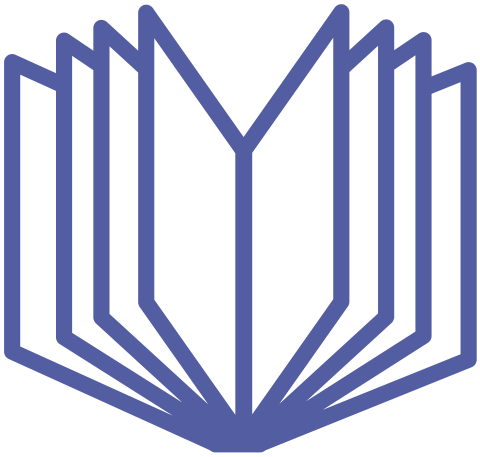

A MATERIALS VACUUM DEPOSITION GUIDE

Technical Guide about Thin Films Deposition

KEY OF SYMBOLS

*	Influenced by composition
**	Cr-plated rod or strip
***	All metals alumina coated
Gr	Graphite
Q	Quartz
VC	Vitreous carbon
SS	Stainless steel
Int	Intermetallic
Ex	Excellent
G	Good
F	Fair
P	Poor
S	Sublimes
D	Decomposes
RF	RF sputtering is effective
RF-R	Reactive RF sputter is effective
DC	DC sputtering is effective
DC-R	Reactive DC sputtering is effective

REMARK:
Data have been obtained from reliable literature sources or scientists doing vacuum deposition work. Whilst great care has been taken to ensure that the information contained in this table is accurate, data should be used as a general guide and at your own risk. Do not hesitate to use a second source for very critical data or consult us.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Aluminum	Al	660	-	2.70	677	807	972	Ex	Gr, Int	Int, W, Al_2O_3	W	W	Int	RF, DC	0.93@0.6	Alloys and wets W. Stranded W is best. Slow sputtering.
Aluminum Antimonide	AlSb	1080	-	4.3	-	-	-	-	-	-	-	-	-	RF	3.62	-
Aluminum Arsenide	AlAs	1600	-	3.7	-	-	~1300	-	-	-	-	-	-	RF	-	-
Aluminum Bromide	$AlBr_3$	97	-	2.64	-	-	~50	-	-	Mo	-	-	Gr	RF	-	-
Aluminum Carbide	Al_4C_3	~1400	-	2.36	-	-	~800	F	-	-	-	-	-	RF	2.75@0.7	-
Aluminum Fluoride	AlF_3	1291	S	2.88	410	490	700	P	Gr	Mo, W, Ta	-	-	Gr	RF	1.4@0.5	-
Aluminum Nitride	AlN	>2200	S/D	3.26	-	-	~1750	F	-	-	-	-	-	RF, RF-R	-	Reactive evap in 10^{-3} N_2 with glow discharge. Good electrical stability.
Aluminum Oxide	Al_2O_3	2072	-	3.97	-	-	1550	Ex	-	W	-	W	-	RF-R	1.63@0.55	Sapphire excellent in E-beam. Forms smooth, hard films.
Aluminum Phosphide	AlP	2000	-	2.42	-	-	-	-	-	-	-	-	-	RF	-	-
Aluminum, 2% Copper	Al2%Cu	640	-	2.82	-	-	-	-	-	-	-	-	-	RF, DC	-	Wire feed and flash. Difficult from dual sources.
Aluminum, 2% Silicon	Al2%Si	640	-	2.69	-	-	1010	G	Gr, Int	-	-	-	Int	RF, DC	-	Wire feed and flash. Difficult from dual sources.
Aluminum-doped Zinc Oxide	AZO	-	-	-	-	-	-	-	Mo	-	-	-	-	RF, DC	-	-

