Analysis of Silicon Germanium Standards for the Quantification of SiGe Microelectronic Devices using AES

SECTION A - Authors

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SECTION A - Overview

A-3. Abstract: Four samples of well-defined silicon-germanium alloys were used as standards for calibration purposes to allow accurate quantification of silicon-germanium-on-insulator (SGOI) microelectronic devices using Auger electron spectroscopy. Narrow Si KLL and the Ge LMM, high resolution Si KL_{2,3}L_{2,3} and Ge L₃M_{4,5}M_{4,5} together with survey spectra were collected and are presented from each sample. A matrix effect was observed for silicon in germanium and calculated as 0.85 and 0.95 for the Ge_{77.5}Si_{22.5} Ge_{52.4}Si_{47.6} alloys respectively.

A-3a. Introduction: As microelectronic devices continue to get smaller Auger electron spectroscopy (AES) and scanning Auger microscopy (SAM) remain one of the few experimental techniques with the capability to perform quantification at such high spatial resolution. While high energy (0.05 %) resolutions make the analysis of elemental and chemical composition possible for a range of elements, reliable quantification remains a problem.

Here calibration samples were used to quantify the silicon content of a microelectronic device (Ref. 1). These standards were provided with concentrations of 52.4 and 77.5 at.% germanium, together with high purity silicon and germanium. All samples were analysed by AES using a Thermo Scientific Microlab 350. Spectra were collected with beam energy of 15 keV, sample current of 5 nA, energy step size of between 2 and 0.2 eV, dwell time of 50 ms and a retard ratios of 2-20. Argon ion sputtering was carried out using a Thermo Scientific EX05 argon ion gun, a 3 keV beam energy and 25 nA cm⁻² sample current density was used for 20 seconds to remove the oxide and surface contamination. The system pressure was increased from 1x10⁻⁶ Pa to 1 x10⁻⁴ with an argon flow for ion sputtering. The possibility of preferential sputtering was not considered. Samples were previously etched in 5% HF solution to remove a protective oxide film (Ref. 2). The concentration of the standards was checked using XPS, this was carried out using a Thermo Scientific Theta Probe.

For the quantitative analysis of the Auger electron spectra the relative atomic concentrations of silicon and germanium are calculated using the maximum amplitude of the Si KLL (1614 eV) and the Ge LMM (1143 eV) transitions in the Auger high resolution spectra, following a linear background subtraction. The lower kinetic energy Si LMM and Ge MNN Auger transitions were not used because of their overlapping positions. Higher resolution spectra are also included with a smaller step size and pass energy to assess the peak positions.

For accurate quantification the experimental conditions remained constant. When the unknown sample composition is similar to that of a standard, quantification can be based upon peak amplitude (Ref. 3). Average values from 8 analysis points on each sample are noted in section I.

A-6a. # of digitally submitted specimen spectra for SSS publication: 16

A-6b. # of digitally submitted specimen spectra for electronic database only: 4

A-6c. # of digitally submitted calibration spectra: 5

A-7. Publish Auger Derivative Spectra: Display N(E) only

A-9. Spectra Category: reference

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Submission Publication & Review Info

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A-13. Comments on WCF:

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A-15b. Reviewer 2: John Wolstenholme, wolstenholmej@btinternet.com

A-15c. Reviewer 3:

Keywords: Silicon, Germanium, SGOI, Silicon-Germanium on Insulator, AES, Quantification

Major Elements in Spectra: Silicon, Germanium

Minor Elements in Spectra: O

SECTION A - REFERENCES

SECTION B - SPECIMEN DESCRIPTION

Specimen #: 1

B-1. Host Material: Germanium

B-2. Chemical Abstract Service (CAS) Registry #: 7440-56-4

B-3a. Material Designation Code:

B-3b. Material Designating Organization:

