

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, UCT 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

1 $^2S_{1/2}$
H
Hydrogen
1.00794

IIA

3 $^2S_{1/2}$ **Li**
Lithium
6.941

4 1S_0 **Be**
Beryllium
9.01218

11 $^2S_{1/2}$ **Na**
Sodium
22.98977

12 1S_0 **Mg**
Magnesium
24.3050

19 $^2S_{1/2}$ **K**
Potassium
39.0983

20 1S_0 **Ca**
Calcium
40.078

37 $^2S_{1/2}$ **Rb**
Rubidium
85.4678

38 1S_0 **Sr**
Strontium
87.62

55 $^2S_{1/2}$ **Cs**
Cesium
132.90545

56 1S_0 **Ba**
Barium
137.327

87 $^2S_{1/2}$ **Fr**
Francium
(223)

88 1S_0 **Ra**
Radium
(226)

IIIB

21 $^2D_{3/2}$ **Sc**
Scandium
44.95591

22 $^2F_7/2$ **Ti**
Titanium
47.867

23 $^4F_3/2$ **V**
Vanadium
50.9415

24 3F_4 **Cr**
Chromium
51.9961

25 $^6S_{5/2}$ **Mn**
Manganese
54.93805

26 5D_4 **Fe**
Iron
55.845

27 $^4F_{7/2}$ **Co**
Cobalt
58.93320

28 3F_4 **Ni**
Nickel
58.6934

29 $^2S_{1/2}$ **Cu**
Copper
63.546

30 1S_0 **Zn**
Zinc
65.39

31 $^2P_{1/2}$ **Ga**
Gallium
69.723

32 3P_0 **Ge**
Germanium
72.61

33 $^4S_{3/2}$ **As**
Arsenic
74.92160

34 3P_2 **Se**
Selenium
78.96

35 $^2P_{3/2}$ **Br**
Bromine
79.904

36 1S_0 **Kr**
Krypton
83.80

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Rubidium
85.4678

38 1S_0 **Sr**
Strontium
87.62

39 $^2D_{3/2}$ **Y**
Yttrium
88.90585

40 $^2F_7/2$ **Zr**
Zirconium
91.224

41 $^4D_{5/2}$ **Nb**
Niobium
92.90638

42 $^2F_5/2$ **Mo**
Molybdenum
95.94

43 $^4S_{3/2}$ **Tc**
Technetium
(98)

44 5F_4 **Ru**
Ruthenium
101.07

45 $^4F_7/2$ **Rh**
Rhodium
102.90550

46 1S_0 **Pd**
Palladium
106.42

47 $^2S_{1/2}$ **Ag**
Silver
107.8682

48 1S_0 **Cd**
Cadmium
112.411

49 $^2P_{1/2}$ **In**
Indium
114.818

50 3P_0 **Sn**
Tin
118.710

51 $^4S_{3/2}$ **Sb**
Antimony
121.760

52 3P_2 **Te**
Tellurium
127.60

53 $^2P_{3/2}$ **I**
Iodine
126.90447

54 1S_0 **Xe**
Xenon
131.29

55 $^2S_{1/2}$ **Cs**
Cesium
132.90545

56 1S_0 **Ba**
Barium
137.327

57 $^2D_{3/2}$ **La**
Lanthanum
138.9055

58 1G_4 **Ce**
Cerium
140.116

59 $^4F_{7/2}$ **Pr**
Praseodymium
140.90765

60 3F_4 **Nd**
Neodymium
144.24

61 $^4H_{9/2}$ **Pm**
Promethium
(145)

62 7F_6 **Sm**
Samarium
150.36

63 $^6S_{5/2}$ **Eu**
Europium
151.964

64 5D_4 **Gd**
Gadolinium
157.25

65 $^6H_{15/2}$ **Tb**
Terbium
158.92534

66 5I_8 **Dy**
Dysprosium
162.50

67 $^4I_{13/2}$ **Ho**
Holmium
164.93032

68 2H_8 **Er**
Erbium
167.26

69 $^2F_{7/2}$ **Tm**
Thulium
168.93421

70 1S_0 **Yb**
Ytterbium
173.04

71 $^2D_{3/2}$ **Lu**
Lutetium
174.967

72 $^2D_{3/2}$ **Ac**
Actinium
(227)

73 $^2F_7/2$ **Th**
Thorium
232.0381

74 $^4K_{1/2}$ **Pa**
Protactinium
231.03588

75 5L_6 **U**
Uranium
238.0289

76 $^6L_{10}$ **Np**
Neptunium
(237)

77 7F_6 **Pu**
Plutonium
(244)

78 $^8S_{7/2}$ **Am**
Americium
(243)

79 3D_5 **Cm**
Curium
(247)

80 $^6H_{15/2}$ **Bk**
Berkelium
(247)

81 5I_8 **Cf**
Californium
(251)

82 $^4I_{13/2}$ **Es**
Einsteinium
(252)

83 3H_8 **Fm**
Fermium
(257)

84 $^2F_{7/2}$ **Md**
Mendelevium
(258)

85 1S_0 **No**
Nobelium
(259)

86 $^3P_{1/2}$ **Lr**
Lawrencium
(262)

IIIB

26 5D_4 **Fe**
Iron
55.845

27 $^4F_{7/2}$ **Co**
Cobalt
58.93320

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Palladium
106.42

47

200_{mm} SILICON WAFERS

**VPD ICP-MS
METHOD DETECTION
LIMITS, ATOMS/CM²**

Method detection limits
for WSS, DFS & 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