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Antimony	Sb	630	S	6.68	279	345	425	P	Gr, Al_2O_3, BN	Mo, Ta, Al_2O_3, ***	Mo, Ta	Mo, Ta	BN, C, Al_2O_3	RF, DC	3.4@1	Toxic. Evaporates well. Film structure is rate dependent.
Antimony Oxide	Sb_2O_3	656	S	5.2	-	-	~300	G	Al_2O_3, BN	Pt	-	Pt	BN, Al_2O_3	RF-R	2.1@0.55	Toxic. Decomposes on W. Use low rate.
Antimony Selenide	Sb_2Se_3	611	D	-	-	-	-	-	-	Ta	-	-	Gr	RF	3.01@0.55	Stoichiometry variable. Toxic.
Antimony Sulfide	Sb_2S_3	550	-	4.64	-	-	~200	G	Al_2O_3	Mo, Ta	-	Mo, Ta	-	-	3.2@0.55	Toxic. No decomposition.
Antimony Telluride	Sb_2Te_3	629	-	6.50	-	-	600	-		-	-	-	Gr	RF	-	Toxic. Decomposes over 750°C.
Arsenic	As	817	S	5.73	107	150	210	P	Gr, VC, Al_2O_3	Gr	-	-	Al_2O_3, VC	-	-	Toxic. Sublimes rapidly at low temperature.
Arsenic Oxide	As_2O_3	312	-	3.74	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic Selenide	As_2Se_3	~360	-	4.75	-	-	-	-	-	-	-	-	Q	RF	3.03@0.82	Toxic.
Arsenic Sulfide	As_2S_3	300	-	3.43	-	-	~400	F	Mo	Mo	-	-	Q	RF	2.69@0.56	Toxic.
Arsenic Telluride	As_2Te_3	362	-	-	-	-	-	-	-	-	-	-	-	-	-	Flash. Toxic.
Barium	Ba	725	-	3.51	287	354	462	F	-	W, Ta, Mo	W	W	Metals	RF	0.9@0.57	Toxic. Wets without alloying from refractory metals. Reacts with ceramics. Evaporates easily.
Barium Chloride	$BaCl_2$	963	-	3.92	-	-	~650	-	-	Ta, Mo	-	-	-	RF	0.74@0.58	Preheat gently to outgas.
Barium Fluoride	BaF_2	1355	S	4.89	-	-	~700	G	-		-	-	-	RF	1.3@0.55	Denstity rate dependent.
Barium Oxide	BaO	1918	-	5.72	-	-	~1300	P	Al_2O_3	Pt	-	Pt	Al_2O_3	RF, RF-R	1.98@0.59	Decomposes slightly.
Barium Sulfide	BaS	1200	-	4.25	-	-	1100	-	-	Mo	-	-	-	RF	2.16@ 0.59	-
Barium Titanate	$BaTiO_3$	-	D	6.02	-	-	-	-	-	-	-	-	-	RF	2.4@0.55	Gives Ba. Co-evap. from 2 sources or sputter.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Beryllium	Be	1278	-	1.85	699	827	987	Ex	Gr, VC	W, Ta	W	W	BeO, Gr, VC	RF, DC	2.5@0.5	Wets W/Mo/Ta. Powder and oxides toxic. Evaporates easily.
Beryllium Carbide	Be_2C	>2100	D	1.90	-	-	-	-	-	-	-	-	-	-	-	-
Beryllium Chloride	$BeCl_2$	405	-	1.90	-	-	~150	-	-	-	-	-	-	RF	-	Toxic.
Beryllium Fluoride	BeF_2	800	S	1.99	-	-	~200	G	-	-	-	-	-	-	1.33@0.59	-
Beryllium Oxide	BeO	2530	-	3.01	-	-	1900	G	-	-	-	W	-	RF, RF-R	1.72@0.55	Toxic powder. No decomposition from E-beam guns.
Bismuth	Bi	271	-	9.80	330	410	520	G	VC, Al_2O_3	W, Mo, Ta, Al_2O_3	W	W	Al_2O_3, VC	DC, RF	2.61@0.8	Toxic vapor. High resistivity. No shorting of baskets.
Bismuth Fluoride	BiF_3	727	S	5.32	-	-	~300	-	-	-	-	-	-	RF	1.7@0.55	Toxic.
Bismuth Oxide	Bi_2O_3	860	-	8.55	-	-	~1400	P	-	Pt	-	Pt	-	RF, RF-R	1.9@0.55	Toxic vapor.
Bismuth Selenide	Bi_2Se_3	710	D	6.82	-	-	~650	G	Gr	-	-	-	Gr, Q	RF	-	Toxic. Co-evaporate from two sources or sputter.
Bismuth Sulfide	Bi_2S_3	685	D	7.39	-	-	-	-	-	-	-	-	-	RF	1.5	Toxic.
Bismuth Telluride	Bi_2Te_3	573	D	7.7	-	-	~600	-	Gr	W, Mo	-	-	Gr, Q	RF	-	Toxic. Co-evaporate from two sources or sputter.
Bismuth Titanate	$Bi_2Ti_2O_7$	-	D	-	-	-	-	-	-	-	-	-	-	RF	-	Toxic. Sputter or co-evaporate from two sources in 10^{-2} Torr oxygen.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Boron	B	2300	-	2.34	1278	1548	1797	G	-	Gr	-	-	Gr, VC	RF	-	Explodes with rapid cooling. Forms carbide with Gr. Boats must be heated.
Boron Carbide	B_4C	2350	-	2.52	2500	2580	2650	Ex	-	-	-	-	-	RF	-	Similar to chromium. Films very adherent. Sputter quickly.
Boron Nitride	BN	~3000	S	2.25	-	-	~1600	P	-	-	-	-	-	RF, RF-R	-	Decomposes under sputtering; sensitive to thermic shocks. Sputtering preferred.
Boron Oxide	B_2O_3	~450	-	1.81	-	-	~1400	G	-	Pt, Mo	-	-	-	-	1.46	-
Boron Sulfide	B_2S_3	310	-	1.55	-	-	800	-	-	-	-	-	Gr	RF	-	-
Cadmium	Cd	321	-	8.64	64	120	180	F	Al_2O_3	W, Mo, Ta	-	W, Mo, Ta	Al_2O_3, Q	DC, RF	1.13@0.6	Bad for vacuum systems. Low sticking coefficient.
Cadmium Antimonide	Cd_3Sb_2	456	-	6.92	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium Arsenide	Cd_3As_2	721	-	6.21	-	-	-	-	-	-	-	-	Q	RF	-	Toxic.
Cadmium Bromide	$CdBr_2$	567	-	5.19	-	-	~300	-	-	-	-	-	-	-	-	-
Cadmium Chloride	$CdCl_2$	568	-	4.05	-	-	~400	-	-	-	-	-	-	-	-	-
Cadmium Fluoride	CdF_2	1100	-	6.64	-	-	~500	-	-	-	-	-	-	RF	1.56@0.58	-
Cadmium Iodide	CdI_2	387	-	5.67	-	-	~250	-	-	-	-	-	-	-	-	-
Cadmium Oxide	CdO	>1500	D	6.95	-	-	~530	-	-	-	-	-	-	RF-R	2.49@0.67	Reactive RF (O_2 + Ar) or (O_2 + N_2).
Cadmium Selenide	CdSe	>1350	S	5.81	-	-	540	G	Al_2O_3	Mo, Ta	-	-	Al_2O_3, Q	RF	2.4@0.58	Toxic. Evaporates easily.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Cadmium Sulfide	CdS	1750	S	4.82	-	-	550	F	Gr, Al_2O_3	W, Mo, Ta	-	W	Al_2O_3, Q	RF	2.5@0.55	Sticking coefficient affected by substrate temperature. Stoichiometry variable.
Cadmium Telluride	CdTe	1121	-	5.85	-	-	450	-	-	W, Mo, Ta	W	Ta, Mo	-	RF	2.6	Toxic. Stoichiometry depends on substrate temperature.
Calcium	Ca	839	S	1.54	272	357	459	P	Al_2O_3	W	W	W	Al_2O_3, Q	-	0.29@0.58	Flammable. Corrodes in air.
Calcium Fluoride	CaF_2	1423	-	3.18	-	-	~1100	-	-	W, Mo, Ta	W, Mo, Ta	W, Mo, Ta	Q	RF	1.4@0.55	Rate control important. Preheat gently to outgas.
Calcium Oxide	CaO	2614	-	~3.3	-	-	~1700	-	-	W, Mo	-	-	ZrO_2	RF, RF-R	1.84@0.59	Forms volatile oxides with tungsten and molybdenum.
Calcium Silicate	$CaSiO_3$	1540	-	2.91	-	-	-	G	-	-	-	-	Q	RF	-	-
Calcium Sulfide	CaS	-	D	2.5	-	-	1100	-	-	Mo	-	-	-	RF	2.14@0.59	-
Calcium Titanate	$CaTiO_3$	1975	-	4.10	1490	1600	1690	P	-	-	-	-	-	RF	2.34@0.59	Disproportionates except in sputtering.
Calcium Tungstate	$CaWO_4$	-	-	6.06	-	-	-	G	-	W	-	-	-	RF	1.92@0.59	-
Carbon	C	~3652	S	1.8-2.1	1677	1867	2107	G	-	-	-	-	-	RF	1.47	E-beam preferred. Arc evaporation. Poor film adhesion.
Parylene	C_8H_8	300-400	-	1.1	-	-	-	-	-	-	-	-	-	-	-	Vapor-depositableplastic.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Cerium	Ce	798	-	~6.70	970	1150	1380	G	Al_2O_3, VC	W, Ta	W	W, Ta	Al_2O_3, VC	DC, RF	1.91@0.59	Films oxide easily.
Cerium Fluoride	CeF_3	1460	-	6.16	-	-	~900	G	-	W, Mo, Ta	-	Mo, Ta	-	RF	1.63@0.55	Preheat gently to outgas.
Cerium (III) Oxide	Ce_2O_3	1692	-	6.86	-	-	-	F	-	W	-	-	-	-	2.18@0.58	Alloys with source. Use 0.015 "-0.020" tungsten boat. E-beam gun preferred.
Cerium (IV) Oxide	CeO_2	~2600	S	7.13	1890	2000	2310	G	Gr	W	-	-	-	RF, RF-R	2.18@0.55	Very little decomposition. Use 250°C substrate temperature.
Cesium	Cs	28	-	1.88	-17	22	75	-	-	SS	-	-	Q	-	-	Flammable.
Cesium Bromide	CsBr	636	-	3.04	-	-	~400	-	-	W	-	-	-	RF	-	-
Cesium Chloride	CsCl	645	-	3.99	-	-	~500	-	-	W	-	-	-	RF	-	Hygroscopic.
Cesium Fluoride	CsF	682	-	4.12	-	-	~500	-	-	W	-	-	-	RF	1.5@0.55	-
Cesium Hydroxide	CsOH	272	-	3.68	-	-	550	-	-	Pt	-	-	-	-	-	-
Cesium Iodide	CsI	626	-	4.51	-	-	~500	-	-	W	-	-	-	RF	1.99@0.23	-
Chromium	Cr	1857	S	7.20	852	977	1162	G	Gr, VC	**	W	W	VC	RF, DC	3.28@0.7	Films very adherent. High rates possible.
Chromium Boride	CrB	2760	-	6.17	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Chromium Bromide	$CrBr_2$	842	-	4.36	-	-	550	-	-		-	-	-	RF	-	-
Chromium Carbide	Cr_3C_2	1980	-	6.68	-	-	~2000	F	-	W	-	-	-	RF, DC	-	-
Chromium Chloride	$CrCl_2$	824	-	2.88	-	-	550	-	-	Fe	-	-	-	RF	-	Sublimes easily.
Chromium Oxide	Cr_2O_3	2266	-	5.21	-	-	~2000	G	-	W, Mo	-	W	-	RF, RF-R	2.55@0.59	Disproportionates to lower oxides; reoxidizes at 600°C in air.
Chromium Silicide	Cr_3Si_2	-	-	5.5	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Chromium-Silicon Monoxide	Cr-SiO	-	-	*	*	*	*	G	-	W	-	W	-	DC, RF	-	Flash.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Cobalt	Co	1495	-	8.9	927	1072	1262	Ex	Al_2O_3	W	-	W	Al_2O_3	DC, RF	2.17@0.62	Alloys with refractory metals.
Cobalt Bromide	$CoBr_2$	678	S	4.91	-	-	400	-	-	-	-	-	-	RF	-	-
Cobalt Chloride	$CoCl_2$	724	S	3.36	-	-	472	-	-	-	-	-	-	RF	1.51@0.63	-
Cobalt Oxide	CoO	1795	-	6.45	-	-	-	-	-	-	-	-	-	DC-R, RF-R	-	Sputter preferred.
Copper	Cu	1083	-	8.92	727	857	1017	Ex	Gr, Al_2O_3, Mo, Ta	Mo	W	W	Al_2O_3, Int	DC, RF	0.17@0.8	Adhesion poor. Use interlayer (Cr). Evaporates using any source material.
Copper Chloride	CuCl	430	-	4.14	-	-	~600	-	-	-	-	-	-	RF	1.93	-
Copper Oxide	Cu_2O	1235	S	6.0	-	-	~600	G	Al_2O_3	Ta	-	-	Al_2O_3	DC-R, RF-R	2.71@0.59	Evaporate in 10^{-2} to 10^{4} of O_2.
Copper Sulfide	Cu_2S	1100	-	5.6	-	-	-	-	-	-	-	-	-	-	-	-
Dysprosium	Dy	1412	S	8.55	625	750	900	G	-	Ta	-	-	-	RF, DC	-	Flammable.
Dysprosium Fluoride	DyF_3	1360	S	-	-	-	~800	G	-	Ta	-	-	-	RF	1.6@0.55	-
Dysprosium Oxide	Dy_2O_3	2340	-	7.81	-	-	~1400	-	-	Ir	-	-	-	RF, RF-R	1.9@0.55	Loses oxygen.
Erbium	Er	1529	S	9.07	650	775	930	G	-	W, Ta	-	-	-	DC, RF	-	-
Erbium Fluoride	ErF_3	1350	-	-	-	-	~750	-	-	-	-	-	-	RF	1.5@0.55	-
Erbium Oxide	Er_2O_3	Infus.	-	8.64	-	-	~1600	-	-	Ir	-	-	-	RF, RF-R	1.9@0.55	Loses oxygen.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Europium	Eu	822	-	5.24	280	360	460	F	Al_2O_3	W, Ta	-	-	Al_2O_3	RF, DC	-	Flammable. Low tantalum solubility.
Europium Fluoride	EuF_2	1380	-	6.50	-	-	~950	-	-	Mo	-	-	-	RF	-	-
Europium Oxide	Eu_2O_3	-	-	7.42	-	-	~1600	G	W	Ir, Ta, W	-	-	ThO_2	RF, RF-R	1.9@0.55	Loses oxygen. Films clear and hard.
Europium Sulfide	EuS	-	-	5.75	-	-	-	G	-	-	-	-	-	RF	-	-
Gadolinium	Gd	1313	-	7.90	760	900	1175	Ex	Al_2O_3	Ta	-	-	Al_2O_3	RF, DC	-	Flammable. High tantalum solubility.
Gadolinium Carbide	GdC_2	-	-	-	-	-	1500	-	-	-	-	-	Gr	RF	-	Decomposes under sputtering.
Gadolinium Oxide	Gd_2O_3	2330	-	7.41	-	-	-	F	-	Ir	-	-	-	RF, RF-R	1.8@0.55	Loses oxygen.
Gallium	Ga	30	-	5.90	619	742	907	G	Gr, VC, Al_2O_3	-	-	-	Al_2O_3, Q	-	-	Alloys with refractory metals. Use E-beam gun. Attack crucibles above 1000°C.
Gallium Antimonide	GaSb	710	-	5.6	-	-	-	F	-	W, Ta	-	-	-	RF	3.8@2.2	Flash evaporate.
Gallium Arsenide	GaAs	1238	-	5.3	-	-	-	G	Gr	W, Ta	-	-	Gr	RF	3.34@0.78	Flash evaporate.
Gallium Nitride	GaN	800	S	6.1	-	-	~200	-	-	-	-	-	Al_2O_3	RF, RF-R	-	Evaporates gallium in 10^{-3} Torr nitrogen.
Gallium Oxide	Ga_2O_3	1900	-	6.44	-	-	-	-	-	Pr, W	-	-	-	RF	-	Loses oxygen.
Gallium Phosphide	GaP	1540	-	4.1	-	770	920	-	-	W, Ta	-	W	Q	RF	3@2.15	Does not decompose. Rate control important.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Germanium	Ge	937	-	5.35	812	952	1142	Ex	Gr, Al_2O_3	W, Gr, Ta	-	-	Q, Al_2O_3	DC, RF	4@2	Excellent films from E-beam guns. Wets W, Ta and Mo.
Germanium Nitride	Ge_3N_2	450	S	5.2	-	-	~650	-	-	-	-	-	-	RF-R	-	Sputtering preferred.
Germanium (II) Oxide	GeO	710	-	-	-	-	500	-	-	-	-	-	Q	RF	-	-
Germanium (III) Oxide	GeO_2	1086	-	6.24	-	-	~625	G	VC, Al_2O_3	Ta, Mo	-	W, Mo	Q, Al_2O_3	RF-R	1.61@0.59	Similar to SiO; film predominantly GeO.
Germanium Telluride	GeTe	725	-	6.20	-	-	381	-	-	W, Mo	-	W	Q, Al_2O_3	RF	-	-
Glass, Schott 8329	-	-	-	2.20	-	-	-	Ex	-	-	-	-	-	RF	1.47	Evaporable alkali glass. Melt in air before evaporating.
Gold	Au	1064	-	19.32	807	947	1132	Ex	Gr, VC, Al_2O_3, BN	W	W	W,*** Mo,***	Al_2O_3, BN, VC	DC, RF	0.2@0.6	Films soft, not very adherent. Wets W and Mo. Sputtering preferred.
Hafnium	Hf	2227	-	13.31	2160	2250	3090	G	Mo	-	-	-	-	DC, RF	-	-
Hafnium Boride	HfB_2	3250	-	10.5	-	-	-	-	-	-	-	-	-	DC, RF	-	-
Hafnium Carbide	HfC	~3890	S	12.20	-	-	~2600	-	-	-	-	-	-	DC, RF	-	-
Hafnium Nitride	HfN	3305	-	-	-	-	-	-	-	-	-	-	-	RF, RF-R	-	-
Hafnium Oxide	HfO_2	2758	-	9.68	-	-	~2500	F	Mo	W	-	-	-	DC, RF, RF-R	1.9@0.55	Film HfO.
Hafnium Silicide	$HfSi_2$	1750	-	7.2	-	-	-	-	-	-	-	-	-	RF	-	-

