DENTON VACUUM

BARRIERS BECOME BREAKTHROUGHS

Thin Film Evaporation Material Source Reference

				Temp (°C) at Vap. Press.			Evaporation Techniques				
Name	**Symbol**	**Melting Point (°C)**	**Density (g/cm3)**	**10^{-8} Torr**	**10^{-6} Torr**	**10^{-4} Torr**	**Electron Beam**	**Crucible**	**Coil**	**Boat**	**Remarks (n = index of refraction)**
Aluminum	Al	660	2.7	677	821	1010	XInt.	TiB_2-BN ZrB_2 BN	W	TiB_2 W	Alloys and wets; tungsten-stranded superior
Aluminum Antimonide	AlSb	1080	4.3								
Aluminum Arsenide	AlAs	1600	3.7			~1300					
Aluminum Bromide	$AlBr_3$	97	3.01			~50		Graphite		Mo	
Aluminum Carbide	Al_4C_3	1400	2.36			~800	Fair				n=2.7
Aluminum 2% Copper	Al2%Cu	640	2.82								Wire feed and flash. Difficult from dual sources.
Aluminum Fluoride	AlF_3	1257 Subl.	3.07	410 Subl.	490 Subl.	700 Subl.	Poor	Graphite		Mo, W	n=1.38 at 0.55µ
Aluminum Nitride	AlN	Subl.	3.26			~1750	Fair				Decomposes. Reactice evaporate in 10^{-3} N_2 with glow discharge.
Aluminum Oxide (alumina)	Al_2O_3	2045	3.97			1550	XInt.			W	Sapphire xInt in EB, forms smooth hard films. N=1.66
Alumnium 2% Silicon	Al2%Si	640	2.69			1010		TiB_2-BN			Wire feed and flash. Difficult from dual sources.
Antimony	Sb	630	6.68	279 Subl.	345 Subl.	425 Subl.	Poor	BN C Al_2O_3	Mo Ta	Mo Ta Al_2O_3 Coated	Toxic. Evaporates well. Film structure is rate-dependent.
Antimony Telluride	Sb_2Te_3	619	6.5			600		Carbon			Decomposes over 750 degrees C.
Antimony Trioxide	Sb_2O_3	656	5.2 or 5.76	Subl.	Subl.	~300 Subl.	Good	BN Al_2O_3		Pt	Toxic. Decomposes on W. n=2.05
Antimony Triselenide	Sb_2Se_3	611						Carbon		Ta	Stoichiometry variable.

Antimony Trisulphide	Sb_2S_3	550	4.64			~200	Good	Al_2O_3		Mo Ta	n=3.01 at 0.55µ. No decomposition.
Arsenic	As	814	5.73	107 Subl.	150 Subl.	210 Subl.	Poor	Al_2O_3 BeO Vit. Carbon		C	Toxic. Sublimes rapidly at low temperature.
Arsenic Selenide	As_2Se_3	360	4.75					Al_2O_3 Quartz			n=2.41 at 3.8µ.
Arsenic Trisulphide	As_2S_3	300	3.43			~400	Fair	Al_2O_3 Quartz		Mo	n=2.8
Arsenic Telluride	As_2Te_3	362								Flash	
Barium	Ba	710	3.78	545	627	735	Fair	Metals	W	W Ta Mo	Wets w/o alloying - reacts with ceramics
Barium Chloride	$BaCl_2$	962	3.86			~650				Ta, Mo	Use gentle preheat to outgas
Barium Fluoride	BaF_2	1280	4.83	Subl.	Subl.	~700 Subl.	Good			Mo	n=1.29 at 5µ. Density Rate Dependent.
Barium Oxide	BaO	1923	5.72 or 5.32			~1300	Poor	Al_2O_3		Pt	Decomposes slightly. n=1.98
Barium Sulphide	BaS	2200	4.25			1100				Mo	n=2.16
Barium Titanate	$BaTiO_3$	Dec- omposes	6	Dec.	Dec.	Dec.					Decomposes, yields free Ba from single source; sputtering preferred; or co-evaporate from 2 sources
Beryllium	Be	1278	1.85	710	878	1000	Xlnt.	BeO C Vit. Carbon	W	W Ta	Wets W/Mo/Ta. Metal powder and oxides are toxic. Evaporates easily.
Beryllium Chloride	$BeCl_2$	440	1.9			~150					
Beryllium Fluoride	BeF_2	800	1.99	Subl.	Subl.	~200 Subl.	Good				Toxic.
Beryllium Oxide	BeO	2530	3.01			1900	Good				Powders toxic. No decomposition from EB guns. n=1.72
Bismuth	Bi	271	9.8	330	410	520	Xlnt.	Al_2O_3 Vit. Carbon	W	W Mo Al_2O_3 Ta	Vapors are toxic. High Resistivity. No shorting of baskets.
Bismuth Fluoride	BiF_3	727	8.75	Subl.	Subl.	~300 Subl.		Graphite			n=1.74 at 1µ. 1.64 at 10µ