- B-4. Host Composition: 99.999%
- B-5. Chemical Name: Ge
- B-6. Specimen Manufacturer/Supplier: ihp-microelectronics
- B-7. Specimen Form: 10x10x1 mm sheet, with a mirror smooth surface
- B-8. Lot Number:
- B-9. Structural Formula:
- B-10. Homogeneity: Homogeneous
- B-11. Phase: Solid
- B-12. Crystallinity: Polycrystalline
- B-13. Electrical Characteristics: Semiconductor
- B-14. Material Family: Semiconductor
- B-15. Special Material Classes: Other
- B-16. History and Significance: None
- B-17. As Received Condition: Sample arrived secure in a Gel-Pak box
- B-18. Analyzed Region: 8 points from across the surface were analysed by AES
- B-19. Ex Situ Preparation and Mounting: Sample mounted on a stainless steel holder using sprung copper clips
- B-20. In Situ Preparation: Sample was argon ion etched for ~20 seconds to remove surface oxide and carbon contamination. The system pressure was increased from 1×10^{-6} Pa to 1×10^{-4} with an argon flow for ion sputtering.
- B-21. Specimen Temperature During Analysis (Kelvin): 300
- B-22. Maximum Chamber Pressure During Analysis (in Pa): 1×10^{-6}
- B-23. Pre-Analysis Beam Exposures: Sample was previously analysed by XPS for ten minutes to check its composition
- B-24. Charge Control Conditions and Procedures: None
- Specimen #: 2
- B-1. Host Material: Silicon
- B-2. Chemical Abstract Service (CAS) Registry #: 7440-21-3
- B-3a. Material Designation Code:

B-3b. Material Designating Organization:

B-4. Host Composition: 99.999%

B-5. Chemical Name: Si

B-6. Specimen Manufacturer/Supplier: ihp-microelectronics

B-7. Specimen Form: 10x10x1 mm sheet, with a mirror smooth surface

B-8. Lot Number:

B-9. Structural Formula:

B-10. Homogeneity: Homogeneous

B-11. Phase: Solid

B-12. Crystallinity: Polycrystalline

B-13. Electrical Characteristics: Semiconductor

B-14. Material Family: Semiconductor

B-15. Special Material Classes: -

B-16. History and Significance: None

B-17. As Received Condition: Sample arrived secure in a Gel-Pak box

B-18. Analyzed Region: 8 points from across the surface were analysed by AES

B-19. Ex Situ Preparation and Mounting: Sample was mounted on a stainless steel holder using sprung copper clips.

B-20. In Situ Preparation: Sample was argon ion etched for ~20s to remove oxide and carbon contamination. The system pressure was increased from 1×10^{-6} Pa to 1×10^{-4} with an argon flow for ion sputtering.

B-21. Specimen Temperature During Analysis (Kelvin): 300

B-22. Maximum Chamber Pressure During Analysis (in Pa): 1×10^{-6}

B-23. Pre-Analysis Beam Exposures: Sample was previously analysed by XPS for ten minutes to check its composition

B-24. Charge Control Conditions and Procedures: None

Specimen #: 3

B-1. Host Material: Si_{22.5} Ge_{77.5} alloy

B-2. Chemical Abstract Service (CAS) Registry #: Unknown

B-3a. Material Designation Code:

B-3b. Material Designating Organization:

B-4. Host Composition: 22.5 Si
77.5 Ge

B-5. Chemical Name:

B-6. Specimen Manufacturer/Supplier: ihp-microelectronics

B-7. Specimen Form: Alloy sample was ~10x10x1 mm, with a mirror smooth surface

B-8. Lot Number:

B-9. Structural Formula:

B-10. Homogeneity: Homogeneous

B-11. Phase: Solid

B-12. Crystallinity: Polycrystalline

B-13. Electrical Characteristics: Semiconductor

B-14. Material Family: Semiconductor

B-15. Special Material Classes:

B-16. History and Significance: None

B-17. As Received Condition: Sample arrived secure in a Gel-Pak box, 400 nm thick alloy on silicon substrate

B-18. Analyzed Region:

B-19. Ex Situ Preparation and Mounting: Sample was mounted on a stainless steel holder using sprung copper clips.

B-20. In Situ Preparation: Sample was argon ion etched for ~20s to remove oxide and carbon contamination. The system pressure was increased from 1×10^{-6} Pa to 1×10^{-4} with an argon flow for ion sputtering.