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Holmium	Ho	1474	S	8.80	650	770	950	G	-	W, Ta	W	W	-	-	-	-
Holmium Fluoride	HoF_3	1143	-	-	-	-	~800	-	-	-	-	-	Q	DC, RF	1.6@0.55	-
Holmium Oxide	Ho_2O_3	2370	-	8.41	-	-	-	-	-	Ir	-	-	-	RF, RF-R	1.9@0.55	Loses oxygen.
Indium	In	157	-	7.30	487	597	742	Ex	Gr, Al_2O_3, Mo	W, Mo	-	W	Gr, Al_2O_3	DC, RF	1.38@0.71	Wets tungsten and copper.
Indium Antimonide	InSb	535	D	5.8	-	-	-	-	-	W	-	-	-	RF	1@0.55	Toxic. Sputter preferred or co-evaporate on heated substrat 900°C. Flash.
Indium Arsenide	InAs	943	D	5.7	780	870	970	-	-	W	-	-	-	RF	4.5@1	Toxic. Sputtering preferred or co-evap from 2 sources. Flash.
Indium Nitride	InN	1200	-	7.0	-	-	-	-	-	-	-	-	-	RF	-	-
Indium (I) Oxide	In_2O	~600	S	6.99	-	-	650	-	-	-	-	-	-	RF	-	Decomposes under sputtering.
Indium (III) Oxide	In_2O_3	850	-	7.18	-	-	~1200	G	Al_2O_3	W, Pt	-	-	Al_2O_3	-	2@0.55	Film In_2O. Transparent conductor.
Indium Phosphide	InP	1070	-	4.8	-	630	730	-	-	W, Ta	-	W, Ta	Gr	RF	3@2	Deposits are phosphorus rich. Flash evaporate.
Indium Selenide	In_2Se_3	890	-	5.67	-	-	-	-	-	-	-	-	-	RF	-	Sputtering preferred; or co-evaporate from two sources; flash.
Indium (I) Sulfide	In_2S	653	-	5.87	-	-	650	-	-	-	-	-	Gr	RF	2	-
Indium (II) Sulfide	InS	692	S	5.18	-	-	650	-	-	-	-	-	Gr	RF	-	-
Indium (III) Sulfide	In_2S_3	1050	S	4.90	-	-	850	-	-	-	-	-	Gr	RF	-	Film In_2S.
Indium (II) Telluride	InTe	696	-	6.29	-	-	-	-	-	-	-	-	-	-	-	-

