VPD ICP-MS METHOD DETECTION LIMITS AND RECOVERIES

FOR TRACE METALS CONTAMINATION ANALYSIS OF SILICON WAFERS

Vapor Phase Decomposition (VPD) Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is the most widely used analytical technique to monitor trace metals of bare wafers and wafers with silicon oxide or silicon nitride film. Based on this technique, ChemTrace has introduced additional methods of analysis that include Wafer Surface Scan (WSS) ICP-MS, Direct Film Stripping (DFS) ICP-MS and Bulk Silicon Etch (BSE) ICP-MS. These new techniques allow for monitoring of a broader variety of process films, including metal films, low-k and high-k dielectric films, SiGe and polysilicon films.

Legends:

- *Excellent Recovery (100% -85%)*
- *Good Recovery (84% -70%)*
- *Low Recovery (<70%)*
- *No Data Yet*
- *Not Analyzed*

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 $^2S_{1/2}$ **H** Hydrogen 1.00794																	2 $^1S_0$ **He** Helium 4.00260
3 $^2S_{1/2}$ **Li** Lithium 6.941 5e8 100	4 $^1S_0$ **Be** Beryllium 9.01218 2e9 100											5 $^2P^o_{1/2}$ **B** Boron 10.811 5e10 100	6 $^3P_0$ **C** Carbon 12.0107	7 $^4S^o_{3/2}$ **N** Nitrogen 14.00674	8 $^3P_2$ **O** Oxygen 15.9994	9 $^2P^o_{3/2}$ **F** Fluorine 18.99840	10 $^1S_0$ **Ne** Neon 20.1797
11 $^2S_{1/2}$ **Na** Sodium 22.98977 2e9 100	12 $^1S_0$ **Mg** Magnesium 24.3050 1e9 100											13 $^2P^o_{1/2}$ **Al** Aluminum 26.98154 3e9 100	14 $^3P_0$ **Si** Silicon 28.0855	15 $^4S^o_{3/2}$ **P** Phosphorus 30.97376 1e11 99	16 $^3P_2$ **S** Sulfur 32.066	17 $^2P^o_{3/2}$ **Cl** Chlorine 35.4527	18 $^1S_0$ **Ar** Argon 39.948
19 $^2S_{1/2}$ **K** Potassium 39.0983 2e9 100	20 $^1S_0$ **Ca** Calcium 40.078 3e9 100	21 $^2D_{3/2}$ **Sc** Scandium 44.95591 1e9 98	22 $^3F_2$ **Ti** Titanium 47.867 5e8 100	23 $^4F_{3/2}$ **V** Vanadium 50.9415 1e8 100	24 $^7S_3$ **Cr** Chromium 51.9961 6e8 100	25 $^6S_{5/2}$ **Mn** Manganese 54.93805 3e8 100	26 $^5D_4$ **Fe** Iron 55.845 1e9 100	27 $^4F_{9/2}$ **Co** Cobalt 58.93320 5e8 100	28 $^3F_4$ **Ni** Nickel 58.6934 5e8 100	29 $^2S_{1/2}$ **Cu** Copper 63.546 2e8 100	30 $^1S_0$ **Zn** Zinc 65.39 5e8 100	31 $^2P^o_{1/2}$ **Ga** Gallium 69.723 3e7 100	32 $^3P_0$ **Ge** Germanium 72.61 1e8 100	33 $^4S^o_{3/2}$ **As** Arsenic 74.92160 5e9 100	34 $^3P_2$ **Se** Selenium 78.96 1e11	35 $^2P^o_{3/2}$ **Br** Bromine 79.904	36 $^1S_0$ **Kr** Krypton 83.80
37 $^2S_{1/2}$ **Rb** Rubidium 85.4678 1e9 100	38 $^1S_0$ **Sr** Strontium 87.62 1e8 100	39 $^2D_{3/2}$ **Y** Yttrium 88.90585 3e8 71	40 $^3F_2$ **Zr** Zirconium 91.224 1e8 100	41 $^6D_{1/2}$ **Nb** Niobium 92.90638 1e8 100	42 $^7S_3$ **Mo** Molybdenum 95.94 2e7 100	43 $^6S_{5/2}$ **Tc** Technetium (98)	44 $^5F_5$ **Ru** Ruthenium 101.07 1e9 69	45 $^4F_{9/2}$ **Rh** Rhodium 102.90550 1e9 70	46 $^1S_0$ **Pd** Palladium 106.42 1e9 21	47 $^2S_{1/2}$ **Ag** Silver 107.8682 5e9 95	48 $^1S_0$ **Cd** Cadmium 112.411 3e7 100	49 $^2P^o_{1/2}$ **In** Indium 114.818 2e8 100	50 $^3P_0$ **Sn** Tin 118.710 3e8 100	51 $^4S^o_{3/2}$ **Sb** Antimony 121.760 2e7 100	52 $^3P_2$ **Te** Tellurium 127.60 1e9 85	53 $^2P^o_{3/2}$ **I** Iodine 126.90447	54 $^1S_0$ **Xe** Xenon 131.29