Bismuth Oxide	Bi_2O_3	820	8.9			~1400	Poor			Pt	Vapors are toxic. n=2.55
Bismuth Selenide	Bi_2Se_3	710	7.66			~650	Good	Graphite Quartz			Sputtering preferred; or co-evaporate from 2 sources.
Bismuth Telluride	Bi_2Te_3	585	7.85			~600		Graphite Quartz		W Mo	Sputtering preferred; or co-evaporate from 2 sources.
Bismuth Titanate	$Bi_2Ti_2O_7$			Dec.	Dec.	Dec.					Decomposes. Sputtering preferred; or co-evaporate from 2 sources in 10-$2O_2$
Bismuth Trisulphide	Bi_2S_3	685	7.39								n = 1.5 (approx.)
Boron	B	2100	2.36	1278 Subl.	1548 Subl.	1797 Subl.	Xlnt.	C Vit. Carbon		C	Material explodes with rapid cooling. Forms carbide with container.
Boron Carbide	B_4C	2350	2.5	2500	2580	2650	Xlnt.				Similar to chromium.
Boron Nitride	BN	2300	2.2	Subl.	Subl.	~1600 Subl.	Poor				Sputtering preferred; Decomposes.
Boron Oxide	B_2O_3	460	1.82			~1400	Good			Pt Mo	n=1.46
Boron Trisulphide	B_2S_3	310	1.55			800		Graphite			
Cadmium	Cd	321	8.64	64	120	180	Poor	Al_2O_3 Quartz		W Cb Mo Ta	Poisons vacuum systems, low sticking coefficient
Cadmium Antimonide	CdSb	456	6.92								
Cadmium Arsenide	Cd_3As_2	721	6.21					Quartz			
Cadmium Bromide	$CdBr_2$	567	5.19			~300					
Cadmium Chloride	$CdCl_2$	570	4.05			~400					
Cadmium Fluoride	CdF2	1070	6.64			~500					n=1.56
Cadmium Iodide	CdI_2	400	5.3			~250					
Cadmium Oxide	CdO	900	6.95			~530					Disproportionates. n=2.49
Cadmium Selenide	CdSe	1264	5.81	Subl.	Subl.	540 Subl.	Good	Al_2O_3 Quartz		Mo Ta	Evaporates easily. n=2.4 at 0.6μ

Cadmium Silicide	$CdSiO_2$					~600					n=1.69
Cadmium Sulphide	CdS	1750	4.82	Subl.	Subl.	550 Subl.	Fair	Al_2O_3 Quartz		W Mo Ta	Sticking coefficient strongly affected by substrate temperature. n=2.4, JVST 12, 188 (1975)
Cadmium Telluride	CdTe	1098	6.2			450			W	W Mo Ta	Stoichiometry depends on substrate temperature. n=2.6
Calcium	Ca	842	1.55	272 Subl.	357 Subl.	459 Subl.	Poor	Al_2O_3 Quartz	W	W	Corrodes in air.
Calcium Fluoride	CaF_2	1360	3.18			~1100	Xlnt.	Quartz	W Mo Ta	W Mo Ta	Rate control important. Use gentle preheat to outgas. n=1.2 - 1.4
Calcium Oxide	CaO	2580	3.35			~1700		ZrO_2		W Mo	Forms volatile oxides with W and Mo. n=1.84
Calcium Silicate	$CaO\text{-}SiO_2$	1540	2.9				Good	Quartz			n=1.61
Calcium Sulphide	CaS	Subl.	2.18			1100				Mo	Decomposes. n=2.14
Calcium Titanate	$CaTiO_3$	1975	4.1	1490	1600	1690	Poor				Disproportionates except in sputtering.
Calcium Tungstate	$CaWO_4$	1620	6.06				Good			W	n=1.92
Carbon	C	Subl.	1.8 - 2.3	1657 Subl.	1867 Subl.	2137 Subl.	Xlnt.				EB preferred. Arc evaporation. Poor film adhesion. Vitreous carbon n=1.47
Cerium	Ce	795	8.23	970	1150	1380	Good	Al_2O_3 BeO Vit. Carbon	W	W Ta	Films oxidize easily.
Ceric Oxide	CeO_2	2600	7.3	1890 Subl.	2000 Subl.	2310 Subl.	Good			W	Use 250-300 °C substrate temperature. n=2.2-2.4. Reacts with W.
Cerium Fluoride	CeF_3	1418	6.16			~900	Good			W Mo Ta	Use gentle preheat to outgas. n=1.63 at 0.55µ
Cerium Oxide	Ce_2O_3	1692	6.87				Fair			W	Alloys with source; use 0.015-0.020 W boat. n=1.95
Cesium	Cs	28	1.87	-16	22	30		Quartz		S.S.	
Cesium Bromide	CsBr	636	4.44			~400				W	n=1.70
Cesium Chloride	CsCl	646	3.97			~500				W	n=1.64 Hygroscopic
Cesium Fluoride	CsF	684	3.59			~500				W	