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GROUP IA

IIA

IIIB

IVB

VB

VIB

VII B

VIII B

IB

IIB

IIIA

IVA

VA

VIA

VIIA

VIIIA

IX

X

XI

XII

XIII

XIV

XV

XVI

XVII

XVIII

ACTINIDE

LANTHANIDE

Method Detection Limit (atoms/cm²)

Percentage Recovery on Si wafers (%)

Atomic Number

Ground-state Level

Symbol

Name

Atomic Weight

1 ¹H Hydrogen 1.00794

3 ³Li Lithium 6.941

11 ¹¹Na Sodium 22.98977

19 ¹⁹K Potassium 39.0983

37 ³⁷Rb Rubidium 85.4678

55 ⁵⁵Cs Cesium 132.90545

87 ⁸⁷Fr Francium (223)

2 ²He Helium 4.00260

4 ⁴Be Beryllium 9.01218

12 ¹²Mg Magnesium 24.3050

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38 ³⁸Sr Strontium 87.62

56 ⁵⁶Ba Barium 137.327

88 ⁸⁸Ra Radium (226)

5 ⁵B Boron 10.811

13 ¹³Al Aluminum 26.98154

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57 ⁵⁷La Lanthanum 138.9055

89 ⁸⁹Ac Actinium (227)

6 ⁶C Carbon 12.0107

14 ¹⁴Si Silicon 28.0855

22 ²²Ti Titanium 47.867

40 ^{40Zr Zirconium 91.224}

58 ⁵⁸Ce Cerium 140.116

90 ⁹⁰Th Thorium 232.0381

7 ⁷N Nitrogen 14.00674

15 ¹⁵P Phosphorus 30.97376

23 ²³V Vanadium 50.9415

41 ⁴¹Nb Niobium 92.90638

59 ⁵⁹Pr Praseodymium 140.90768

91 ⁹¹Pa Protactinium 231.03588

8 ⁸O Oxygen 15.9994

16 ¹⁶S Sulfur 32.066

24 ²⁴Cr Chromium 51.9961

42 ⁴²Mo Molybdenum 95.94

60 ⁶⁰Nd Neodymium 144.24

92 ⁹²U Uranium 238.0289

9 ⁹F Fluorine 18.99840

17 ¹⁷Cl Chlorine 35.4527

25 ²⁵Mn Manganese 54.93805

43 ⁴³Tc Technetium (98)

61 ⁶¹Pm Promethium (145)

93 ⁹³Np Neptunium (237)

10 ¹⁰Ne Neon 20.1797

18 ¹⁸Ar Argon 39.948

26 ²⁶Fe Iron 55.845

44 ⁴⁴Ru Ruthenium 101.07

62 ⁶²Sm Samarium 150.36

94 ⁹⁴Pu Plutonium (244)

11 ¹¹Na Sodium 22.98977

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27 ²⁷Co Cobalt 58.93320

45 ⁴⁵Rh Rhodium 102.90550

63 ⁶³Eu Europium 151.964

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28 ²⁸Ni Nickel 58.6934

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64 ⁶⁴Gd Gadolinium 157.25

96 ⁹⁶Cm Curium (247)

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65 ⁶⁵Tb Terbium 158.92534

97 ⁹⁷Bk Berkelium (247)

14 ¹⁴Si Silicon 28.0855

32 ³²Ge Germanium 72.61

50 ⁵⁰Sn Tin 118.710

68 ⁶⁸Er Erbium 167.26

98 ⁹⁸Cf Californium (251)

15 ¹⁵P Phosphorus 30.97376

33 ³³As Arsenic 74.92160

51 ⁵¹Sb Antimony 121.760

69 ⁶⁹Tm Thulium 168.93421

99 ⁹⁹Es Einsteinium (252)

16 ¹⁶S Sulfur 32.066

34 ³⁴Se Selenium 78.96

52 ⁵²Te Tellurium 127.60

70 ⁷⁰Yb Ytterbium 173.04

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17 ¹⁷Cl Chlorine 35.4527

35 ³⁵Br Bromine 79.904

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101 ¹⁰¹Md Mendelevium (258)

18 ¹⁸Ar Argon 39.948

36 ³⁶Kr Krypton 83.80

54 ⁵⁴Xe Xenon 131.29

72 ⁷²Hf Hafnium 178.49

80 ⁸⁰Hg Mercury 200.59

86 ⁸⁶Rn Radon (222)

102 ¹⁰²No Nobelium (259)

103 ¹⁰³Lr Lawrencium (262)

28 ²⁸Ni Nickel 58.6934

46 ⁴⁶Pd Palladium 106.42

64 ⁶⁴Gd Gadolinium 157.25

82 ⁸²Pb Lead 207.2

110 ¹¹⁰Uun Ununnilium (269)

112 ¹¹²Uub Unbibium (272)

29 ²⁹Cu Copper 63.546

47 ⁴⁷Ag Silver 107.8682

65 ⁶⁵Tb Terbium 158.92534

83 ⁸³Bi Bismuth 208.98038

101 ¹⁰¹Md Mendelevium (258)

103 ¹⁰³Lr Lawrencium (262)

30 ³⁰Zn Zinc 65.39

48 ⁴⁸Cd Cadmium 112.411

66 ⁶⁶Dy Dysprosium 162.50

84 ⁸⁴Po Polonium (209)

102 ¹⁰²No Nobelium (259)

31 ³¹Ga Gallium 69.723

49 ⁴⁹In Indium 114.818

67 ⁶⁷Ho Holmium 164.93032

85 ⁸⁵At Astatine (2

300_{mm} SILICON WAFERS

**VPD ICP-MS
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LIMITS, ATOMS/CM²**

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for WSS, DFS & BSE
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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