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Indium (III) Telluride	In_2Te_3	667	-	5.78	-	-	-	-	-	-	-	-	-	RF	-	Sputtering preferred; or co-evaporate from two sources; flash.
Indium Tin Oxide (ITO)	In_2O_3-SnO_2	1800	S	7.1	-	-	600	Ex	Mo	-	-	-	-	-	-	Loses oxygen.
Iridium	Ir	2410	-	22.42	1850	2080	2380	F	W	-	-	-	W	DC, RF	-	-
Iron	Fe	1535	-	7.86	877	1017	1207	Ex	VC, Al_2O_3	W	W	W	Al_2O_3	DC, RF	2@0.58	Attacks tungsten. Films hard, smooth. Preheat gently to outgas.
Iron Bromide	$FeBr_2$	684	-	4.64	-	-	561	-	-	-	-	-	-	RF	-	-
Iron Chloride	$FeCl_2$	670	S	3.16	-	-	300	-	-	-	-	-	-	RF	1.57@0.59	-
Iron Iodide	FeI_2	-	-	5.32	-	-	400	-	-	-	-	-	-	RF	-	-
Iron (II) Oxide	FeO	1369	D	5.7	-	-	-	P	-	-	-	-	-	RF, RF-R	2.32@0.59	Sputtering preferred.
Iron (III) Oxide	Fe_2O_3	1565	-	5.24	-	-	-	G	-	W	-	W	-	-	3@0.55	Disproportionates to Fe_3O_4 at 1530°C.
Iron Sulfide	FeS	1193	D	4.74	-	-	-	-	-	-	-	-	Al_2O_3	RF	-	-
Kanthal	FeCrAl	-	-	7.1	-	-	-	-	-	W	W	-	-	DC, RF	1.74@0.58	-
Lanthanum	La	921	-	6.15	990	1212	1388	Ex	Al_2O_3	W, Ta	-	-	Al_2O_3	RF	-	Films will burn in air if scraped.
Lanthanum Boride	LaB_6	2210	-	2.61	-	-	-	G	-	-	-	-	-	RF	-	Toxic.
Lanthanum Bromide	$LaBr_3$	783	-	5.06	-	-	-	-	-	-	-	Ta	-	RF	-	Hygroscopic.
Lanthanum Fluoride	LaF_3	1490	S	~6.0	-	-	900	G	-	Ta, Mo	-	Ta	-	RF	1.6@0.55	No decomposition. Heat substrate over 300°C.
Lanthanum Oxide	La_2O_3	2307	-	6.51	-	-	1400	G	-	W, Ta	-	-	-	RF	1.9@0.55	Loses oxygen.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Lead	Pb	328	-	11.34	342	427	497	Ex	Gr, Al_2O_3	W, Mo	W	W, Ta	Al_2O_3, Q	DC, RF	1.51@0.8	Toxic.
Lead Bromide	$PbBr_2$	373	-	6.66	-	-	~300	-	-	-	-	-	-	-	-	Toxic.
Lead Chloride	$PbCl_2$	501	-	5.85	-	-	~325	-	-	Pt	-	-	Al_2O_3	RF	2.3@0.55	Toxic. Little decomposition.
Lead Fluoride	PbF_2	855	S	8.24	-	-	~400	-	-	W, Pt, Mo	-	-	Al_2O_3	RF	1.75@0.55	Toxic.
Lithium	Li	181	-	0.53	227	307	407	G	Al_2O_3	Ta, SS	-	-	Al_2O_3	-	-	Metal reacts quickly in air.
Lithium Bromide	LiBr	550	-	3.46	-	-	~500	-	-	Ni	-	-	-	RF	1.78@0.59	-
Lithium Iodide	LiI	449	-	4.08	-	-	400	-	-	Mo, W	-	-	-	RF	1.96@0.59	-
Lithium Oxide	Li_2O	>1700	-	2.01	-	-	850	-	-	Pt, Ir	-	-	-	RF	1.64@0.59	-
Lutetium	Lu	1663	S	9.84	-	-	1300	Ex	Al_2O_3	Ta	-	-	Al_2O_3	RF, DC	-	-
Lutetium Oxide	Lu_2O_3	-	D	9.42	-	-	1400	-	-	Ir	-	-	-	RF	1.9@0.55	-
Magnesium	Mg	649	S	1.74	185	247	327	G	VC, Al_2O_3	W, Mo, Ta	W	W	Al_2O_3, VC	DC, RF	0.52@0.4	Flammable. Extremely high rates possible. Sputtering possible but enough slow.
Magnesium Aluminate	$MgAl_2O_4$	2135	-	3.6	-	-	-	G	-	-	-	-	-	RF	-	Natural spinel.
Magnesium Bromide	$MgBr_2$	700	D	3.72	-	-	~450	-	-	Ni	-	-	-	RF	-	-
Magnesium Chloride	$MgCl_2$	714	D	2.32	-	-	400	-	-	Ni	-	-	-	RF	1.6	-
Magnesium Fluoride	MgF_2	1261	-	2.9-3.2	-	-	1000	Ex	Al_2O_3, Mo	-	-	-	Al_2O_3	RF	1.38@0.55	Rate control and substrate heat important for optical films. Reacts with tungsten. Excellent with molybdenum.
Magnesium Iodide	MgI_2	<637	-	4.43	-	-	200	-	-	Pr	-	-	-	RF	-	-

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Magnesium Oxide	MgO	2852	-	3.58	-	-	1300	G	Al_2O_3	-	-	-	Gr, Al_2O_3	RF, RF-R	1.7@0.55	Evaporates in 10^{-3} Torr oxygen for stoichiometry. Tungsten gives volatile oxides.
Manganese	Mn	1244	S	7.20	507	572	647	G	Al_2O_3	W, Ta, Mo	W	W	Al_2O_3	DC, RF	2.59@0.59	Flammable. Wets refractair metals.
Manganese Bromide	$MnBr_2$	-	-	4.39	-	-	500	-	-	-	-	-	-	RF	-	-
Manganese Chloride	$MnCl_2$	650	-	2.98	-	-	450	-	-	-	-	-	-	RF	-	-
Manganese (III) Oxide	Mn_2O_3	1080	-	4.50	-	-	-	-	-	-	-	-	-	-	-	-
Manganese (IV) Oxide	MnO_2	535	-	5.03	-	-	-	P	-	W	-	W	-	RF-R	-	Loses oxygen at 535°C.
Manganese Sulfide	MnS	-	D	3.99	-	-	1300	-	-	Mo	-	-	-	RF	2.7	-
Mercury	Hg	-39	-	13.55	-68	-42	-6	-	-	-	-	-	-	-	-	Toxic.
Mercury Sulfide	HgS	584	S/D	8.10	-	-	250	-	-	-	-	-	Al_2O_3	RF	-	Toxic.
Molybdenum	Mo	2610	-	10.2	1592	1822	2117	Ex	Gr	-	-	-	-	DC, RF	3.65@0.59	Films smooth, hard. Careful degas required.
Molybdenum Boride	MoB_2	2100	-	7.12	-	-	-	P	-	-	-	-	-	RF, DC	-	-
Molybdenum Carbide	Mo_2C	2687	-	8.9	-	-	-	F	-	-	-	-	-	RF, DC	-	Evaporation of $Mo(CO)_6$ yields Mo_2C.
Molybdenum Disulfide	MoS_2	1185	-	4.80	-	-	~50	-	-	-	-	-	-	RF	-	-
Molybdenum Oxide	MoO_3	795	-	4.69	-	-	~900	-	Al_2O_3, Mo	Mo, Pt	-	Mo	Al_2O_3, BN	RF	1.9@0.55	Slight oxygen loss.
Molybdenum Silicide	$MoSi_2$	2050	D	6.31	-	-	-	-	-	W	-	-	-	RF	1.9	Slight O_2 loss.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Neodymium	Nd	1021	-	7.01	731	871	1062	Ex	Al_2O_3	Ta	-	-	Al_2O_3	DC, RF	0.3@0.88	Flammable. Low tantalum solubility.
Neodymium Fluoride	NdF_3	1410	-	6.5	-	-	~900	G	Al_2O_3	Mo, W	-	Mo, Ta	Al_2O_3	RF	1.61@0.55	Very little decomposition.
Neodymium Oxide	Nd_2O_3	~1900	-	7.24	-	-	~1400	G	W	Ta, W	-	-	W	RF, RF-R	2@0.55	Loses oxygen. Films clear. E-beam preferred. Hygroscopic. N varies with substrate temperature.
Nickel	Ni	1455	-	8.90	927	1072	1262	Ex	VC, Al_2O_3	W	W	W	Al_2O_3, VC	DC, RF	2.37@0.81	Alloys with refractory metals. Forms smooth adherent films.
Nickel Bromide	$NiBr_2$	963	S	5.10	-	-	362	-	-	-	-	-	-	RF	-	-
Nickel Chloride	$NiCl_2$	1001	S	3.55	-	-	444	-	-	-	-	-	-	RF	-	-
Nickel Oxide	NiO	1984	-	6.67	-	-	~1470	-	Al_2O_3	-	-	-	Al_2O_3	RF-R	2.18@0.48	Dissociates on heating.
Inconel	Ni/Cr/Fe	1425	-	8.5	-	-	-	G	-	W	W	W	-	DC, RF	-	Use fine wire wrapped on tungsten. Low rate required for smooth films.
Nichrome IV	Ni/Cr	1395	-	8.50	847	987	1217	Ex	Gr, VC, Al_2O_3	***	W	W, Ta	Al_2O_3, VC	DC, RF	3.74@8.8	Alloys with refractory metals.
Permalloy	Ni/Fe	1395	-	8.7	947	1047	1307	G	VC, Al_2O_3	W	-	-	Al_2O_3, VC	DC, RF	-	Film low in nickel. Use 84% Ni source.
Supermalloy	Ni/Fe/Mo	1410	-	8.9	-	-	-	G	-	-	-	-	-	RF, DC	-	Sputtering preferred; or co-evaporate from two sources, permalloy and molybdenum.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Niobium	Nb	2468	-	8.57	1728	1977	2287	Ex	-	W	-	-	-	DC, RF	1.8@0.58	Attacks tungsten source.
Niobium Boride	NbB_2	3050	-	6.97	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Niobium Carbide	NbC	3500	-	7.6	-	-	-	F	-	-	-	-	-	RF, DC	-	-
Niobium Nitride	NbN	2573	-	8.4	-	-	-	-	-	-	-	-	-	RF, RF-R	-	Sputters reactive or evaporates niobium in 10^{-3} Torr nitrogen.
Niobium (II) Oxide	NbO	-	-	7.30	-	-	1100	-	-	Pt	-	-	-	RF	-	-
Niobium (III) Oxide	Nb_2O_3	1780	-	7.5	-	-	-	-	-	W	-	W	-	RF, RF-R	-	-
Niobium (V) Oxide	Nb_2O_5	1485	-	4.47	-	-	-	-	-	W	-	W	-	RF, RF-R	2.3@0.55	-
Niobium Stannide	Nb_3Sn	-	-	-	-	-	-	Ex	-	-	-	-	-	RF, DC	-	Co-evaporate from two sources.
Niobium Telluride	$NbTe_x$	-	-	7.6	-	-	-	-	-	-	-	-	-	RF	-	Composition variable.
Osmium	Os	2700	-	22.48	2170	2430	2760	F	-	-	-	-	-	DC, RF	-	Toxic.
Osmium Oxide	Os_2O_3	-	D	-	-	-	-	-	-	-	-	-	-	-	-	Deposits osmium in 10^{-3} Torr oxygen.
Palladium	Pd	1554	S	12.02	842	992	1192	Ex	Gr, Al_2O_3	W	W	W	Al_2O_3	DC, RF	2.3@0.54	Alloys with refractory metals. Rapid evaporation suggested. Spits in E-beam.
Palladium Oxide	PdO	870	D	9.70	-	-	575	-	Al_2O_3	-	-	-	Al_2O_3	RF-R	-	-
Phosphorus	P	44.1	-	1.82	54	88	129	-	-	-	-	-	Al_2O_3	-	-	Material reacts violently in air.
Phosphorus Nitride	P_3N_5	-	-	2.51	-	-	-	-	-	-	-	-	-	RF, RF-R	-	-