Cesium Hydroxide	CsOH	272	3.67			550				Pt	
Cesium Iodide	CsI	621	4.51			~500		Pt Quartz		W Pt	n=1.79
Chiolote	$Na_5Al_3F_{14}$		2.9			~800				Mo W	n=1.33
Chromium	Cr	1890	7.2	837 Subl.	977 Subl.	1157 Subl.	Good	Vit. Carbon	W	Cr-plated rod or strip	Films very adherent. High rates possible.
Chromium Boride	CrB	2760	6.17								
Chromium Bromide	CrB_2	842	4.36			550				Inconel	
Chromium Carbide	Cr_3C_2	1890	6.68			~2000	Fair			W	
Chromium Chloride	$CrCl_2$	824	2.75			550				Fe Inconel	Sublimes easily.
Chromium Oxide	Cr_2O_3	2435	5.21			~2000	Good			W, Mo	Disproportionates to lower oxides, reoxidizes at 600 °C in air. n=2.4
Chromium Silicide	Cr_3Si	1710	6.51								
Chromium Silicon Monoxide	Cr-SiO	Influenced by composition…					Good			W	Flash.
Cobalt	Co	1495	8.9	850	990	1200	Xlnt.	Al_2O_3 BeO		W Cb	Alloys with refractory metals.
Cobalt Bromide	$CoBr_2$	678	4.91	Subl.	Subl.	400 Subl.				Inconel	
Cobalt Chloride	$CoCl_2$	740	3.36	Subl.	Subl.	472 Subl.				Inconel	
Cobalt Oxide	CoO	1935	5.68								Sputtering preferred.
Copper	Cu	1083	8.92	727	857	1017	Xlnt.	Al_2O_3 Mo, Ta	W	Mo	Films do not adhere well. Use intermediate layer, e.g. chromium. Evaporates from any source materials.
Copper Chloride	CuCl	422	3.53			~600					n=1.93
Copper Oxide	Cu_2O	1235	6	Subl.	Subl.	~600 Subl.	Good	Al2O3		Ta	Evaporate in 10^{-2} - 10^{-4} of O2; n=2.70 J. Electrochem. Soc. 110, 119 (1967)
Copper Sulphide	CuS	1113	6.75	Subl.	Subl.	~500 Subl.					n=1.45
Cryolite	Na_3AlF_6	1000	2.9	1020	1260	1480	Xlnt.	Vit. Carbon		W, Mo, Ta	Large chunks reduce spitting. Little decomposition. n=2.34 at 6330A.

Dysprosium	Dy	1409	8.54	625	750	900	Good			Ta	
Dysprosium Fluoride	DyF_3	1360		Subl.	Subl.	~800 Subl.	Good			Ta	
Dysprosium Oxide	Dy_2O_3	2340	7.81			~1400				Ir	Loses oxygen.
Erbium	Er	1497	9.06	650 Subl.	775 Subl.	930 Subl.	Good			W, Ta	
Erbium Fluoride	ErF_3	1350	7.81			~750				Mo	
Erbium Oxide	Er_2O_3	2400	8.64			~1600				Ir	Loses oxygen.
Europium	Eu	822	5.26	280 Subl.	360 Subl.	480 Subl.	Fair	Al_2O_3		W, Ta	Low tantalum solubility.
Europium Fluoride	EuF_2	1380	6.5			~950				Mo	
Europium Oxide	Eu_2O_3	2056	7.42			~1600	Good	ThO_2		Ir, Ta, W	Loses oxygen; films clear and hard.
Europium Sulphide	EuS		5.75				Good				
Gadolinium	Gd	1312	7.89	760	900	1175	XInt.	Al_2O_3		Ta	High Ta solubility.
Gadolinium Oxide	Gd_2O_3	2310	7.41				Fair			Ir	Loses oxygen. n=1.8 at 0.55µ
Gallium	Ga	30	5.9	619	742	907	Good	Al_2O_3 BeO Quartz			Alloys with refractory metals. Use EB gun.
Gallium Antimonide	GaSb	710	5.6				Fair			W, Ta	Flash evaporate.
Gallium Arsenide	GaAs	1238	5.3				Good	Carbon		W, Ta	Flash evaporate. n=5.64 at 10.6µ
Gallium Nitride	GaN	Subl.	6.1			~200		Al_2O_3			Evaporate Ga in 10^{-3} N2.
Gallium Oxide	Ga_2O_3	1900	5.88							Pr, W	Loses oxygen.
Gallium Phosphide	GaP	1540	4.1		770	920		Quartz		W, Ta	Decomposes vapor mostly P.
Germanium	Ge	937	5.35	812	957	1167	XInt.	Quartz Al_2O_3		W, C, Ta	Excellent filsm from EB sources. Use 0.040 W. n=4.01
Germanium Nitride	Ge_3N_2	450	5.2	Subl.	Subl.	~650 Subl.					Sputtering preferred.
Germanium Oxide	GeO_2	1086	6.24			~625	Good	Quartz Al_2O_3		Ta, Mo	Similar to SiO, film predominantly GeO.