55 $^2S_{1/2}$ **Cs** Cesium 132.90545 5e7 100	56 $^1S_0$ **Ba** Barium 137.327 2e7 100	57 $^2D_{3/2}$ **La** Lanthanum 138.9055 2e7 85	72 $^3F_2$ **Hf** Hafnium 178.49 5e7 100	73 $^4F_{3/2}$ **Ta** Tantalum 180.9479 3e7 100	74 $^5D_0$ **W** Tungsten 183.84 1e7 100	75 $^6S_{5/2}$ **Re** Rhenium 186.207 1e9 100	76 $^5D_4$ **Os** Osmium 190.23	77 $^4F_{9/2}$ **Ir** Iridium 192.217 1e9 100	78 $^3D_3$ **Pt** Platinum 195.078 1e9 46	79 $^2S_{1/2}$ **Au** Gold 196.96655 5e9 22	80 $^1S_0$ **Hg** Mercury 200.59	81 $^2P^o_{1/2}$ **Tl** Thallium 204.3833 5e7 100	82 $^3P_0$ **Pb** Lead 207.2 3e7 100	83 $^4S^o_{3/2}$ **Bi** Bismuth 208.98038 1e7 100	84 $^4P_2$ **Po** Polonium (209)	85 $^2P^o_{3/2}$ **At** Astatine (210)	86 $^1S_0$ **Rn** Radon (222)
87 $^2S_{1/2}$ **Fr** Francium (223)	88 $^1S_0$ **Ra** Radium (226)	89 $^2D_{3/2}$ **Ac** Actinium (227)	104 $^3F_2$ **Rt** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (268)	110 **Uun** Ununnilium (269)	111 **Uuu** Ununnium (272)	112 **Uub** Ununbium						
		58 $^1G^o_4$ **Ce** Cerium 140.116 2e7 91	59 $^4I^o_{9/2}$ **Pr** Praseodymium 140.90765 2e7 90	60 $^5I_4$ **Nd** Neodymium 144.24 5e7 91	61 $^6H^o_{5/2}$ **Pm** Promethium (145)	62 $^7F_0$ **Sm** Samarium 150.36 2e7 94	63 $^8S^o_{7/2}$ **Eu** Europium 151.964 1e7 94	64 $^9D^o_2$ **Gd** Gadolinium 157.25 2e7 93	65 $^6H^o_{15/2}$ **Tb** Terbium 158.92534 1e7 94	66 $^5I_8$ **Dy** Dysprosium 162.50 2e7 95	67 $^4I^o_{15/2}$ **Ho** Holmium 164.93032 1e7 94	68 $^3H_6$ **Er** Erbium 167.26 1e7 95	69 $^2F^o_{7/2}$ **Tm** Thulium 168.93421 1e7 94	70 $^1S_0$ **Yb** Ytterbium 173.04 2e7 94	71 $^2D_{3/2}$ **Lu** Lutetium 174.967 5e6 94
		90 $^3F_2$ **Th** Thorium 232.0381 5e7 84	91 $^4K_{11/2}$ **Pa** Protactinium 231.03588	92 $^5L_6$ **U** Uranium 238.0289 5e8 100	93 $^6L_{11/2}$ **Np** Neptunium (237)	94 $^7F_0$ **Pu** Plutonium (244)	95 $^8S^o_{7/2}$ **Am** Americium (243)	96 $^9D^o_2$ **Cm** Curium (247)	97 $^6H^o_{15/2}$ **Bk** Berkelium (247)	98 $^5I_8$ **Cf** Californium (251)	99 $^4I^o_{15/2}$ **Es** Einsteinium (252)	100 $^3H_6$ **Fm** Fermium (257)	101 $^2F^o_{7/2}$ **Md** Mendelevium (258)	102 $^1S_0$ **No** Ytterbium (259)	103 $^2F^o_{1/2}$ **Lr** Lawrencium (262)		

Atomic Number · Ground-state Level · Symbol · Name · Atomic Weight† · Method Detection Limit (atoms/cm²) · Percntage Recovery on Si wafers (%)

200mm SILICON WAFERS

VPD ICP-MS METHOD DETECTION LIMITS, ATOMS/CM²

Method detection limits for WSS, DFS and BSE ICP-MS vary depending on techniques.