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Platinum	Pt	1772	-	21.45	1292	1492	1747	Ex	Gr, W	W	W, Pt	W	Gr, W	DC, RF	3.42@1.0	Alloys with metals. Films soft, poor adhesion. E-beam required.
Platinum Oxide	PtO_2	450	-	10.2	-	-	-	-	-	-	-	-	-	RF-R	-	-
Plutonium	Pu	641	-	19.84	-	-	-	-	-	W	-	-	-	DC, RF	-	Toxic, radioactive.
Polonium	Po	254	-	9.4	117	170	244	-	-	-	-	-	Q	-	-	Radioactive.
Potassium	K	63	-	0.86	23	60	125	-	-	Mo	-	-	Q	-	0.74@0.25	Metal reacts rapidly in air. Preheat gently to outgas.
Potassium Bromide	KBr	734	-	2.75	-	-	~450	-	-	Ta, Mo	-	-	Q	RF	1.56@0.48	Preheat gently to outgas.
Potassium Chloride	KCl	770	-	1.98	-	-	510	F	-	Ta, Ni	-	-	-	RF	1.72@0.2	Preheat gently to outgas.
Potassium Fluoride	KF	858	-	2.48	-	-	~500	P	-	-	-	-	Q	RF	1.35@1.4	Preheat gently to outgas.
Potassium Hydroxide	KOH	360	-	2.04	-	-	~400	-	-	Pt	-	-	-	-	-	Preheat gently to outgas. Hygroscopic.
Potassium Iodide	KI	681	-	3.13	-	-	~500	-	-	Ta	-	-	-	RF	1.92@0.27	Preheat gently to outgas.
Praseodymium	Pr	931	-	6.77	800	950	1150	F	-	Ta	-	-	-	RF, DC	-	Flammable.
Praseodymium Oxide	Pr_2O_3	-	-	7.07	-	-	1400	G	W	Ir	-	-	W	RF, RF-R	2@0.55	Loses oxygen.
Radium	Ra	700	-	5	246	320	416	-	-	-	-	-	-	-	-	-
Rhenium	Re	3180	-	20.53	1928	2207	2571	G	-	-	-	-	-	DC, RF	3.18@0.59	Fine wire will self-evaporate.
Rhenium Oxide	ReO_3	-	-	~7	-	-	-	-	-	-	-	-	-	RF	-	Evaporate rhenium in 10^{-3} Torr.