Germanium Telluride	GeTe	725	6.2			381		Quartz Al_2O_3		W, Mo	
Glass, Schott 8329			2.2				XInt.				Evaporable alkali glass. Melt in air before evaporating. N=1.47
Gold	Au	1062	19.32	807	947	1132	XInt.	Al_2O_3 BN Vit. Carbon	W	W, Mo Coated Al_2O_3	Films soft, not very adherent.
Hafnium	Hf	2230	13.09	2160	2250	3090	Good				
Hafnium Boride	HfB_2	3250	10.5								
Hafnium Carbide	HfC	4160	12.2	Subl.	Subl.	~2600 Subl.					
Hafnium Nitride	HfN	2852	13.8								
Hafnium Oxide	HfO2	2812	9.68			~2500	Fair			W	Film HfO n=2.0 at 0.5µ
Hafnium Silicide	$HfSi_2$	1750	7.2								
Holmium	Ho	1470	8.8	650 Subl.	770 Subl.	950 Subl.	Good		W	W, Ta	
Holmium Fluoride	HoF_3	1143	7.64			~800		Quartz			
Holmium Oxide	Ho_2O_3	2370	8.41							Ir	Loses oxygen.
Inconel	Ni/Cr/Fe	1425	8.5				Good		W	W	Use fnie wire pre-wrapped on W. Low rate req'd for smooth films.
Indium	In	157	7.3	487	597	742	XInt.; Mo Liner req'd	Graphite Al_2O_3	W	W, Mo	Wets W and Cu; use Mo liner in guns.
Indium Antimonide	InSb	535	5.8	500		~400				W	Toxic, Decomposes; sputtering preferred; or co-evaporate from 2 sources; flash. n=4.3 at 1µ
Indium Arsenide	InAs	943	5.7	780	870	970				W	Toxic, Sputtering preferred; or co-evaporate from 2 sources; flash. n=4.5 at 1µ
Indium Oxide	In_2O_3	1565	7.18	Subl.	Subl.	~1200 Subl.	Good	Al_2O_3		W, Pt	Film In2O; transparent conductor.
Indium Phosphide	InP	1058	4.8		630	730		Graphite		W, Ta	Deposits P rich. Flash evaporate.
Indium Selenide	In_2Se_3	890	5.7								Sputtering preferred; or co-evaporate from 2 sources. Flash.

Indium Sesqui-sulphide	In_2S_3	1050	4.9	Subl.	Subl.	850 Subl.		Graphite			Film In_2S
Indium Sulphide	In_2S	653	5.87			650		Graphite			
Indium Telluride	In_2Te_3	667	5.8								Sputtering preferred; or co-evaporate from 2 sources; flash.
Iridium	Ir	2459	22.65	1850	2080	2380	Fair	ThO_2			
Iron	Fe	1535	7.86	858	998	1180	Xlnt.	Al_2O_3 BeO	W	W	Attacks W. Films hard, smooth. Use gentle preheat to outgas.
Iron Bromide	$Fe\ Br_2$	689	4.64			561		Fe			
Iron Chloride	$FeCl_2$	670	2.98	Subl.	Subl.	300 Subl.		Fe			
Iron Iodide	FeI_2	592	5.31			400		Fe			
Iron Oxide	FeO	1425	5.7				Poor				Decomposes; sputtering preferred.
Iron Oxide	Fe_2O_3	1565	5.24				Good			W	Disproportionates to Fe_3O_4 at 1530 °C, n=3.0
Iron Sulphide	FeS	1195	4.84					Al_2O_3			Decomposes.
Kanthal	FeCrAl	1500	7.1			~1150			W	W	
Lanthanum	La	920	6.17	990	1212	1388	Xlnt.	Al_2O_3		W, Ta	Films will burn in air if scraped.
Lanthanum Boride	LaB_6	2210	2.61				Good				
Lanthanum Bromide	$LaBr_3$	783	5.06								n=1.94 Hygroscopic
Lanthanum Fluoride	LaF_3	1490	6	Subl.	Subl.	900 Subl.	Good			Ta, Mo	No decomposition. n=1.59 at 0.55μ
Lanthanum Oxide	La_2O_3	2250	5.84			1400	Good			W, Ta	Loses oxygen. n=1.9 at 0.5μ
Lead	Pb	328	11.34	342	427	497	Xlnt.	Al_2O_3 Quartz	W	W, Mo	Toxic. Carefully controlled rates req'd for superconductors.
Lead Bromide	$PbBr_2$	373	6.66			~300					
Lead Chloride	$PbCl_2$	501	5.85			~325		Al_2O_3		Pt	Little decomposition. n=2.2
Lead Fluoride	PbF_2	822	8.24	Subl.	Subl.	~400 Subl.		BeO		W, Pt, Mo	Toxic. n=1.75 at 0.3μ
Lead Iodide	PbI_2	502	6.16			~500		Quartz		Pt	n=2.7
Lead Oxide	PbO	890	9.53			~550		Quartz Al_2O_3		Pt	No decomposition. n=2.55
Lead Stannate	$PbSnO_3$	1115	8.1	670	780	905	Poor	Al_2O_3		Pt	Disproportionates.

