

**ION BEAM ETCH RATES AND SPUTTER YIELDS**  
**Ar, 500ev, 1mA/cm<sup>2</sup> Beam Current Density**

Element	Symbol	Atomic Number	Atomic Weight	Ionization Potential (Volts)	Ion Beam Etch Rate	Sputter Yield (Atoms & Ion)	Y-Factor
Actinium	Ac	89	(227)	6.9, 12.1, 20			
Aluminum	Al	13	26.982	5.984, 8.823, 28.44	610	1.0	621
Americium	Am	95	(243)				
Antimony	Sb	51	121.75	8.639, 16.5, 25.3	3238		1131
Argon	Ar	18	39.948	15.755, 27.62, 40.9			
Arsenic	As	33	74.922	9.81, 18.63, 28.34			
Astatine	At	85	(210)	9.5			
Barium	Ba	56	137.34	5.21, 10.001, 35.5			
Berkelium	Bk	97	(247)				
Beryllium	Be	4	9.012	9.32, 18.206, 153.85	130	.43	303
Bismuth	Bi	83		7.287, 16.68, 25.56	8800		1333
Boron	B	5	10.811	8.296, 25.149, 37.92			290
Bromine	Br	35	79.909	11.84, 21.6, 35.9			
Cadmium	Cd	48	112.4	8.991, 16.904, 37.47			
Calcium	Ca	20	40.08	6.111, 11.868, 51.21			
Californium	Cf	98	(249)				

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Carbon	C	6	12.011	11.256, 24.376, 47.871	110	.36	393
Cerium	Ce	58	140.12	5.6, 12.3, 20			
Cesium	Cs	55	132.905	3.893, 25.1, 35			
Chlorine	Cl	17	35.453	13.01, 23.8, 39.9			
Chromium	Cr	24	51.996	6.764, 16.49, 30.95	530	1.2	450
Cobalt	Co	27	58.933	7.86, 17.05, 33.49	450	1.1	412
Copper	Cu	29	63.544	7.724, 20.29, 36.83	880	2.0	441
Curium	Cm	(247)					
Dysprosium	Dy	66	162.5	6.8	1100	.95	1182
Einsteinium	Es	99	(254)				
Erbium	Er	68	167.26	6.08	1000	.85	
Europium	Eu	63	151.96	5.67, 11.24			
Fermium	Fm	100	(257)				
Fluorine	F	9	18.998	17.418, 34.98, 62.646			
Francium	Fr	87	(223)	4			
Gadolinium	Gd	64	157.25	6.16, 12	1100	.90	1238
Gallium	Ga	31	69.72	6, 20.57, 30.7			
Germanium	Ge	32	72.59	7.88, 15.93, 34.21	920	1.1	848
Gold	Au	79	196.967	9.22, 20.5	1080	1.7	635
Hafnium	Hf	72	178.49	7, 14.9, 23.2	660	.79	833

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Helium	He	2	4.003	24.481, 54.403			
Holmium	Ho	67	164.930				
Hydrogen	H	1	1.008	13.595			
Indium	In	49	114.82	5.785, 18.86, 28.03			
Iodine	I	53	126.904	10.454, 19.13			
Iridium	Ir	77	192.2	9	590	1.1	533
Iron	Fe	26	55.847	7.87, 16.18, 30.643	350	.80	441
Krypton	Kr	36	83.8	13.996, 24.56, 6.9			
Lanthanum	La	57	138.91	5.61, 11.43, 19.17			
Lawrencium	Lr	103	(260)				
Lead	Pb	82	207.194	7.415, 15.028, 31.93	2600	2.3	1135
Lithium	Li	3	6.939	5.39, 75.619, 122.419			
Lutetium	Lu	71	174.97	0.0, 14.7			
Magnesium	Mg	12	24.312	7.644, 15.031, 80.14	225		
Manganese	Mn	25	54.938	7.432, 15.636, 33.69	870	.19	459
Mendelevium	Md	101	(258)				
Mercury	Hg	80	200.59	10.43, 18.751, 34.2			
Molybdenum	Mo	42	95.944	7.10, 16.15, 27.13	410	.70	584
Neodymium	Nd	60	144.24	5.51			
Neon	Ne	10	20.183	21.559, 41.07, 63.5			

