

# Etch Rates For Micromachining Processing II (nm/min)

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## Notation:

W = Etch known to *work*, but etch rate not measured  
 R = Film was visibly *roughened* or attacked  
 I = *Incubation* time before etching fully starts  
 F = Etch known to be *fast*, but etch rate not measured  
 T = *Thicker* after etch (due to swelling or compound formation)  
 C = Film *congealed*  
 S = Etch rate known to be *slow* or zero, but etch rate not measured  
 P = Some of film *peeled* during etch or when rinsed  
 soft = a *soft* material remained after etching

Etchant	Etchant Abbrev.	Target Material	Si	Float-	Poly Si	Poly Si	Poly Ge	Poly SiGe					
			(100)	Zone Si	LPCVD	LPCVD	LPCVD	LPCVD	Graphite	Quartz	7740	Oxide	LPCVD
			Wafer	Wafer	Undoped	In-situ n <sup>+</sup>	Undoped	P-type	Ion-Milled	Wafer	Wafer	Wet-Grn	Calogic
Isotropic Silicon Etchant "Trilogy Etch" (126 HNO <sub>3</sub> : 60 H <sub>2</sub> O : 5 NH <sub>4</sub> F), ~20°C	Si Iso Etch	Silicon	150	W	100	310	890	550	60	12	R 140	8.7	15
KOH (30% by weight), 80°C	KOH	Silicon ODE	1100	F	670	>1000	-	-	-	6.7	11	7.7	8.1
10:1 HF (10 H <sub>2</sub> O : 1 49% HF), ~20°C	10:1 HF	Silicon Dioxide	S	S	0	0.7	0	0.42	-	26	W	23	W
5:1 BHF (5 40% NH <sub>4</sub> F : 1 49% HF), ~20°C	5:1 BHF	Silicon Dioxide	0	S	0.2	0.9	R 1.8	0.45	R 17	130	43	100	150
Pad Etch 4 from Ashland (13% NH <sub>4</sub> F + 32% HAC + 49% H <sub>2</sub> O + 6% propylene glycol + surfactant),	Pad Etch 4	SiO <sub>2</sub> , not Al	S	S	S	S	-	-	-	29	17	31	W
Phosphoric Acid (85% by weight), 160°C	Phosphoric	Silicon nitride	0.17	S	S	0.7	0.13	0.40	-	0.23	3.7	0.18	S
Al Etchant Type A from Transene (80% H <sub>3</sub> PO <sub>4</sub> + 5% HNO <sub>3</sub> + 5% HAC + 10%H <sub>2</sub> O), 50°C	Al Etch A	Aluminum	S	S	<0.9	<1	13	0.11	-	S	-	0	S
Titanium wet etchant (20 H <sub>2</sub> O : 1 H <sub>2</sub> O <sub>2</sub> : 1 HF), ~20°C	Ti Etch	Titanium	S	S	S	1.2	-	-	-	-	-	12	W
Chromium etchant CR-7 from Cyantek (9% (NH <sub>4</sub> ) <sub>2</sub> Ce(NO <sub>3</sub> ) <sub>6</sub> ) + 6% HClO <sub>4</sub> + H <sub>2</sub> O), ~20°C	CR-7	Chromium	0	S	0	S	260	0.35	< 0.5	R < 0.4	R 0	0.02	0
Chromium etchant CR-14 from Cyantek (22% (NH <sub>4</sub> ) <sub>2</sub> Ce(NO <sub>3</sub> ) <sub>6</sub> ) + 8% HAC + H <sub>2</sub> O), ~20°C	CR-14	Chromium	S	S	0	S	-	-	-	S	-	0.01	S
Molybdenum etchant (180 H <sub>3</sub> PO <sub>4</sub> : 11 HAC : 11 HNO <sub>3</sub> : 150 H <sub>2</sub> O), ~20°C	Moly Etch	Molybdenum	-	-	-	-	-	-	-	-	-	-	-
Hydrogen peroxide (30wt% H <sub>2</sub> O <sub>2</sub> , 70wt% H <sub>2</sub> O), 50°C	H <sub>2</sub> O <sub>2</sub> 50°C	Tungsten	S	S	S	S	460	0.13	-	S	S	0	S