Lead Selenide	PbSe	1065	8.1	Subl.	Subl.	~500 Subl.		Graphite Al_2O_3		W, Mo	
Lead Sulphide	PbS	1114	7.5	Subl.	Subl.	550 Subl.		Quartz Al_2O_3		W	Little decomposition. n=3.91
Lead Telluride	PbTe	917	8.16	780	910	1050		Al_2O_3 Graphite		Mo, Pt, Ta	Vapors toxic. Deposits Te rich. Sputtering preferred, or co-evaporate from sources. n=5.6 at 5μ
Lead Titanate	$PbTiO_3$		7.52							Ta	
Lithium	Li	179	0.53	227	307	407	Good	Al_2O_3 BeO		Ta, S.S.	Metal reacts violently in air.
Lithium Bromide	LiBr	547	3.46			~500				Ni	n=1.78
Lithium Chloride	LiCl	613	2.07			400				Ni	Use gentle preheat for outgas. n=1.66
Lithium Fluoride	LiF	870	2.6	875	1020	1180	Good	Al_2O_3		Ni, Ta, Mo, W	Rate control important for optical films. Use gentle preheat for outgas. n=1.36
Lithium Iodide	LiI	446	4.06			400				Mo, W	
Lithium Oxide	Li_2O	1427	2.01			850				Pt, Ir	n=1.64
Lutetium	Lu	1652	9.84			1300	XInt.	Al_2O_3		Ta	
Lutetium Oxide	Lu_2O_3	2489	9.41			1400				Ir	Decomposes.
Magnesium	Mg	651	1.74	185 Subl.	247 Subl.	327 Subl.	Good	Al_2O_3 Vit. Carbon	W	W, Mo Ta, Cb	Extremely high rates possible.
Magnesium Aluminate	$MgAl_2O_4$	2135	3.6				Good				Natural spinel.
Magnesium Bromide	$MgBr_2$	700	3.72			~450				Ni	Decomposes.
Magnesium Chloride	$MgCl_2$	708	2.32			400				Ni	Decomposes. n=1.6
Magnesium Fluoride	MgF_2	1266	2.9-3.2			1000	XInt.	Al_2O_3		Mo, Ta	Rate control and substrate heat important for optical films. n=1.38
Magnesium Iodide	MgI_2	700	4.24			200				Ir	
Magnesium Oxide	MgO	2800	3.58			1300	Good	Carbon Al_2O_3			W produces volatile oxides. n=1.7.
Manganese	Mn	1244	7.2	507 Subl.	572 Subl.	647 Subl.	Good	Al_2O_3 BeO	W	W, Ta, Mo	
Manganese Bromide	$MnBr_2$	695	4.38			500				Inconel	

Manganese Chloride	$MnCl_2$	650	2.98			450				Inconel	
Manganese Oxide	Mn_3O_4	1705	4.86							W	
Manganese Sulphide	MnS	1615	3.99			1300				Mo	Decomposes. n=2.7.
Mercury	Hg	-39	13.55	-68	-42	-6					
Mercury Sulphide	HgS	Subl.	8.1	Subl.	Subl.	250 Subl.		Al_2O_3			Decomposes.
Molybdenum	Mo	2610	10.22	1592	1822	2117	XInt.				Films smooth, hard. Careful degas req'd.
Molybdenum Boride	MoB_2	2100	7.12				Poor				
Molybdenum Carbide	Mo_2C	2687	9.18				Fair				Evaporation of $Mo(CO)_6$ yields Mo_2C.
Molybdenum Disulphide	MoS_2	1185	4.8			~50					
Molybdenum Silicide	$MoSi_2$	2050	6.3							W	Decomposes.
Molybdenum Trioxide	MoO_3	795	4.7			~900		Al_2O_3 BN		Mo, Pt	Slight O_2 loss. n=1.9
Neodymium	Nd	1024	7	731	871	1062	XInt.	Al_2O_3		Ta	Low Ta solubility.
Neodymium Fluoride	NdF_3	1410	6.5			~900	Good	Al_2O_3		Mo, W	Very little decomposition. n=1.61 at 0.55µ
Neodymium Oxide	Nd_2O_3	2272	7.24			~1400	Good	ThO_2		Ta, W	Loses oxygen, films clear, EB preferred. Hygroscopic n=1.79 n varies with substrate temp.
Nichrome IV	Ni/Cr	1395	8.5	847	987	1217	XInt.	Al_2O_3 Vit. Carbon BeO	W	Al_2O_3 Coated	Alloys with refractory metals.
Nickel	Ni	1453	8.9	927	1072	1262	XInt.	Al_2O_3 BeO Vit. Carbon	W	W	Alloys with refractory metals. Forms smooth adherent films.
Nickel Bromide	$NiBr_2$	963	4.64	Subl.	Subl.	362 Subl.				Inconel	
Nickel Chloride	NiCl2	1001	3.55	Subl.	Subl.	444 Subl.				Inconel	
Nickel Oxide	NiO	1990	7.45			~1470		Al_2O_3			Dissociates upon heating. n=2.18
Niobium (Columbium)	Nb	2468	8.55	1728	1977	2287	XInt.			W	Attacks W source.
Niobium Boride	NbB_2	3050	6.97								