B-21. Specimen Temperature During Analysis (Kelvin): 300

B-22. Maximum Chamber Pressure During Analysis (in Pa): 1×10^{-6}

B-23. Pre-Analysis Beam Exposures: Sample was previously analysed by XPS for ten minutes to check its composition

B-24. Charge Control Conditions and Procedures: None

Specimen #: 4

B-1. Host Material: Si_{47.6}Ge_{52.4} alloy

B-2. Chemical Abstract Service (CAS) Registry #: [Unknown](#)

B-3a. Material Designation Code:

B-3b. Material Designating Organization:

B-4. Host Composition: [47.6 Si](#)
[52.4 Ge](#)

B-5. Chemical Name:

B-6. Specimen Manufacturer/Supplier: [ihp-microelectronics](#)

B-7. Specimen Form: [Alloy sample was ~10x10x1 mm, with a mirror smooth surface](#)

B-8. Lot Number:

B-9. Structural Formula:

B-10. Homogeneity: [Homogeneous](#)

B-11. Phase: [Solid](#)

B-12. Crystallinity: [Polycrystalline](#)

B-13. Electrical Characteristics: [Semiconductor](#)

B-14. Material Family: [Semiconductor](#)

B-15. Special Material Classes:

B-16. History and Significance: [None](#)

B-17. As Received Condition: [Sample arrived secure in a Gel-Pak box, 400 nm thick alloy on silicon substrate](#)

B-18. Analyzed Region: [8 points from across the surface were analysed by AES](#)

B-19. Ex Situ Preparation and Mounting: [Sample was mounted on a stainless steel holder using sprung copper clips.](#)

B-20. In Situ Preparation: [Sample was argon ion etched for ~20 seconds to remove oxide and carbon contamination. The system pressure was increased from \$1 \times 10^{-6}\$ Pa to \$1 \times 10^{-4}\$ with an argon flow for ion sputtering.](#)

B-21. Specimen Temperature During Analysis (Kelvin): [300](#)

B-22. Maximum Chamber Pressure During Analysis (in Pa): [\$1 \times 10^{-6}\$](#)

B-23. Pre-Analysis Beam Exposures: [Sample was previously analysed by XPS for ten minutes to check its composition](#)

B-24. Charge Control Conditions and Procedures: [None](#)

Specimen #: [5](#)

- B-1. Host Material: [Gold](#)
- B-2. Chemical Abstract Service (CAS) Registry #: [7440-57-5](#)
- B-3a. Material Designation Code:
- B-3b. Material Designating Organization:
- B-4. Host Composition: [99.99%](#)
- B-5. Chemical Name: [Au](#)
- B-6. Specimen Manufacturer/Supplier:
- B-7. Specimen Form: [10x10x1 mm Gold foil, with a mirror smooth surface](#)
- B-8. Lot Number:
- B-9. Structural Formula:
- B-10. Homogeneity: [Homogeneous](#)
- B-11. Phase: [Solid](#)
- B-12. Crystallinity: [Polycrystalline](#)
- B-13. Electrical Characteristics: [Conductor](#)
- B-14. Material Family: [Metal](#)
- B-15. Special Material Classes:
- B-16. History and Significance: [None](#)
- B-17. As Received Condition: [Sample is kept wrapped in clean aluminium foil and routinely used as a reference material in XPS and AES](#)
- B-18. Analyzed Region: [One point from the centre of the foil was analysed](#)
- B-19. Ex Situ Preparation and Mounting: [Sample mounted on a stainless steel holder using sprung copper clips](#)
- B-20. In Situ Preparation: [Sample was argon ion etched for 10 seconds to remove carbon contamination](#)
- B-21. Specimen Temperature During Analysis (Kelvin): [300](#)
- B-22. Maximum Chamber Pressure During Analysis (in Pa): [1x10⁻⁶](#)
- B-23. Pre-Analysis Beam Exposures: [Sample has previously been analysed numerous times by XPS and AES. It has also undergone argon ion sputtering. Sample is used as a laboratory standard.](#)
- B-24. Charge Control Conditions and Procedures: [None](#)

Specimen #: 6

B-1. Host Material: Silver

B-2. Chemical Abstract Service (CAS) Registry #: 7440-22-4

B-3a. Material Designation Code:

B-3b. Material Designating Organization:

B-4. Host Composition: 99.9

B-5. Chemical Name: Ag

B-6. Specimen Manufacturer/Supplier:

B-7. Specimen Form: 10x10x1 mm sheet, with a mirror smooth surface

B-8. Lot Number:

B-9. Structural Formula:

B-10. Homogeneity: Homogeneous

B-11. Phase: Solid

B-12. Crystallinity: Polycrystalline

B-13. Electrical Characteristics: Conductor

B-14. Material Family: Metal

B-15. Special Material Classes:

B-16. History and Significance: None

B-17. As Received Condition: Sample is kept wrapped in clean aluminium foil and routinely used as a reference material in XPS and AES

B-18. Analyzed Region: One point from the centre of the foil was analysed

B-19. Ex Situ Preparation and Mounting: Sample was mounted on a stainless steel holder using sprung copper clips

B-20. In Situ Preparation: Sample was argon ion etched for 10 seconds to remove carbon contamination

B-21. Specimen Temperature During Analysis (Kelvin): 300

B-22. Maximum Chamber Pressure During Analysis (in Pa): 1×10^{-6}

B-23. Pre-Analysis Beam Exposures: Sample has previously been analysed numerous times by XPS and AES. It has also undergone argon ion sputtering. Sample is used as a laboratory standard.

B-24. Charge Control Conditions and Procedures: **None**

Specimen #: **7**

B-1. Host Material: **Copper**

B-2. Chemical Abstract Service (CAS) Registry #: **7440-50-8**

B-3a. Material Designation Code:

B-3b. Material Designating Organization:

B-4. Host Composition: **99.9**

B-5. Chemical Name: **Cu**

B-6. Specimen Manufacturer/Supplier:

B-7. Specimen Form: **10x10x1 mm sheet, with a mirror smooth surface**

B-8. Lot Number:

B-9. Structural Formula:

B-10. Homogeneity: **Homogeneous**

B-11. Phase: **Solid**

B-12. Crystallinity: **Polycrystalline**

B-13. Electrical Characteristics: **Conductor**

B-14. Material Family: **Metal**

B-15. Special Material Classes:

B-16. History and Significance: **None**

B-17. As Received Condition: **Sample is kept wrapped in clean aluminium foil and routinely used as a reference material in XPS and AES**

B-18. Analyzed Region: **One point from the centre of the foil was analysed**

B-19. Ex Situ Preparation and Mounting: **Sample mounted on a stainless steel holder using sprung copper clips**

B-20. In Situ Preparation: **Sample was argon ion etched for 30 seconds to remove oxide and carbon contamination**

B-21. Specimen Temperature During Analysis (Kelvin): **300**

B-22. Maximum Chamber Pressure During Analysis (in Pa): **1×10^{-6}**

B-23. Pre-Analysis Beam Exposures: Sample has previously been analysed numerous times by XPS and AES. It has also undergone argon ion sputtering. Sample is used as a laboratory standard.

B-24. Charge Control Conditions and Procedures: None

SECTION C - INSTRUMENT DESCRIPTION

C-1. Spectrometer Manufacturer: Thermo

C-2. Manufacturer Model #: Microlab 350

C-2a. Short identifying name for instrument: MicroLab

C-3. Analyzer Type: SSA

C-4. Non-Standard Analyzer or Lens:

C-5. Acceptance Angle from Analyzer Axis (degrees): 50

C-6. Analyzer Mode: constant retarding ratio

C-7. Instrument Throughput Function: other

C-8. Instrument Throughput Function Comment: The transmission function is calculated from a cubic polynomial fit to a plot of LOG (Peak Area * XSF / PE) vs. LOG (RR)
RR=KE/PE (Retard Ratio = Kinetic Energy / Pass Energy)
XSF is a term to account for the difference in absolute sensitivities of the Ag MNN and Ag 3d peaks.

