9MMO	Call
40	17.0	2.030	1.020	0.250	15°	EVCEB-6MMO	Call

Copper Crucibles (Cu)

NOTE: Custom sizes available upon request.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
4	2.1	0.885	0.595	0.093	15°	EVCEB-22CU	Call
7	4.4	1.167	0.563	0.093	15°	EVCEB-4CU	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13CU	Call
25 (4 Pocket)	12.8	1.850	0.680	0.125	15°	EVCEB-16CU	Call
25 (6 Pocket)	14.0	1.633	0.940	0.125	15°	EVCEB-25CU	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26CU	Call
30 (Without Web)	18.5	1.775	0.940	0.125	15°	EVCEB-9MCU	Call
40	17.0	2.030	1.020	0.250	15°	EVCEB-6MCU	Call

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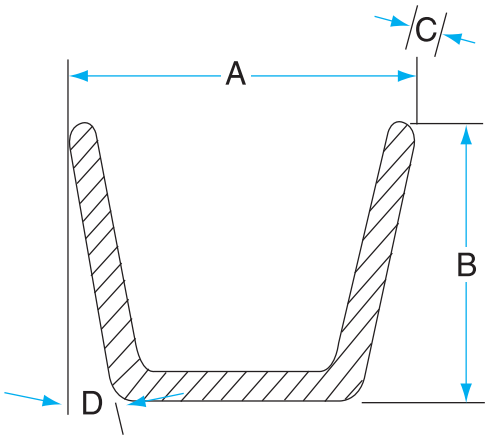
➤ Crucibles Liners for E-Beam Sources

Tungsten Crucibles (W)



NOTE: Custom sizes available upon request.
NOTE: Recommended for chrome evaporation.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
4	2.1	0.885	0.595	0.093	15°	EVCEB-22W	Call
7	4.4	1.167	0.563	0.093	15°	EVCEB-4W	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13W	Call
25 (4 Pocket)	12.8	1.850	0.680	0.125	15°	EVCEB-16MW	Call
25 (6 Pocket)	14.0	1.633	0.940	0.125	15°	EVCEB-25MW	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26W	Call
30 (Without Web)	18.5	1.775	0.940	0.125	15°	EVCEB-9MW	Call
40	27.0	2.030	1.020	0.125	15°	EVCEB-6MW	Call

Boron Nitride Crucibles (BN)

NOTE: Custom sizes available upon request.

Pocket Volume (cc)	Liner Volume (cc)	Dimensions (in.) A	B	C	Angle D	Part No.	Price
7	4.4	1.167	0.563	0.093	15°	EVCEB-4BN	Call
15	8.2	1.480	0.670	0.125	15°	EVCEB-13BN	Call
25 (4 Pocket)	17.1	1.850	0.680	0.093	15°	EVCEB-16BN	Call
25 (6 Pocket)	16.3	1.633	0.940	0.093	15°	EVCEB-25BN	Call
30 (With Web)	21.9	1.920	0.810	0.093	15°	EVCEB-26BN	Call
30 (Without Web)	20.2	1.775	0.940	0.093	15°	EVCEB-9BN	Call
40	30.4	2.030	1.020	0.093	15°	EVCEB-6BN	Call