Niobium Carbide	NbC	3800	7.82				Fair				
Niobium Nitride	NbN	2573	8.4								Reactive, evaporate Nb in 10^{-3} N_2.
Niobium Oxide	NbO		6.27			1100				Pt	
Niobium Pentoxide	Nb_2O_5	1530	4.47							W	n=2.3
Niobium Telluride	$NbTe_X$		7.6								Composition variable.
Niobium-Tin	Nb_3Sn						XInt.				Co-evaporate from 2 sources.
Niobium Trioxide	Nb_2O_3	1780	7.5							W	
Osmium	Os	1700	22.5	2170	2340	2760	Fair				
Palladium	Pd	1550	12.4	842	992	1192	XInt.	Al_2O_3 BeO	W	W	Alloys with refractory metals; rapid evaporation suggested. Spits in EB.
Palladium Oxide	PdO	870	8.31			575		Al_2O_3			Decomposes.
Parylene (Union Carbide)	C_8H_8	300-400	1.1								Vapor depositable plastic
Permalloy	Ni/Fe	1395	8.7	947	1047	1307	Good	Al_2O_3 Vit. Carbon		W	Film low in Ni content. Use 84% Ni source.
Phosphorus	P	41.4	1.82	327	361	402		Al_2O_3			Metal reacts violently in air.
Platinum	Pt	1769	21.45	1292	1492	1747	XInt.	C, ThO_2	W	W	Alloys with metals. Films soft, poor adhesion.
Plutonium	Pu	635	19							W	Toxic, radioactive.
Polonium	Po	254	9.4	117	170	244		Quartz			Radioactive
Potassium	K	64	0.86	23	60	125		Quartz		Mo	Metal reacts violently in air. Use gentle preheat to outgas.
Potassium Bromide	KBr	730	2.75			~450		Quartz		Ta, Mo	Use gentle preheat to outgas. n=1.56
Potassium Chloride	KCl	776	1.98			510	Good			Ta, Ni	Use gentle preheat to outgas. n=1.49
Potassium Fluoride	KF	880	2.48			~500	Poor	Quartz			Use gentle preheat to outgas. n=1.35
Potassium Hydroxide	KOH	360	2.04			~400				Pt	Use gentle preheat to outgas.
Potassium Iodide	KI	723	3.13			~500				Ta	Use gentle preheat to outgas. n=1.68
Praseody-mium	Pr	931	6.78	800	950	1150	Good			Ta	

Praseody-mium Oxide	Pr_2O_3	2125	6.88			1400	Good	ThO_2		Ir	Loses oxygen. n=2.0
Radium	Ra	700	5	246	320	416					
Rhenium	Re	3180	20.53	1928	2207	2571	Poor				Fine wire will self-evaporate.
Rhenium Oxide	Re_2O_7	297	8.2			~100					
Rhodium	Rh	1966	12.41	1277	1472	1707	Good	ThO_2 Vit. Carbon	W	W	EB gun preferred.
Rubidium	Rb	38.5	1.47	-3	37	111		Quartz			
Rubidium Chloride	RbCl	715	2.76			~550		Quartz			n=1.49
Rubidium Iodide	RbI	642	3.55			~400		Quartz			
Ruthenium	Ru	2700	12.45	1780	1990	2260	Poor			W	Spits violently in EB. Requires degas.
Samarium	Sm	1072	7.54	373	460	573	Good	Al_2O_3		Ta	
Samarium Oxide	Sm_2O_3	2350	7.43				Good	ThO_2		Ir	Loses O_2. Films smooth, clear.
Samarium Sulphide	Sm_2S_3	1900	5.72				Good				
Scandium	Sc	1539	2.99	714	837	1002	Xlnt.	Al_2O_3 BeO		W	Alloys with Ta
Scandium Oxide	Sc_2O_3	2300	3.86			~400	Fair				Loses oxygen. n=1.88 at 0.5μ
Selenium	Se	217	4.79	89	125	170	Good	Al_2O_3 Vit. Carbon	W Mo	W, Mo	Toxic. Poisons vacuum systems.
Silicon	Si	1410	2.42	992	1147	1337	Fair	BeO Ta Vit. Carbon		W Ta	Alloys with W; use heavy W boat. SiO produced above 4×10^{-6} Torr. EB best. n=3.42
Silicon Boride	SiB_6		2.47				Poor				
Silicon Carbide	SiC	2700	3.22			1000					Sputtering preferred.
Silicon Dioxide	SiO_2	1610-1710	2.2-2.7			~1025	Xlnt.	Al_2O_3			Quartz excellent in EB. n=1.47
Silicon Monoxide	SiO	1702	2.1	Subl.	Subl.	850 Subl.	Fair	Ta	W	Ta	Baffle box source best for resistance evaporation. Low rate suggested. n=1.6
Silicon Nitride	Si_3N_4	Subl.	3.44			~800					n=2.1
Silicon Selenide	SiSe					550		Quartz			