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								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Rhodium	Rh	1966	-	12.4	1277	1472	1707	G	VC, W	W	W	W	W, VC	DC, RF	2.03@0.8	E-beam gun preferred.
Rubidium	Rb	39	-	1.48	-3	37	111	-	-	-	-	-	Q	DC, RF	1.03@0.25	-
Rubidium Chloride	RbCl	718	-	2.09	-	-	~550	-	-	-	-	-	Q	RF	1.49	-
Rubidium Iodide	RbI	647	-	3.55	-	-	~400	-	-	-	-	-	Q	RF	1.68@0.58	-
Ruthenium	Ru	2310	-	12.3	1780	1990	2260	P	-	W	-	-	-	DC, RF	-	Spit violently in E-beam. Require long degas.
Samarium	Sm	1074	-	7.52	373	460	573	G	Al_2O_3	Ta	-	-	Al_2O_3	RF, DC	-	-
Samarium Oxide	Sm_2O_3	2350	-	8.35	-	-	-	G	W	Ir	-	-	W	RF, RF-R	1.9@0.55	Loses oxygen. Films smooth, clear.
Samarium Sulfide	Sm_2S_3	1900	-	5.73	-	-	-	G	-	-	-	-	-	-	-	-
Scandium	Sc	1541	S	2.99	714	920	1100	Ex	Al_2O_3	W	-	-	Al_2O_3	RF	-	Flammabble. Alloys with tantalum.
Scandium Oxide	Sc_2O_3	2300	-	3.86	-	-	~400	F	-	-	-	-	-	RF, RF-R	1.89@0.55	Loses oxygen.
Selenium	Se	217	-	4.81	89	125	170	G	Gr, VC, Al_2O_3	W, Mo	W, Mo	W, Mo	Al_2O_3, VC	RF, DC	2.78	Toxic. Bad for vacuum systems. Wets all sources.
Silicon	Si	1410	-	2.32	992	1147	1337	G	VC, Ta	W, Ta, Mo	-	-	BeO, Ta, VC	DC, RF	4.06@0.8	Alloys with tungsten; use heavy tungsten boat. SiO produced above 4.10^{-6} Torr. E-beam preferred.
Silicon Boride	SiB_4	-	-	-	-	-	-	P	-	-	-	-	-	RF	-	-
Silicon Carbide	SiC	~2700	-	3.22	-	-	1000	-	-	-	-	-	-	RF	2.7@0.55	Sputtering preferred.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Silicon Nitride	Si_3N_4	1900	S	3.44	-	-	~800	-	-	-	-	-	-	RF, RF-R	2@0.12	-
Silicon (II) Oxide	SiO	>1702	S	2.13	-	-	850	G	Gr, Ta	Ta	W	W	Ta	RF, RF-R	1.9@2	For resistance evaporation, use baffle box and low rate. E-beam preferred.
Silicon (IV) Oxide	SiO_2	1610	-	~2.65	*	*	1025*	Ex	Gr, Al_2O_3, Mo	-	-	-	Al_2O_3	RF	1.46@0.55	Quartz excellent in E-beam.
Silicon Selenide	SiSe	-	-	-	-	-	550	-	-	-	-	-	Q	RF	-	Toxic.
Silicon Sulfide	SiS	940	S	1.85	-	-	450	-	-	-	-	-	Q	RF	-	-
Silicon Telluride	$SiTe_2$	-	-	4.39	-	-	550	-	-	-	-	-	Q	RF	-	Toxic.
Silver	Ag	962	-	10.5	574	685	832	Ex	Gr, VC, Al_2O_3, Mo	W	Mo	Ta, Mo	Al_2O_3	DC, RF	0.06@0.6	Evaporates well from any source.
Silver Bromide	AgBr	432	-	6.47	-	-	~380	-	-	Ta	-	-	Q	RF	2.28@0.58	-
Silver Chloride	AgCl	455	-	5.56	-	-	~520	-	-	Mo, Pt	-	Mo	Q	RF	2.13@0.43	-
Silver Iodide	AgI	558	-	6.01	-	-	~500	-	-	Ta	-	-	-	RF	2.02@0.59	-
Sodium	Na	98	-	0.97	74	124	192	-	-	Ta, SS	-	-	Q	-	0.03@0.59	Preheat gently to outgas. Metal reacts quickly in air.
Sodium Bromide	NaBr	747	-	3.20	-	-	~400	-	-	-	-	-	Q	RF	1.64@0.59	Preheat gently to outgas.
Sodium Chloride	NaCl	801	-	2.17	-	-	530	F	-	Ta, W, Mo	-	-	Q	RF	1.79@0.2	Copper oven. Little decomposition. Preheat gently to outgas. Hygrocsopic.
Sodium Cyanide	NaCN	564	-	-	-	-	~550	-	-	Ag	-	-	-	RF	1.45@0.59	Toxic. Preheat gently to outgas.
Sodium Fluoride	NaF	993	-	2.56	-	-	~1000	F	-	Mo, Ta, W	-	-		RF	1.3@0.55	Preheat gently to outgas. No decomposition.
Sodium Hydroxide	NaOH	318	-	2.13	-	-	~470	-	-	Pt	-	-	-	-	1.36	Preheat gently to outgas.
Chiolote	$Na_5Al_3F_{14}$	-	-	2.9	-	-	~800	-	-	Mo, W	-	-	-	RF	-	-
Cryolite	Na_3AlF_6	1000	-	2.9	1020	1260	1480	Ex	Gr, VC	W, Mo, Ta	-	W, Mo, Ta	VC	RF	1.35@0.55	Large chunks reduce spitting. Little decomposition.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Strontium	Sr	769	-	2.6	239	309	403	F	VC	W, Ta, Mo	W	W	VC	RF, DC	0.61@0.58	Toxic. Wets but does not alloy with refractory metals. May react in air.
Strontium Chloride	$SrCl_2$	875	-	3.05	-	-	-	-	-	-	-	-	-	-	-	-
Strontium Fluoride	SrF_2	1473	-	4.24	-	-	~1000	-	-	-	-	-	Al_2O_3	RF	1.44@0.59	-
Strontium Oxide	SrO	2430	S	4.7	-	-	1500	-	-	Mo	-	-	Al_2O_3	RF	1.88@0.58	Reacts with molybdenum and tungsten.
Strontium Sulfide	SrS	>2000	D	3.70	-	-	-	-	-	Mo	-	-	-	RF	2.11@0.59	-
Sulfur	S	113	-	2.07	13	19	57	P	-	W	-	W	Q	-	-	Toxic. Bad for vacuum systems.
Tantalum	Ta	2996	-	16.6	1960	2240	2590	Ex	Gr	-	-	-	-	DC, RF	2.05@0.58	Forms good films. Traps O_2. Sputtering preferred.
Tantalum Boride	TaB_2	3000	-	11.15	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Tantalum Carbide	TaC	3880	-	13.9	-	-	~2500	-	-	-	-	-	-	RF, DC	-	-
Tantalum Nitride	TaN	3360	-	16.30	-	-	-	-	-	-	-	-	-	RF, RF-R, DC	-	Evaporates tantalum in 10^{-3} Torr nitrogen.
Tantalum Pentoxide	Ta_2O_5	1872	-	8.2	1550	1780	1920	G	VC	Ta	W	W	VC	RF, RF-R	2.1@0.50	Slight decomposition. Evaporates in 10^{-3} Torr oxygen. Films with high dielectric constant.
Tantalum Sulfide	TaS_2	>1300	-	-	-	-	-	-	-	-	-	-	-	RF	-	-
Technetium	Tc	2200	-	11.5	1570	1800	2090	-	-	-	-	-	-	-	-	-

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Teflon	PTFE	330	-	2.9	-	-	-	-	-	W	-	-	-	RF	-	Baffled source. Film structure doubtful.
Tellurium	Te	452	-	6.25	157	207	277	P	Gr, VC, Al_2O_3	W	W	W, Ta	Al_2O_3, Q	RF	4.7@0.55	Toxic. Wets refractory metals without alloying.
Terbium	Tb	1356	-	8.23	800	950	1150	Ex	Al_2O_3	Ta	-	-	Al_2O_3	RF	-	-
Terbium Fluoride	TbF_3	1172	-	-	-	-	~800	-		-	-	-	-	RF	-	-
Thorium	Th	1875	S	11.7	1430	1660	1925	Ex	-	W, Ta, Mo	W	W	-	-	-	Toxic, radioactive. Wets W.
Thorium Bromide	$ThBr_4$	610	S	5.67	-	-	-	-	-	Mo	-	-	-	-	2.47	Radioactive. Toxic.
Thorium Carbide	ThC_2	2655		8.96	-	-	~2300	-	-	-	-	-	C	RF, DC	-	Radioactive.
Thorium Fluoride	ThF_4	>900	-	6.32	-	-	~750	F	VC	Ni	-	W	VC	RF	1.52@0.5	Radioactive. Heat substrate to above 150°C.
Thorium Oxide	ThO_2	3220	-	9.86	-	-	~2100	G	-	W	-	-	-	RF, RF-R	1.8@0.55	Radioactive.
Thorium Oxyfluoride	$ThOF_2$	900	-	9.1	-	-	-	-	-	Mo, Ta	-	-	-	-	1.52	Radioactive.Films often ThF_4.
Thorium Sulfide	ThS_2	1925	-	7.30	-	-	-	-	-	-	-	-	-	RF	-	Radioactive. Sputtering preferred or co-evaporate from two sources.
Thulium	Tm	1545	S	9.32	461	554	680	G	Al_2O_3	Ta	-	-	Al_2O_3	DC	-	-
Thulium Oxide	Tm_2O_3	-	D	8.90	-	-	1500	-	-	Ir	-	-	-	RF	-	-

