No.	Method	Principle (primary excitation /detected emission)	Coverage	Maximum sensitivity		Duration (min)	Surface survey capability	Pressure required (torr)	Non-destructive	Reproducibility (%)	Probe diameter (μm)
				abs. (g)	rel. (ppma)						
0	1	2	3	4	5	6	7	8	9	10	11
1	Wet chemical analysis	solution/ various	All elements	10^{-9}		300	No	ambient	No		—
2	Emission spectroscopy	opticaly excited vapour/ optical analysis	All elements	10^{-9} up to 10^{-6}		60	No	ambient	No		—
3	Atomic absorption	optically excited vapour/ optical analysis	50 elements	10^{-10} up to 10^{-5}		30	No	ambient	No		—
4	Neutron activation	neutron bombardment/ particle energy analysis	75 elements	10^{-12} up to 10^{-6}		600	No	ambient	Yes		—
5	Radiotracer	Radiotracer inclusion/ γ or β radioactivity measurement	All elements			300	No	ambient	Yes		—
6	X-ray fluorescence	X-ray bombardment/ X-ray analysis	$Z \geqslant 9$	10^{-7}	1—100	30	Yes	ambient	Yes	±1	10^4

Sampling depth		Calibration	Depth profiling	Advantages	Disadvantages	Examples of CVD application			
(μm)	atomic layers					Doping	Impurity	Composition/ Stoichiometry	Depth profiling
12	13	14	15	16	17	18	19	20	21
bulk		No	No	Quantitative Cheap set-up	Slow Sample dissolution required Bulk analysis	B in *poly*-Si		Si_3N_4	
10^2		Yes	No	Quantitative	Bulk analysis				
bulk		Yes	Yes	Quantitative	Special sample preparation Very wide range of detection limits Bulk analysis		Na in SiO_2	O in SIPOS; B in *a*-Si:B:H	
bulk		Yes	No	Quantitative	Slow Bulk analysis Safety problems		Metals in *epi*-Si; Na in SiO_2		
		Yes	No	Quantitative	Slow Bulk analysis Safety problems	p- and n-type dopants in Si	Na in SiO_2; Surface impurities on semiconductors	H in SiO_2	
10	10^4	Yes	No	Quantitative Readily applied to insulators Fast Nondestructive	No lateral resolution $Z \geqslant 9$	P in PSG	Si in Al, Mo, Ta films deposited on Si or SiO_2	SnO_2: Sb; $MoSi_2$; $TaSi_2$; WSi_2; $TiSi_2$	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
X-ray photoelectron spectroscopy X.P.S. ESCA.	X-ray bombardment/ electron-energy analysis	$Z \geqslant 3$	10^{-11}	0.1—1%	120	Yes	10^{-6}	Yes	± 20	10^4	10^{-3}	2	Yes	Yes	Readily applied to insulators. Information on chemical bonding	Semi-quantitative Slow No lateral resolution Low detection sensitivity Requires skilled operation			Interface analysis ($Si—SiO_2$, $SiO_2—Si_3N_4$) $Si_xO_yN_z$; $Si_xN_yH_z$	
Solids mass spectrography	radiation ionized vapour/ ion mass analysis	All	10^{-12} up to 10^{-8}	0.01—1.0	60	No	10^{-4}	No	± 20	10—100	1	10^3	Yes	No	High sensitivity	Semi-quantitative Surface charging of insulators Expensive instrument	Si in $GaAs_{1-x}P_x$ and $In_{1-x}Ga_xP$	Trace impurities in SnO_2:Sb, In_2O_3:Sn	H in *a*-Si:H and $Si_xN_yH_z$	
Electron-probe micro-analysis E.P.M.A.	electron bombardment/ X-ray analysis	$Z \geqslant 4$	10^{-14}	100—1000	60	Yes	10^{-5}	Yes	± 2	1	1	10^2	Yes	Yes	Quantitative Nondestructive Fast	Surface charging of insulators $Z \geqslant 4$ Expensive instrument			$Si:SiO_2$; $Si:Si_3N_4$; SIPOS; SiO_2; PSG; AsSG; Si_3N_4; AlN; Ta_2N; Al_2O_3; SnO_2; GaAs; $Al_xGa_{1-x}As$ ZnSe	