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Neptunium	Np	93	(237)				
Nickel	Ni	28	58.71	7.633, 18.15, 35.16	530	1.3	410
Niobium	Nb	41	92.906	6.88, 14.32, 25.04	470	.7	674
Nitrogen	N	7	14.007	14.53, 29.593, 47.426			
Nobelium	No	102	(259)				
Osmium	Os	76	190.2	8.5, 17	500	.96	524
Oxygen	O	8	15.999	13.614, 35.108, 54.886			
Palladium	Pd	46	106.4	8.33, 19.42, 32.92	1100	2.0	550
Phosphorous	P	15	30.974	10.484, 19.72, 30.156			
Platinum	Pt	78	195.09	9.0, 18.56	620	1.1	565
Plutonium	Pu	94	(242)	5.1			
Polonium	Po	84	(201)	8.43			
Potassium	K	19	39.102	4.339, 31.81, 46			
Praseodymium	Pr	59	140.907	5.46			
Promethium	Pm	61	(147)				
Protactinium	Pa	91	(231)				
Radium	Ra	88	(226)	6.9, 12.1, 20			
Radon	Rn	86	(222)	10.746			
Rhenium	Re	75	186.1	7.87, 16.6	520	.95	551
Rhodium	Rh	45	1025.95	7.46, 18.07, 31.05	720	1.4	516
Rubidium	Rb	37	85.47	4.176, 27.5, 40	4000		3090-4020

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Ruthenium	Ru	44	101.07	7.364, 16.76, 28.46	610	1.2	506
Samarium	Sm	62	150.35	5.6, 11.2	1100	.87	1244
Scandium	Sc	21	44.956	6.54, 12.8, 24.75			
Selenium	Se	34	78.966	9.75, 21.5, 32			
Silicon	Si	14	28.086	8.149, 16.34, 33.488	370	.5	750
Silver	Ag	47	107.87	7.574, 21.48, 34.82	1800	2.8	639
Sodium	Na	11	22.990	5.138, 47.29, 71.715			
Strontium	Sr	38	87.62	5.692, 11.027, 57			
Sulfur	S	16	32.064	10.357, 23.4, 35			
Tantalum	Ta	73	180.948	7.88, 16.2	420	.62	675
Technetium	Tc	43	(98)	7.28, 15.26, 29.54			
Tellurium	Te	52	127.60	9.01, 18.6, 31			1271
Terbium	Tb	65	158.924	5.98			
Thallium	Tl	81	204.37	6.106, 20.42, 29.58			
Thorium	Th	90	232.038	6.95	810	.66	1231
Thulium	Tm	69	168.934	5.81			
Tin	Sn	50	118.69	7.342, 14.628, 30.49	1200	1.2	1010
Titanium	Ti	22	47.90	6.82, 13.57, 27.47	330	.50	655

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Tungsten	W	74	183.85	7.98, 17.7	340	.60	592
Uranium	U	92	238.03	6.08	730	.94	781
Vanadium	V	23	50.942	6.74, 14.65, 29.31	310	.60	518
Xenon	Xe	54	131.3	12.127, 21.2, 31.3			
Ytterbium	Yb	70	173.04	6.2, 12.10			
Yttrium	Y	39	88.905	6.38, 12.23, 20.5	950	.77	1237
Zinc	Zn	30	65.373	9.391, 17.96, 39.7			
Zirconium	Zr	40	91.223	6.84, 13.13, 22.98	570	.63	872

Compound	Symbol	MW (amu)	Etch Rate (Å/min)	Sputter Yield (molecules/ion)	Y-Factor
Aluminum Oxide (1102)	Al <sub>2</sub> O <sub>3</sub>	101.90	83	0.05	1600
Cadmium Sulphide (1010)	CdS	144.46	2200	1.20	1860
Gallium Arsenide (100)	GaAs	144.64	650	0.38	1690
Gallium Arsenide (110)	GaAs	144.64	1600	0.95	1690
Gallium Phosphide (111)	GaP	100.69	1590	1.04	1530
Gallium Antimonide (111)	GaSb	191.47	1870	0.88	2130
Indium Antimonide	InSb	236.57	1520	0.60	2540
Lead Telluride (111)	PbTe	344.80	3770	1.48	2550
Lithium Niobate (Y-cut)	LiNbO <sub>3</sub>	147.85	390	0.20	1960
Molybdenum Carbide	Mo <sub>2</sub> C	203.89	280	0.20	1420
Permalloy	Ni <sub>80</sub> Fe <sub>20</sub>	58.128	500	1.20	415
Silicon Carbide (0001)	SiC	40.09	350	0.45	770
Silicon Dioxide (001)	SiO <sub>2</sub>	60.086	330	0.23	1420
Tantalum Carbide	TaC	192.95	150	0.17	860
Tantalum Pentoxide	Ta <sub>2</sub> O <sub>5</sub>	441.89	600	0.18	3350
Sode-lime glass	0 <sub>60</sub> Si <sub>25</sub> Na <sub>10</sub> Ca <sub>2</sub> MgAl		200		
PZT Ceramic			106		
Photoresists					
Riston 14			250		
Shipley AZ 1350			200		

**Sputter Etch Rate = Sputter Yield x Y-Factor**