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Tin	Sn	232	-	7.28	682	807	997	Ex	Gr, Al_2O_3	Mo	W	W	Al_2O_3	DC, RF	1.48@0.59	Wets molybdenum.
Tin Oxide	SnO_2	1630	S	6.95	-	-	~1000	Ex	Al_2O_3	W	W	W	Q, Al_2O_3	RF, RF-R	2.08@0.58	Films from tungsten are oxygen deficient, oxidize in air.
Tin Selenide	SnSe	861	-	6.18	-	-	~400	F	-	-	-	-	Q	RF	-	-
Tin Sulfide	SnS	882	-	5.22	-	-	~450	-	-	-	-	-	Q	RF	-	-
Tin Telluride	SnTe	780	D	6.48	-	-	~450	-	-	-	-	-	Q	RF	-	-
Titanium	Ti	1660	-	4.5	1067	1235	1453	Ex	Gr	Ta	-	-	TiC, VC	DC, RF	2.64@0.58	Alloys with refractory metals; evolves gas on first heating.
Titanium Boride	TiB_2	2900	-	4.50	-	-	-	P	-	-	-	-	-	RF, DC	-	-
Titanium Carbide	TiC	3140	-	4.93	-	-	~2300	-	-	-	-	-	-	RF, DC	-	-
Titanium Nitride	TiN	2930	-	5.22	-	-	-	G	-	Mo	-	-	-	RF, RF-R, DC	-	Sputtering preferred. Decomposes with thermal evaporation.
Titanium (II) Oxide	TiO	1750	-	4.93	-	-	~1500	G	Gr, VC	W, Ta	-	-	VC	RF	2.4@0.55	Film TiO_2 if evaporated like TiO_2. Preheat gently to outgas.
Titanium (III) Oxide	Ti_2O_3	2130	D	4.6	-	-	-	G	-	W	-	-	-	RF	2.3@0.5	-
Titanium (IV) Oxide	TiO_2	1830	-	4.26	-	-	~1300	F	Mo	W	-	W	-	RF, RF-R	2.3@0.5	Suboxide, must be reoxidized to rutile. Tantalum reduces TiO_2 to TiO and titanium.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Tungsten	W	3410	-	19.35	2117	2407	2757	G	-	-	-	-	-	RF, DC	2.76@0.58	Forms volatile oxides. Films hard and adherent.
Tungsten Boride	WB_2	~2900	-	10.77	-	-	-	P	-	-	-	-	-	RF	-	-
Tungsten Carbide	WC	2860	-	15.8	1480	1720	2120	-	-	-	-	-	-	RF, DC	-	-
Tungsten Carbide	W_2C	2860	-	17.15	1480	1720	2120	Ex	-	C	-	-	-	RF, DC	-	-
Tungsten Disulfide	WS_2	1250	D	7.5	-	-	-	-	-	-	-	-	-	RF	-	-
Tungsten Oxide	WO_3	1473	S	7.16	-	-	980	G	-	W, Pt	-	-	-	RF-R	1.7@0.55	Preheat gently to outgas. Tungsten reduces oxide slightly.
Tungsten Selenide	WSe_2	-	-	9.0	-	-	-	-	-	-	-	-	-	RF	-	-
Tungsten Silicide	WSi_2	>900	-	9.4	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Tungsten Telluride	WTe_3	-	-	9.49	-	-	-	-	-	-	-	-	Q	RF	-	-
Uranium	U	1132	-	19.05	1132	1327	1582	G	-	Mo, W	W	W	-	-	-	Films oxidize. Radioactive.
Uranium Carbide	UC_2	2350	D	11.28	-	-	2100	-	-	-	-	-	C	RF	-	-
Uranium Fluoride	UF_4	960	-	6.70	-	-	300	-	-	Ni	-	-	-	RF	-	-
Uranium (III) Oxide	U_2O_3	1300	D	8.30	-	-	-	-	-	W	-	W	-	RF-R	-	Disproportionates at 1300°C to UO_2.
Uranium (IV) Oxide	UO_2	2878	-	10.96	-	-	-	-	-	W	-	W	-	RF	-	Tantalum causes decomposition.
Uranium Phosphide	UP_2	-	D	8.57	-	-	1200	-	-	Ta	-	-	-	RF	-	-
Uranium (II) Sulfide	US	>2000	-	10.87	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (IV) Sulfide	US_2	>1100	-	7.96	-	-	-	-	-	W	-	-	-	RF	-	Slight decomposition.

Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Vanadium	V	1890	-	5.96	1162	1332	1547	Ex	-	Mo	-	-	-	DC, RF	3.03@0.58	Wets molybdenum. E-beam-evaporated films preferred. Alloy slightly with W.
Vanadium Boride	VB_2	2400	-	5.10	-	-	-	-	-	-	-	-	-	RF, DC	-	-
Vanadium Carbide	VC	2810	-	5.77	-	-	~1800		-	-	-	-	-	RF, DC	-	-
Vanadium Nitride	VN	2320	-	6.13	-	-	-	-	-	-	-	-	-	RF, RF-R, DC	-	-
Vanadium (IV) Oxide	VO_2	1967	S	4.34	-	-	~575	-	-	-	-	-	-	RF, RF-R	2.51@0.63	Sputtering preferred.
Vanadium (V) Oxide	V_2O_5	690	-	3.36	-	-	~500	-	-	-	-	-	Q	RF	-	-
Vanadium Silicide	VSi_2	1700	-	4.42	-	-	-	-	-	-	-	-	-	RF	-	-
Ytterbium	Yb	819	-	6.96	247	317	417	G	-	Ta	-	-	-	DC, RF	-	-
Ytterbium Fluoride	YbF_3	1157	-	-	-	-	~800	-	-	Mo	-	-	-	RF	1.5@0.55	-
Ytterbium Oxide	Yb_2O_3	2346	S	9.17	-	-	~1500	-	-	Ir	-	-	-	RF, RF-R	1.9@0.55	Loses oxygen.
Yttrium	Y	1522	-	4.47	830	973	1157	Ex	Al_2O_3	W, Ta	-	W	Al_2O_3	RF, DC	-	High tantalum solubility.
Yttrium Aluminum Oxide	$Y_3Al_5O_{12}$	1990	-	-	-	-	-	G	-	-	W	-	-	RF	-	Films not ferroelectric.
Yttrium Fluoride	YF_3	1387	-	4.01	-	-	-	-	-	-	-	-	-	RF	1.5@0.55	-
Yttrium Oxide	Y_2O_3	2410	-	5.01	-	-	~2000	G	Gr	W	-	-	Gr	RF, RF-R	1.79@0.589	Loses oxygen, films smooth and clear.

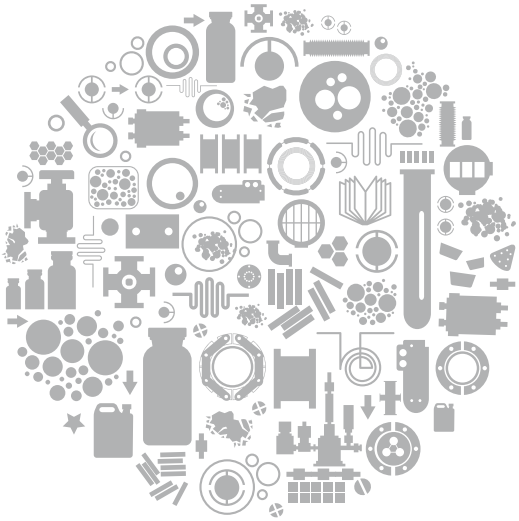
Material	Symbol	Melting Point (°C)	S/D	Density g/cm³ @20°C	Temp.(°C) for given Vap. Press. (mBar)			Evaporation Techniques						Sputter	Index of Refraction (@µm)	Comments
								E-Beam		Thermal Sources						
					10^{-8}	10^{-6}	10^{-4}	Suitability	Liner	Boat	Coil	Basket	Crucible			
Zinc	Zn	420	-	7.14	127	177	250	Ex	Al_2O_3	Mo, W, Ta	W	W	Al_2O_3, Q	DC, RF	1.93@0.589	Evaporates well under wide range of conditions. Bad for vacuum systems. Wets refractory metals.
Zinc Antimonide	Zn_3Sb_2	570	-	6.33	-	-	-	-	-	-	-	-	-	RF	-	-
Zinc Bromide	$ZnBr_2$	394	D	4.20	-	-	~300	-	W	-	-	-	C	RF	1.58@0.58	-
Zinc Fluoride	ZnF_2	872	-	4.95	-	-	~800	-	-	Pt, Ta	-	-	Q	RF	-	-
Zinc Nitride	Zn_3N_2	-	D	6.22	-	-	-	-	-	Mo	-	-	-	RF	-	-
Zinc Oxide	ZnO	1975	-	5.61	-	-	~1800	F	-	-	-	-	-	RF-R	2@0.55	Anneal in air at 450°C to re oxidize.
Zinc Selenide	ZnSe	>1100	-	5.42	-	-	660	-	-	Ta, W, Mo	W,Mo	W	Q	RF	2.6@0.55	Toxic. Preheat gently to outgas. Evaporates well.
Zinc Sulfide	ZnS	1700	S	3.98	-	-	~800	G	-	Ta, Mo	-	-	Q	RF	2.3@0.55	Preheat gently to outgas. Films partially decompose. Sticking coefficient varies with substrate temperature.
Zinc Telluride	ZnTe	1239	-	6.34	-	-	~600	-	-	Mo, Ta	-	-	-	RF	3.56@0.59	Toxic. Preheat gently to outgas.
Zirconium	Zr	1852	-	6.49	1477	1702	1987	Ex	Mo	W	-	-	-	RF, DC	-	Flammable. Alloys with tungsten. Films oxidize readily.
Zirconium Boride	ZrB_2	~3200	-	6.09	-	-	-	G	-	-	-	-	-	RF, DC	-	-
Zirconium Carbide	ZrC	3540	-	6.73	-	-	~2500	-	-	-	-	-	-	RF, DC	-	-
Zirconium Nitride	ZrN	2980	-	7.09	-	-	-	-	-	-	-	-	-	RF, RF-R, DC	-	Reactively evaporates in 10^{-3} Torr nitrogen.
Zirconium Oxide	ZrO_2	~2700	-	5.89	-	-	~2200	G	Mo	W	-	-	-	RF, RF-R	2.05@0.5	Films oxygen deficient, clear and hard.
Zirconium Silicate	$ZrSiO_4$	2550	-	4.56	-	-	-	-	-	-	-	-	-	RF	1.96@0.59	-
Zirconium Silicide	$ZrSi_2$	1700	-	4.88	-	-	-	-	-	-	-	-	-	RF, DC		-