C-10. Excitation Source Window or Filter: None

C-11. Detector Description: multi-channel parallel detector

C-12. Number of Detector Elements: 6

C-12a. Was an Ion Gun Used? yes

C-13a. Ion Gun Manufacturer: ThermoScientific

C-13b. Ion Gun Model #: EX05

C-14. Sputtering Current Measurement Method: Biased Stage

Ion Gun Operating Parameters

C-15a. Energy (in eV): 3000

C-15b. Current Value: 1

C-15c. Current Units: mA

C-15d. Sputter Species: [Ar](#)

C-15e. Sputter Charge: [+1](#)

C-16. Ion Gun Spot Size (um): [200](#)

Ion Gun Raster Parameters (normal to source):

C-17a. Was Ion Gun rastered? [Yes](#)

C-17b. X-Raster (um): [2000](#)

C-17c. Y-Raster (um): [2000](#)

C-18. Sputtering Comments: [Differentially pumped ion gun](#)

C-19a. Emission Angle (Θ e): [60](#)

C-19b. Incident Angle (Ψ i): [60](#)

C-19c. Source-to-Analyzer Angle (Θ s): [60](#)

C-19d. Specimen Azimuthal Angle (Φ sp): [0](#)

C-19e. Sputter Source Incident Angle (Ψ ig): [67.5](#)

C-19f. Sputter Source Polar Angle (Θ ig): [43](#)

C-19g. Sputter Source Azimuthal Angle (Φ ig): [228](#)

C-20. Angular Geometry Comments:

SECTION D - CALIBRATION INFORMATION

Analyzer Calibration Table

Seq #	Spectrum #	Element	Peak Transition	Peak Energy (eV)	Peak FWHM	Peak Amplitude	Sensitivity Factor	Concentration	Peak Assignment	Peak Assignment Comment
1	2377	Au	NVV	71.6	-	46560	-	100	Au metal	
2	2378	Au	MNN	2015.5	-	20185	-	100	Au metal	
3	2379	Ag	MNN	351.7	-	119457	-	100	Ag metal	
4	2380	Cu	MVV	60.2	-	28731	-	100	Cu metal	
5	2381	Cu	LVV	917.0	-	45170	-	100	Cu metal	

SECTION E - VARIABLE INSTRUMENT PARAMETERS

E-1. Param Set #: 1

E-1a. Technique: AES

E-1b. Describe Technique if you selected 'other' above:

Excitation Source Parameters

ES-1. Source Label: e-beam

ES-2. Describe Source if you selected 'other' above:

E-2. Source Energy (eV): 15000

E-3a. Strength: 5

E-3b. Strength Unit: nanoamps

Excitation Source Beam

E-4a. Source Beam Size, X Value (um): 0.1

E-4b. Source Beam Size, Y Value (um): 0.1

E-5. Was the Source rastered? No

Excitation Source Beam Size at Specimen Surface

E-6a. Source Size at Specimen Surface, X (um): 0.01

E-6b. Source Size at Specimen Surface, Y (um): 0.01

E-7. Raster Frame Rate (Hz):

E-8. Analyzer Resolution: 0.5

E-8a. Analyzer Resolution Unit: % (constant retarding ratio)

E-9 Analyzer Constants: 4

E-9a. Choose eV for pass energy, otherwise blank: -

Analyzer Widths

E-10a. Analyzer Widths, X Value (um): 800

E-10b. Analyzer Widths, Y Value (um): 800

E-10c. Was the Analyzer Width constant with energy? no

E-10d. Analyzer Widths, at Energy (eV):

Analyzer Angular Acceptance Widths

E-11a. Analyzer Angular Acceptance Width, X Angle (degrees): 25

E-11b. Analyzer Acceptance Width, Y Angle (degrees): 25

E-11c. Was the Analyzer Angular Acceptance Width constant with energy? no

E-11d. Analyzer Angular Acceptance Width, at Energy (eV):

E-1. Param Set #: 2

E-1a. Technique: AES

E-1b. Describe Technique if you selected 'other' above:

Excitation Source Parameters

ES-1. Source Label: e-beam

ES-2. Describe Source if you selected 'other' above:

E-2. Source Energy (eV): 15000

E-3a. Strength: 5

E-3b. Strength Unit: nanoamps

Excitation Source Beam

E-4a. Source Beam Size, X Value (um): 0.1

E-4b. Source Beam Size, Y Value (um): 0.1

E-5. Was the Source rastered? No

Excitation Source Beam Size at Specimen Surface

E-6a. Source Size at Specimen Surface, X (um): 0.01

E-6b. Source Size at Specimen Surface, Y (um): 0.01

E-7. Raster Frame Rate (Hz):