Silicon Sulphide	SiS	Subl.	1.85			450		Quartz			
Silicon Telluride	$SiTe_2$		4.39			550		Quartz			
Silver	Ag	961	10.49	847	958	1105	Xlnt.	Al_2O_3 Mo	W	Ta Mo	Evaporates well from any source.
Silver Bromide	AgBr	432	6.47			~380		Quartz		Ta	n=2.25
Silver Chloride	AgCl	455	5.56			~520		Quartz		Mo, Pt	n=2.07
Silver Iodide	AgI	558	5.67			~500				Ta	n=2.21
Sodium	Na	97	0.97	74	124	192		Quartz		Ta, S.S.	Use gentle preheat to outgas. Metal reacts violently in air.
Sodium Bromide	NaBr	755	3.2			~400		Quartz			Use gentle preheat to outgas. n=1.64
Sodium Chloride	NaCl	801	2.16			530	Good	Quartz		Ta, W, Mo	Cu ovens, little decomposition. Use gentle preheat to outgas. n=1.54
Sodium Cyanide	NaCN	563				~550				Ag	Use gentle preheat to outgas. n=1.45
Sodium Fluoride	NaF	988	2.79			~700	Good	BeO		Mo, Ta, W	Use gentle preheat to outgas. No decomposition. n=1.30 at 0.55µ.
Sodium Hydroxide	NaOH	318	2.13			~470				Pt	Use gentle preheat to outgas. n=1.36
Spinel	MgO_3 $5Al_2O_3$		8				Good				n=1.72
Strontium	Sr	769	2.6	239	309	403	Poor	Vit. Carbon	W	W, Ta, Mo	Wets but does not alloy with refractory metals. May react violently in air.
Strontium Fluoride	SrF_2	1190	4.24			~1000		Al_2O_3			n=1.44
Strontium Oxide	SrO	2460	4.7	Subl.	Subl.	1500 Subl.		Al_2O_3		Mo	Reacts with Mo and W; n=1.87
Strontium Sulphide	SrS	Above 2000	3.7							Mo	Decomposes. n=2.11
Sulphur	S_8	115	2	13	19	57	Poor	Quartz		W	Poisons vacuum system.
Supermalloy	Ni/Fe/Mo	1410	8.9				Good				Sputtering preferred; or co-evaporate from 2 sources, Permalloy and Mo.
Tantalum	Ta	2996	16.6	1960	2240	2590	Xlnt.				Forms good films.
Tantalum Boride	TaB_2	3000	12.38								
Tantalum Carbide	TaC	3880	14.65			~2500					
Tantalum Nitride	TaN	3360	16.3								Reactive; evaporate Ta in 10^{-3} N_2.

Tantalum Pentoxide	Ta_2O_5	1800	8.74	1550	1780	1920	Good	Vit. Carbon	W	Ta	Slight decomposition; evaporate in 10^{-3} Torr of O_2. n=2.0 at 1.5μ
Tantalum Sulphide	TaS_2	1300									
Technetium	Tc	2200	11.5	1570	1800	2090					
Teflon	PTFE	330	2.9							W	Baffled Source. Film structure doubtful.
Tellurium	Te	452	6.25	157	207	277	Poor	Al_2O_3 Quartz	W	W, Ta	Wets w/o alloying. Toxic.
Terbium	Tb	1357	8.27	800	950	1150	XInt.	Al_2O_3		Ta	
Terbium Fluoride	TbF_3	1176				~800					
Terbium Oxide	Tb_2O_3	2387	7.87			1300				Ir	Partially decomposes.
Terbium Oxide	Tb_4O_7									Ta	Films TbO.
Thallium	Tl	302	11.85	280	360	470	Poor	Al_2O_3 Quartz		W, Ta	Wets freely, very toxic.
Thallium Bromide	TlBr	480	7.56	Subl.	Subl.	~250 Subl.		Quartz		Ta	Toxic. n=2.3
Thallium Chloride	TlCl	430	7	Subl.	Subl.	~150 Subl.		Quartz		Ta	Toxic. n=2.25
Thallium Iodide (B)	TlI	440	7.09	Subl.	Subl.	~250 Subl.		Quartz			Toxic. n=2.78
Thallium Oxide	Tl_2O_3	717	9.65			350					Toxic, Goes to Tl_2O at 850 °C
Thorium	Th	1875	11.7	1430	1660	1925	XInt.		W	W, Ta, Mo	Toxic, radioactive.
Thorium Bromide	$ThBr_4$		5.67	Subl.	Subl.	Subl.				Mo	Toxic, n=2.47 at 5μ
Thorium Carbide	ThC_2	2773	8.96			~2300		Carbon			Radioactive
Thorium Dioxide	ThO_2	3050	10.03			~2100	Good			W	Radioactive. n=1.86 at 2.2 microns
Thorium Fluoride	ThF_4	1110	6.3			~750	Fair	Vit. Carbon		Mo	Radioactive. n=1.52. Heat substrate to above 150°C.
Thorium Oxyfluoride	$ThOF_2$	900	9.1							Mo, Ta	Radioactive, n=1.52
Thorium Sulphide	ThS_2		6.8								Sputtering preferred; or co-evaporate from 2 sources.
Thulium	Tm	1545	9.32	461 Subl.	554 Subl.	680 Subl.	Good	Al_2O_3		Ta	
Thulium Oxide	Tm_2O_3		8.9			1500				Ir	Decomposes.