Copper etchant type CE-200 from Transene (30% FeCl <sub>3</sub> + 3-4% HCl + H <sub>2</sub> O), ~20°C	Cu FeCl <sub>3</sub> 200	Copper	-	-	-	-	-	-	-	-	-	-	-
Copper etchant APS 100 from Transene (15-20% (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>8</sub> + H <sub>2</sub> O), 30°C	Cu APS 100	Copper	-	-	-	-	-	-	-	-	-	-	-
Dilute aqua regia (3 HCl : 1 HNO <sub>3</sub> : 2 H <sub>2</sub> O), ~30°C	Dil. Aqua regia	Noble metals	0	0	0	0	-	-	-	0	-	0	0
Gold etchant AU-5 from Cyantek (5% I <sub>2</sub> + 10% KI + 85% H <sub>2</sub> O), ~20°C	AU-5	Gold	S	S	0	S	-	-	-	S	-	S	S
Nichrome etchant TFN from Transene (10-20% (NH <sub>4</sub> ) <sub>2</sub> Ce(NO <sub>3</sub> ) <sub>6</sub> ) + 5-6% HNO <sub>3</sub> + H <sub>2</sub> O), ~20°C	NiCr TFN	NiCr	0	S	S	S	-	-	-	S	-	S	S
1 H <sub>2</sub> SO <sub>4</sub> : 1 H <sub>3</sub> PO <sub>4</sub> , 160°C	Phos+Sulf	Sapphire	0.86	S	S	S	-	-	-	S	-	0.057	S
Piranha (~50 H <sub>2</sub> SO <sub>4</sub> : 1 H <sub>2</sub> O <sub>2</sub> ), 120°C	Piranha	Cleaning	0	S	0	0	soft	0	-	R 0	R 0	0	0
Microstrip 2001 photoresist stripper, 85°C	Microstrip	Photoresist	S	S	S	S	-	-	0	S	S	S	S
Acetone, ~20°C	Acetone	Photoresist	S	S	0	0	-	-	-	S	S	0	S
Methanol, ~20°C	Methanol	Cleaning	S	S	0	S	-	-	S	S	S	S	S
Isopropanol, ~20°C	IPA	Cleaning	S	S	S	S	-	-	S	S	S	S	S
XeF <sub>2</sub> , 2.6 mTorr, homemade chamber	XeF <sub>2</sub>	Silicon	460	W	180	190	-	-	-	S	-	0	S
HF + H <sub>2</sub> O vapor, 1 cm over dish with 49% HF	HF vapor	Silicon dioxide	S	S	0	0	-	-	-	W	W	66	W
Technics plasma, O <sub>2</sub> , 400 W @ 30 kHz, 300 mTorr	Technics O <sub>2</sub>	Photoresist	S	S	0	0	-	-	0	S	S	0	S
STS ASE DRIE, mechanical chuck, high frequency, typical recipe	DRIE HF mech.	Silicon	1500	1600	W	W	-	-	-	S	-	S	7.5
STS ASE DRIE, electrostatic chuck, high frequency, typical recipe	DRIE HF ES	Silicon	2400	W	W	W	400	1400	-	S	-	24	W
STS ASE DRIE, mechanical chuck, stop-on-oxide (low-frequency platen), typical recipe	DRIE LF mech.	Silicon	2400	W	W	W	-	-	-	S	-	S	3.6
STS ASE DRIE, electrostatic chuck, stop-on-oxide (low-frequency platen), typical recipe	DRIE LF ES	Silicon	2000	W	W	W	170	1040	-	S	-	24	W
STS 320 RIE, SF <sub>6</sub> , 100 W @ 13.56 MHz, 20 mTorr	STS 320 SF <sub>6</sub>	Si, SiN, metals	W	W	W	W	-	-	-	W	-	W	W
STS 320 RIE, SF <sub>6</sub> + O <sub>2</sub> , 100 W @ 13.56 MHz, 20 mTorr	STS SF <sub>6</sub> +O <sub>2</sub>	Si, SiN, metals	1500	W	W	W	-	-	-	35	10	29	38
STS 320 RIE, CF <sub>4</sub> , 100 W @ 13.56 MHz, 60 mTorr	STS 320 CF <sub>4</sub>	Si, SiO, SiN	W	W	W	W	-	-	-	W	W	W	33
STS 320 RIE, CF <sub>4</sub> + O <sub>2</sub> , 100 W @ 13.56 MHz, 60 mTorr	STS CF <sub>4</sub> +O <sub>2</sub>	Si, SiO, SiN	95	-	-	-	-	-	-	41	31	44	42
Ion milling with argon ions at 500 V, ~1 mA/cm <sup>2</sup> , normal incidence (Commonwealth data)	Ion Mill	Everything	38	38	38	38	-	-	4.4	W	W	39	W