E-8. Analyzer Resolution: 0.1

E-8a. Analyzer Resolution Unit: % (constant retarding ratio)

E-9 Analyzer Constants: 20

E-9a. Choose eV for pass energy, otherwise blank:

Analyzer Widths

E-10a. Analyzer Widths, X Value (um): 800

E-10b. Analyzer Widths, Y Value (um): 800

E-10c. Was the Analyzer Width constant with energy? yes

E-10d. Analyzer Widths, at Energy (eV):

Analyzer Angular Acceptance Widths

E-11a. Analyzer Angular Acceptance Width, X Angle (degrees): 30

E-11b. Analyzer Acceptance Width, Y Angle (degrees): 30

E-11c. Was the Analyzer Angular Acceptance Width constant with energy? yes

E-11d. Analyzer Angular Acceptance Width, at Energy (eV):

E-1. Param Set #: 4

E-1a. Technique: AES

E-1b. Describe Technique if you selected 'other' above:

Excitation Source Parameters

ES-1. Source Label: [e-beam](#)

ES-2. Describe Source if you selected 'other' above:

E-2. Source Energy (eV): [15000](#)

E-3a. Strength: [5](#)

E-3b. Strength Unit: [nanoamps](#)

Excitation Source Beam

E-4a. Source Beam Size, X Value (um): [0.1](#)

E-4b. Source Beam Size, Y Value (um): [0.1](#)

E-5. Was the Source rastered? [No](#)

Excitation Source Beam Size at Specimen Surface

E-6a. Source Size at Specimen Surface, X (um): [0.01](#)

E-6b. Source Size at Specimen Surface, Y (um): [0.01](#)

E-7. Raster Frame Rate (Hz):

E-8. Analyzer Resolution: [0.66](#)

E-8a. Analyzer Resolution Unit: [% \(constant retarding ratio\)](#)

E-9 Analyzer Constants: [3](#)

E-9a. Choose eV for pass energy, otherwise blank:

Analyzer Widths

E-10a. Analyzer Widths, X Value (um): [800](#)

E-10b. Analyzer Widths, Y Value (um): [800](#)

E-10c. Was the Analyzer Width constant with energy? [yes](#)

E-10d. Analyzer Widths, at Energy (eV):

Analyzer Angular Acceptance Widths

E-11a. Analyzer Angular Acceptance Width, X Angle (degrees): [30](#)

E-11b. Analyzer Acceptance Width, Y Angle (degrees): [30](#)

E-11c. Was the Analyzer Angular Acceptance Width constant with energy? [yes](#)

E-11d. Analyzer Angular Acceptance Width, at Energy (eV):

E-1. Param Set #: 3

E-1a. Technique: AES

E-1b. Describe Technique if you selected 'other' above:

Excitation Source Parameters

ES-1. Source Label: e-beam

ES-2. Describe Source if you selected 'other' above:

E-2. Source Energy (eV): 15000

E-3a. Strength: 5

E-3b. Strength Unit: nanoamps

Excitation Source Beam

E-4a. Source Beam Size, X Value (um): 0.1

E-4b. Source Beam Size, Y Value (um): 0.1

E-5. Was the Source rastered? No

Excitation Source Beam Size at Specimen Surface

E-6a. Source Size at Specimen Surface, X (um): 0.01

E-6b. Source Size at Specimen Surface, Y (um): 0.01

E-7. Raster Frame Rate (Hz):

E-8. Analyzer Resolution: 0.2

E-8a. Analyzer Resolution Unit: % (constant retarding ratio)

E-9. Analyzer Constants: 10

E-9a. Choose eV for pass energy, otherwise blank:

Analyzer Widths

E-10a. Analyzer Widths, X Value (um): 800

E-10b. Analyzer Widths, Y Value (um): 800

E-10c. Was the Analyzer Width constant with energy? yes

E-10d. Analyzer Widths, at Energy (eV):