Tin	Sn	232	7.75	682	807	997	Xlnt.	Al_2O_3	W	Mo	Wets Mo; use a Ta liner in EB guns.
Tin Oxide	SnO_2	1127	6.95	Subl.	Subl.	~1000 Subl.	Xlnt.	Quartz Al_2O_3	W	W	Films from W oxygen deficient, oxidize in air. n=2.0
Tin Selenide	SnSe	861	6.18			~400	Good	Quartz			
Tin Sulphide	SnS	882	5.08			~450		Quartz			
Tin Telluride	SnTe	780	6.44			~450		Quartz			
Titanium	Ti	1675	4.5	1067	1235	1453	Xlnt.	TiC		W	Alloys with refractory metals; evolves gas on first heating.
Titanium Boride	TiB_2	2980	4.5				Poor				
Titanium Carbide	TiC	3140	4.93			~2300					
Titanium Dioxide (rutile)	TiO2	1640	4.29			~1300	Fair			W, Mo	Evaporate in 10-4 of O_2 onto 350° substrates. n=2.4
Titanium Monoxide	TiO	1750	4.93			~1500	Good	Vit. Carbon		W, Mo	Use gentle preheat to outgas. Films TiO_2 if evaporated like TiO_2; n=2.2
Titanium Nitride	TiN	2930	5.43				Good			Mo	Sputtering preferred. Decomposes with thermal evaporation.
Titanium Sesquioxide	Ti_2O_3	2130	4.6				Good			W	Decomposes.
Tungsten	W	3410	19.3	2117	2407	2757	Good				Forms volatile oxides. Films hard & adherent.
Tungsten Boride	WB_2	2900	12.75				Poor				
Tungsten Carbide	W_2C	2860	17.15	1480	1720	2120	Xlnt.			C	
Tungsten Telluride	WTe_3		9.49					Quartz			
Tungsten Trioxide	WO_3	1473	7.16	Subl.	Subl.	980 Subl.	Good			W, Pt	Use gentle preheat to outgas. W reduces oxide slightly. n=1.68
Uranium	U	1132	19.07	1132	1327	1582	Good		W	Mo, W	Films oxidize.
Uranium Carbide	UC_2	2260	11.28			2100		Carbon			Decomposes.
Uranium Dioxide	UO_2	2176	10.9							W	Ta causes decomposition
Uranium Fluoride	UF_4	~1000				300				Ni	
Uranium Oxide	U_3O_8	Dec	8.3							W	Decomposes at 1300°C to UO_2
Uranium Phosphide	UP_2		8.57			1200				Ta	Decomposes

Uranium Sulphide	U_2S_3					1400				W	Slight decomposition
Vanadium	V	1890	5.96	1162	1332	1547	XInt.			W, Mo	Wets Mo. EB evaporated films preferred.
Vanadium Boride	VB_2	2400	5.1								
Vanadium Carbide	VC	2810	5.77			~1800					
Vanadium Dioxide	VO_2	1967	4.34	Subl.	Subl.	~575 Subl.					Deposit metal in 1 x 10^{-3} O_2
Vanadium Nitride	VN	2320	6.13								
Vanadium Pentoxide	V_2O_5	690	3.36			~500		Quartz			
Vanadium Silicide	VSi_2	1700	4.42								
Ytterbium	Yb	824	6.98	520 Subl.	590 Subl.	690 Subl.	Good			Ta	
Ytterbium Fluoride	YbF_3	1157	8.17			~800				Mo	n=1.57 at 3.8µ
Ytterbium Oxide	Yb_2O_3	2346	9.17	Subl.	Subl.	~1500 Subl.				Ir	Loses oxygen.
Yttrium	Y	1509	4.48	830	973	1157	XInt.	Al_2O_3	W	W, Ta	High Ta solubility.
Yttrium Aluminum Oxide	$Y_3Al_5O_{12}$	1990					Good		W		Films not ferroelectric
Yttrium Fluoride	YF_3	1387	4.01								
Yttrium Oxide	Y_2O_3	2680	4.84	Subl.	Subl.	~2000 Subl.	Good	C		W	Loses oxygen, films smooth and clear. n=1.79 at 1µ
Zinc	Zn	419	7.14	127	177	250	XInt.	Al_2O_3 Quartz	W	Mo, W, Ta	Evaporates well under wide range of conditions.
Zinc Antimonide	Zn_3Sb_2	546	6.3								
Zinc Bromide	$ZnBr_2$	394	4.22			~300		Carbon		W	Decomposes.
Zinc Fluoride	ZnF_2	872	4.84			~800		Quartz		Pt, Ta	
Zinc Nitride	Zn_3N_2		6.22							Mo	Decomposes.
Zinc Oxide	ZnO	1975	5.61			~1800	Fair				Anneal in air at 450°C to reoxidize; n=2.0
Zinc Selenide	ZnSe	1526	5.42			660		Quartz	W Mo	Ta, W, Mo	Use gentle preheat to outgas. Evaporates well, n=2.6

Zinc Sulphide	ZnS	1830	4.09	Subl.	Subl.	~800 Subl.	Good			Ta, Mo	Use gentle preheat to outgas. Films partially decompose. Sticking coefficient varies with substrate temperature. n=2.3 at 0.5μ
Zinc Telluride	ZnTe	1238	6.34			~600				Mo, Ta	Use gentle preheat to outgas. n=2.85 at 0.5μ
Zircon	$ZrSiO_4$	2550	4.56								
Zirconium	Zr	1852	6.4	1477	1702	1987	Xlnt.			W	Alloys with W. Films oxidize readily.
Zirconium Boride	ZrB2	3040	6.08				Good				
Zirconium Carbide	ZrC	3540	6.73			~2500					
Zirconium Nitride	ZrN	2980	7.09								Reactively evaporate in 10^{-3} N_2 atmosphere.
Zirconium Oxide	ZrO_2	2700	5.49			~2200	Good			W	Films oxygen deficient, clear, and hard. n=2.05 at 0.75μ
Zirconium Silicide	$ZrSi_2$	1700	4.88								