Auger electron spectroscopy A.E.S.	electron beam/ electron energy analysis	$Z \geqslant 3$	10^{-14}	0.01—0.1%	30	Yes	10^{-7}	Yes	± 20	25—100	10^{-4}	2	Yes	Yes	Depth profile Fast	Semi-quantitative Limited sensitivity Surface charging of insulators Requires skilled operation		Surface impurities (Na, K on Si) O in Si_3N_4; Ga in SiO_2, Si_3N_4, or Al_2O_3	*a*-Si:B; Si_3N_4; SIPOS; $Si_xO_yN_z$; ZnO; BN; SiO_2: ZnSe; Interfaces: $Si—SiO_2$; $Si_3N_4—SiO_2$; Pd—*a*-Si:	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
																UHV required			:H; SiO_2—Al, etc. III—V compound oxides	
Scanning Auger microanalysis S.A.M.	electron beam/ electron analysis	$Z \geqslant 3$		0.1—1%	30	Yes		Yes	±20	4—15		2	Yes	Yes	Area and line scans Depth profile Fast	Semi-quantitative Limited sensitivity Surface charging of insulators Expansive instrument UHV required		"	"	
Ion scattering spectrometry	ion bombardment/ ion mass analysis	$Z \geqslant 3$		0.1—1%	180	Yes	10^{-7}	Yes	±20	10^3	10^{-4}	1	Yes	Yes	Depth profile Readily applied to insulators Analysis of the outermost atomic layer	Semi-quantitative Poor depth and lateral resolution Slow		Surface impurities on Si		
Ion-probe microanalysis	ion bombardment/ion mass analysis	All	10^{-12} up to 10^{-8}	0.1—100	30	Yes	10^{-7}	No	±2	1—300	10^{-2}	10	Yes	Yes	Depth profile Excellent mass in-depth and lateral resolution Fast	Semi-quantitative Requires skilled operation Matrix effects Surface charging of insulators Expensive instrument UHV required		Impurities in *epi*-GaAs	III—V compound oxides	B, P, As implanted in Si
Secondary ion mass spectrometry SIMS	ion bombardment/ ion mass analysis	All	10^{-15}	0.1—100	30	Yes	10^{-8}	No	±2	10^3	10^{-4}	3	Yes	Yes	Depth profile Information on chemical	Semi-quantitative Expensive in-		Surface contamination of *epi*-Si;		H in *a*-Si:H; Cl in SiO_2

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
																bonding Good mass and in-depth resolution Fast	strument Requires skilled operation Matrix effects Poor lateral resolution Surface charging of insulators UHV required	I	O in *epi*-$Ga_{1-x}Al_xAs$; Interface contamination (Cr, Ga in $ZnSiAs_2$/GaAs; $Si_xO_yN_z$/InSb)		
15	Rutherford backscattering spectroscopy R.B.S.	$^4He^+$ ion bombardment/ $^4He^+$ ion energy analysis	Heavy elements	10^{-11}		120	No	10^{-3}	Yes		—	1		Yes	Yes	Quantitative Nondestructive High sensitivity High mass resolution	Poor sensitivity to trace amounts of light elements High laboratory space required Expensive instrument	Implanted and diffused dopants in Si	Trace impurities on surfaces Implanted ions in SiO_2, Si_3N_4, and Al_2O_3 Metal impurities in Si	*Epi* layer interface Dielectric layers (SiO_2, Si_3N_4, Al_2O_3, Ta_2O_5) Al-*poly*-Si interface	Cl in SiO_2
16	Nuclear reaction analysis	proton or deuteron bombardment/ γ- or α-ray energy analysis	Light elements			120	No	ambient	Yes		—	1–5		Yes	Yes	Ability to detect light elements on heavier substrates Ability to distinguish isotopes	Restricted to low Z elements High laboratory space required Expensive instrument			H in $Si_xN_yH_z$ and a-Si:H; O and N in $Si_xO_yN_z$	
17	Glow-discharge mass spectrometry	glow discharge ion bombardment/ sputtered ion mass analysis	All			60	Yes	10^{-3}	No		—	Any		Yes	Yes	Fast	Surface charging of insulators Expensive instrument	Dopants in GaAs, Si	Impurities in GaAs, Si	Stoichiometry of GaAs and other III—V compounds	
18	Glow-discharge optical spectrometry	glow discharge ion bombardment/ sputtered atom optical analysis	All			60	Yes	10^{-3}	No		—	Any		Yes	Yes	Fast	Expensive instrument	Diffused and implanted dopants in Si			