	Unan. LTO	Ann. LTO	Unan. PSG	Ann. PSG	Oxide	Oxide		Stoich	Si-Rich	PECVD	PECVD		Aluminum	Aluminum								
	LPCVD	LPCVD	LPCVD	LPCVD	PECVD	PECVD	Oxide	Si Nit.	Si Nit.	Silicon Nit.	Silicon Nit.	Sapphire	Oxide	Oxide	Aluminum	Al + 2% Si	Titanium	Vanadium	Niobium	Tantalum	Tantalum	
Etchant	Tylan	Tylan	Tylan	Tylan	Unannealed	Annealed	Ion-Mill	LPCVD	LPCVD	Low RI	High RI	Wafer	Ion-Mill	Evap	Evap	Sputtered	Sputtered	Evap	Ion-Mill	Evap	Ion-Mill	
Si Iso Etch	-	11	400	170	100	25	43	-	0.23	> 66	12	R < 0.7	99	12	60	400	300	9600	79	5.8	5.3	
KOH	-	9.4	-	38	15	7.8	8.0	0	0	0.67	0	R 0	> 2500	> 800	12,900	F	soft	< 12	3.2	S	2.8	
10:1 HF	W	34	1500	470	W	W	W	1.1	S	-	-	S	-	-	W	250	1100	S	S	S	S	
5:1 BHF	W	120	680	440	490	240	82	S	1.3	60	8.2	0	-	160	11	140	W	< 2	0	S	R 0	
Pad Etch 4	38	W	200	W	160	W	W	0.41	S	-	1.6	S	-	-	1.9	R < 15	< 2	S	S	S	S	
Phosphoric	0.21	0.21	2.7	1.8	-	-	S	4.5	2.7	W	20	< 0.1	-	> 5	> 500	980	-	-	0	-	0	
Al Etch A	S	0	S	< 1	0	S	S	S	< 0.05	-	-	R < 2	65	5.7	530	660	0	-	-	-	-	
Ti Etch	W	W	W	210	W	W	-	0.99	S	-	-	S	-	-	150	240	1100	-	-	-	-	
CR-7	S	S	S	S	0	0	0	S	0	< 0.14	0	R 0	0.34	0.075	3.8	S	< 2	60	R 0	S	< 0.7	
CR-14	S	S	S	S	S	S	S	S	S	-	-	S	-	-	0	0.8	< 2	15	-	-	-	
Moly Etch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	> 20	-	-	-	-	-	-	
H <sub>2</sub> O <sub>2</sub> 50°C	S	S	S	S	S	S	S	0	S	S	S	S	-	-	T 0	0.25	-	-	-	-	-	
Cu FeCl <sub>3</sub> 200	-	-	-	-	-	-	-	-	0	-	-	-	-	-	35	W	-	-	-	-	-	
Cu APS 100	-	-	-	-	-	-	-	-	0	-	-	-	-	-	< 0.3	-	-	-	-	-	-	
Dil. Aqua regia	0	0	0	0	0.7	S	S	0	0	-	-	S	-	1.1	600	W	< 0.5	-	0	S	< 2	
AU-5	S	S	S	S	0	S	S	S	0	-	-	-	-	-	-	-	-	-	-	-	-	
NiCr TFN	S	S	S	S	S	S	S	S	S	-	-	-	-	-	> 46	-	-	-	-	-	-	
Phos+Sulf	S	S	S	S	S	S	S	2.9	S	W	10	< 0.3	-	-	W	W	-	-	-	-	-	
Piranha	S	0	S	0	0	0	0	0	0	< 0.04	0	R 0	97	19	> 5200	W	240	-	6.3	S	T 0	
Microstrip	S	S	S	S	S	S	S	S	S	S	S	S	-	-	-	-	-	-	-	-	-	
Acetone	S	0	S	0	S	S	S	0	0	S	S	S	0	S	S	0	0	S	S	S	S	
Methanol	S	S	S	S	S	S	S	S	0	S	S	S	0	S	S	S	S	S	S	S	S	
IPA	S	S	S	S	S	S	S	S	0	S	S	S	0	S	S	S	S	S	S	S	S	
XeF <sub>2</sub>	S	0	0	0	S	S	S	12	-	-	-	-	-	-	S	0	29	W	W	W	W	
HF vapor	W	78	210	150	W	W	W	1.0	1.9	-	-	S	-	-	R	R	R	-	-	-	-	
Technics O <sub>2</sub>	S	0	0	0	S	S	S	0	S	S	S	S	S	S	S	0	0	S	S	S	S	
DRIE HF mech	6.2	6.9	9.5	11	9.5	S	S	W	21	W	W	S	S	S	-	-	4.9	-	-	-	-	
DRIE HF ES	W	W	W	W	W	W	W	W	W	W	W	S	S	S	-	-	-	-	-	-	-	
DRIE LF mech	9.8	9.4	15	15	4.0	S	S	W	26	W	W	S	S	S	-	-	-	-	-	-	-	
DRIE LF ES	W	W	W	W	W	W	W	W	W	W	W	S	S	S	-	-	-	-	-	-	-	
STS 320 SF <sub>6</sub>	W	W	W	W	W	W	W	W	W	W	W	S	S	S	-	-	-	-	W	W	W	
STS SF <sub>6</sub> +O <sub>2</sub>	55	48	73	60	55	32	30	150	150	200	190	2.2	0.55	0.41	< 2.8	-	-	-	26	W	37	
STS 320 CF <sub>4</sub>	W	W	W	W	W	W	W	34	W	W	W	S	S	S	S	S	-	-	-	-	-	
STS CF <sub>4</sub> +O <sub>2</sub>	51	46	69	62	51	43	21	120	> 130	240	110	0	< 2	< 0.2	0.87	1.5	-	-	14	-	21	
Ion Mill	W	W	W	W	W	W	W	13	9.4	W	W	W	10	10	73	W	38	W	W	42	42	