Vapor Pressures Table

**Table of temperatures (°C)
at which vapor pressures (mbar) are:**

Element	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1	10^{1}	10^{2}	10^{3}
Actinium	772	827	887	957	1032	1117	1217	1332	1467	1632	1827	2077	2387	2757	3237
Silver	448	486	527	574	626	685	752	832	922	1027	1162	1332	1542	1827	2217
Aluminum	542	587	633	685	742	812	887	972	1082	1217	1367	1557	1777	2097	2527
Americium	439	479	524	575	632	698	777	867	972	1102	1267	1472	1747	2127	2697
Arsenic	50	67	85	104	127	150	174	204	237	277	317	372	439	522	627
Astatine	-52	-42	-32	-21	-8	7	23	43	65	91	125	161	207	267	347
Gold	642	691	747	807	877	947	1032	1132	1252	1397	1567	1767	2047	2407	2857
Boron	1062	1132	1207	1282	1367	1467	1582	1707	1867	2027	2247	2507	2827	3227	3727
Barium	177	207	237	272	310	354	402	462	527	610	711	852	1037	1297	1657
Beryllium	559	605	652	707	762	832	907	997	1097	1227	1377	1557	1807	2117	2537
Bismuth	237	267	295	329	367	409	459	517	587	672	777	897	1077	1297	1627
Carbone	1422	1492	1572	1657	1757	1867	1987	2137	2287	2457	2657	2897	3177	3507	3917
Calcium	197	222	251	282	317	357	405	459	522	597	689	802	977	1202	1527
Cadmium	20	37	55	74	95	119	146	177	217	265	320	392	489	612	787
Cerium	777	837	902	972	1052	1147	1252	1377	1522	1697	1907	2167	2507	2947	3557
Cobalt	747	797	857	922	992	1067	1157	1257	1382	1517	1687	1907	2167	2517	2947
Chromium	687	737	782	837	902	977	1062	1157	1267	1397	1552	1737	1967	2277	2727
Cesium	-60	-47	-32	-16	1	24	49	78	114	155	209	280	370	502	707
Copper	582	622	672	722	787	852	937	1027	1132	1257	1417	1617	1867	2187	2647
Dysprosium	487	528	574	625	682	747	817	897	997	1117	1262	1437	1692	2027	2507
Erbium	506	549	596	649	708	777	852	947	1052	1177	1332	1527	1787	2147	2647
Europium	196	222	250	283	319	361	409	466	532	611	708	827	987	1227	1527
Francium	-75	-63	-48	-31	-13	7	33	61	95	137	189	255	347	487	707
Iron	727	777	832	892	957	1032	1127	1227	1342	1477	1647	1857	2117	2467	2927
Gallium	482	523	568	619	677	742	817	907	1007	1132	1282	1472	1707	2027	2457
Gadolinium	607	657	707	762	827	897	977	1077	1192	1327	1487	1682	1947	2307	2827
Germanium	667	707	757	812	877	947	1037	1137	1257	1397	1557	1777	2047	2407	2907
Hafnium	1232	1307	1392	1487	1592	1707	1847	1997	2177	2397	2657	2967	3357	3857	4507

Element	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1	10^{1}	10^{2}	10^{3}
Mercury	-103	-93	-83	-72	-59	-44	-27	-7	16	46	80	125	185	262	369
Holmium	506	549	596	649	708	777	852	947	1052	1177	1332	1527	1787	2137	2637
Indium	368	404	443	488	539	597	664	742	837	947	1082	1247	1467	1757	2157
Iridium	1312	1392	1482	1577	1687	1807	1947	2107	2287	2497	2767	3087	3477	3977	4627
Potassium	-26	-13	3	21	42	65	91	123	161	208	267	345	447	585	797
Lanthanum	827	882	947	1022	1102	1192	1297	1422	1562	1727	1927	2177	2487	2877	3407
Lithium	157	179	207	235	268	306	350	404	467	537	627	747	897	1097	1347
Lutetium	727	787	847	912	987	1072	1167	1277	1412	1572	1757	1997	2277	2637	3097
Magnesium	115	137	159	185	214	246	282	327	377	439	509	605	727	897	1127
Manganese	387	422	461	505	554	611	675	747	837	937	1062	1217	1422	1697	2097
Molybdenum	1337	1417	1497	1592	1702	1822	1957	2117	2307	2527	2787	3117	3517	4027	4747
Sodium	21	37	55	74	97	123	155	93	235	289	357	441	552	705	902
Niobium	1492	1572	1662	1762	1867	1987	2127	2277	2447	2657	2897	3177	3517	3927	4437
Neodymium	573	622	672	727	797	862	947	1047	1167	1302	1497	1727	2027	2467	3157
Nickel	767	817	872	927	997	1072	1157	1262	1382	1527	1697	1907	2157	2497	2957
Osmium	1602	1692	1787	1897	2017	2157	2307	2487	2687	2917	3187	3527	3927	4437	5067
Phosphore	10	24	39	54	69	88	108	129	157	185	220	261	309	369	442
Lead	243	273	307	342	383	429	485	547	625	715	832	977	1162	1427	1797
Palladium	672	722	777	842	912	992	1082	1192	1317	1462	1647	1877	2177	2567	3107
Polonium	59	75	92	111	135	159	187	221	264	315	382	470	589	767	977
Praseodymium	627	677	732	797	867	947	1042	1147	1277	1427	1617	1847	2147	2547	3097
Platinum	1062	1132	1207	1292	1382	1492	1612	1747	1907	2097	2317	2587	2917	3337	3897
Plutonium	658	710	767	832	907	992	1092	1207	1342	1507	1702	1957	2277	2707	3317
Radium	163	187	215	247	279	317	365	417	482	557	647	787	952	1217	1567
Rubidium	-46	-33	-19	-2	16	39	63	94	129	173	227	295	392	529	727
Rhenium	1627	1722	1827	1947	2077	2217	2387	2587	2807	3067	3407	3807	4327	4947	5777
Rhodium	1057	1122	1197	1277	1367	1472	1582	1707	1857	2037	2247	2507	2837	3247	3797
Ruthenium	1267	1337	1422	1507	1607	1717	1847	1987	2147	2347	2587	2857	3207	3627	4177
Sulfur	-43	-33	-21	-10	3	17	37	55	80	109	147	189	246	333	466
Antimony	204	225	253	279	309	345	383	425	475	533	612	757	977	1287	1687
Scandium	608	656	710	772	837	917	1007	1107	1232	1377	1562	1797	2097	2507	3087
Selenium	13	28	44	63	83	107	133	164	199	243	297	363	446	553	699
Silicon	817	872	927	992	1067	1147	1237	1337	1472	1632	1817	2057	2347	2717	3217
Samarium	269	300	335	371	415	465	517	580	653	742	847	987	1177	1442	1847
Tin	532	579	627	682	747	807	897	997	1107	1247	1412	1612	1867	2227	2687
Strontium	160	185	210	241	273	309	353	404	465	537	627	732	887	1097	1407
Tantalum	1657	1747	1847	1957	2097	2237	2407	2587	2807	3057	3357	3707	4127	4657	5307
Terbium	627	677	732	797	867	947	1042	1147	1277	1427	1617	1847	2147	2547	3097
Technetium	1307	1392	1477	1567	1677	1787	1927	2077	2257	2487	2757	3097	3517	4027	4727
Tellurium	93	112	132	155	181	209	242	280	323	374	433	518	632	792	1027
Thorium	1177	1252	1337	1432	1542	1662	1807	1977	2167	2407	2687	3037	3477	4067	4857
Titanium	867	927	992	1062	1137	1227	1327	1442	1577	1737	1937	2177	2487	2857	3367
Thallium	200	226	254	283	319	359	407	463	530	609	706	827	982	1187	1477
Thulium	351	382	418	458	503	552	609	680	757	847	962	1097	1267	1487	1787
Uranium	917	982	1052	1132	1222	1327	1447	1582	1737	1927	2157	2447	2807	3267	3907
Vanadium	962	1022	1092	1162	1237	1332	1432	1547	1687	1847	2047	2287	2577	2947	3447
Tungstene	1777	1877	1997	2117	2247	2407	2567	2757	2977	3227	3537	3907	4357	4927	5627
Yttrium	772	827	887	957	1032	1117	1217	1332	1467	1632	1832	2082	2397	2812	3377
Ytterbium	163	187	215	247	279	317	365	417	482	557	647	787	952	1217	1567
Zinc	63	81	101	123	148	177	209	247	292	344	408	487	597	737	937
Zirconium	1227	1307	1392	1482	1582	1702	1837	1987	2177	2397	2657	2977	3377	3897	4557



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