Aluminum	Al	3e9
Antimony	Sb	2e7
Arsenic	As	5e9
Barium	Ba	2e7
Beryllium	Be	2e9
Bismuth	Bi	1e7
Boron	B	5e10
Cadmium	Cd	3e7
Calcium	Ca	3e9
Cesium	Cs	5e7
Chromium	Cr	6e8
Cobalt	Co	5e8
Copper	Cu	2e8
Gallium	Ga	3e7
Germanium	Ge	1e8
Hafnium	Hf	5e7
Iron	Fe	1e9
Lanthanum	La	2e7
Lead	Pb	3e7
Lithium	Li	5e8
Magnesium	Mg	1e9
Manganese	Mn	3e8
Molybdenum	Mo	2e7
Niobium	Nb	1e8
Nickel	Ni	5e8
Potassium	K	2e9
Rubidium	Rb	1e9
Sodium	Na	2e9
Strontium	Sr	1e8
Tantalum	Ta	3e7
Thallium	Tl	5e7
Thorium	Th	5e7
Tin	Sn	3e8
Titanium	Ti	5e8
Tungsten	W	1e7
Uranium	U	5e8
Vanadium	V	1e8
Yttrium	Y	3e8
Zinc	Zn	5e8
Zirconium	Zr	1e8

CHEMTRACE® Solution Based Chemistry™

VPD ICP-MS METHOD DETECTION LIMITS AND RECOVERIES

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57 $^2D_{3/2}$ **La** Lanthanum 138.9055 1e7 85	58 $^1G^0_4$ **Ce** Cerium 140.116 1e7 91	59 $^4I^0_{9/2}$ **Pr** Praseodymium 140.90765 1e7 90	60 $^5I_4$ **Nd** Neodymium 144.24 2e7 91	61 $^6H^0_{5/2}$ **Pm** Promethium (145)	62 $^7F_0$ **Sm** Samarium 150.36 1e7 94	63 $^8S^0_{7/2}$ **Eu** Europium 151.964 5e6 94	64 $^9D^0_2$ **Gd** Gadolinium 157.25 1e7 93	65 $^6H^0_{15/2}$ **Tb** Terbium 158.92534 5e6 94	66 $^5I_8$ **Dy** Dysprosium 162.50 1e7 95	67 $^4I^0_{15/2}$ **Ho** Holmium 164.93032 5e6 94	68 $^3H_6$ **Er** Erbium 167.26 5e6 95	69 $^2F^0_{7/2}$ **Tm** Thulium 168.93421 5e6 94	70 $^1S_0$ **Yb** Ytterbium 173.04 1e7 94	71 $^2D_{3/2}$ **Lu** Lutetium 174.967 3e6 94
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Atomic Number · Ground-state Level · Symbol · Name · Atomic Weight† · Method Detection Limit (atoms/cm²) · Percntage Recovery on Si wafers (%)

58 $^1G^0_4$ **Ce** Cerium 140.116 2e7 91

300mm SILICON WAFERS

VPD ICP-MS METHOD DETECTION LIMITS, ATOMS/CM²

Method detection limits for WSS, DFS and BSE ICP-MS vary depending on techniques.

Aluminum	Al	1e9
Antimony	Sb	1e7
Arsenic	As	2e9
Barium	Ba	8e6
Beryllium	Be	1e9
Bismuth	Bi	5e6
Boron	B	2e10
Cadmium	Cd	2e7
Calcium	Ca	1e9
Cesium	Cs	3e7
Chromium	Cr	3e8
Cobalt	Co	3e8
Copper	Cu	1e8
Gallium	Ga	2e7
Germanium	Ge	5e7
Hafnium	Hf	3e7
Iron	Fe	5e8
Lanthanum	La	1e7
Lead	Pb	2e7
Lithium	Li	3e8
Magnesium	Mg	5e8
Manganese	Mn	1e8
Molybdenum	Mo	1e7
Niobium	Nb	5e7
Nickel	Ni	3e8
Potassium	K	1e9
Rubidium	Rb	5e8
Sodium	Na	1e9
Strontium	Sr	5e7
Tantalum	Ta	2e7
Thallium	Tl	3e7
Thorium	Th	3e7
Tin	Sn	1e8
Titanium	Ti	3e8
Tungsten	W	5e6
Uranium	U	3e8
Vanadium	V	5e7
Yttrium	Y	1e8
Zinc	Zn	3e8
Zirconium	Zr	5e7

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