Analyzer Angular Acceptance Widths

E-11a. Analyzer Angular Acceptance Width, X Angle (degrees): 30

E-11b. Analyzer Acceptance Width, Y Angle (degrees): 30

E-11c. Was the Analyzer Angular Acceptance Width constant with energy? yes

E-11d. Analyzer Angular Acceptance Width, at Energy (eV):

SECTION F - SPECTRA

Field Name	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4
Spectrum #	1	2	3	4
This spectrum is from which Part B Specimen?	1 - Germanium	1 - Germanium	1 - Germanium	1 - Germanium
Suggested Publication Status:	Print in SSS	Print in SSS	Print in SSS	Database Only
Spectrum Data File Name	Ge 100 survey.txt	Ge LMM 100.txt	Ge narrow 100.txt	OKLL Ge100.txt
Data File Comment:				
Spectrum Figure Image File Name	Ge100 survey.jpg	Ge100 LMM.jpg	Ge100 narrow.jpg	Graph12.jpg
Specimen or Calibration Spectrum:	specimen	specimen	specimen	specimen
Parameter Set # Used	4 - e-beam	1 - e-beam	2 - e-beam	3 - e-beam
Spectrum Date	2014-08-01	2014-08-01	2014-10-10	2014-10-10
Species/Transitions:	Ge MNN, Ge LMM	Ge LMM	Ge L3M45M45	O KL23L23
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abscissa Starting Value (eV):	50	650	1140	490
Abscissa Increment Value:	2	2	0.2	0.2
Ordinate Label:	Intensity	Intensity	Intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec

Field Name	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4
Number of Data Channels:	875	277	50	200
Number of Scans:	10	50	100	10
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	2	0.5	0.2	0.2
Total Signal Accumulation Time (sec):	396	2800	254	502
Total Elapsed Time (sec):	723	3460	496	638
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 5	Spectrum 6	Spectrum 7	Spectrum 8
Spectrum #	5	6	7	8
This spectrum is from which Part B Specimen?	3 - Si22.5 Ge77.5 alloy	3 - Si22.5 Ge77.5 alloy	3 - Si22.5 Ge77.5 alloy	3 - Si22.5 Ge77.5 alloy
Suggested Publication Status:	Print in SSS	Print in SSS	Print in SSS	Print in SSS
Spectrum Data File Name	Ge 77.5 survey.txt	Ge LMM 77.5.txt	Si KLL 77.5.txt	Ge narrow 77.5.txt
Data File Comment:				
Spectrum Figure Image File Name	Ge77.5 survey.jpg	Ge 77.5 LMM.jpg	Si 77.5 KLL.jpg	Ge77.5 narrow.jpg
Specimen or Calibration Spectrum:	specimen	specimen	specimen	specimen
Parameter Set # Used	4 - e-beam	1 - e-beam	1 - e-beam	2 - e-beam
Spectrum Date	2014-08-01	2014-08-01	2014-08-01	2014-10-10
Species/ Transitions:	Ge/Si MNN/LMM, Ge LMM, Si KLL	Ge LMM	Si KLL	Ge L3M4545
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abcissa Starting Value (eV):	50	650	1300	1140
Abcissa Increment Value:	2	0.5	0.5	0.2
Ordinate Label:	Intensity	Intensity	intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec
Number of Data Channels:	875	1120	700	50
Number of Scans:	10	50	50	100

Field Name	Spectrum 5	Spectrum 6	Spectrum 7	Spectrum 8
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	2	0.5	0.5	0.2
Total Signal Accumulation Time (sec):	396	2800	1750	254
Total Elapsed Time (sec):	723	3460	2210	496
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 9	Spectrum 10	Spectrum 11	Spectrum 12
Spectrum #	9	10	11	12
This spectrum is from which Part B Specimen?	3 - Si22.5 Ge77.5 alloy	3 - Si22.5 Ge77.5 alloy	4 - Si47.6Ge52.4 alloy	4 - Si47.6Ge52.4 alloy
Suggested Publication Status:	Print in SSS	Database Only	Print in SSS	Print in SSS
Spectrum Data File Name	Si narrow 77.5.txt	OKLL Ge77.5.txt	Ge 52.4 survey.txt	Ge LMM 52.4.txt
Data File Comment:				
Spectrum Figure Image File Name	Si 77.5 narrow.jpg	Graph15.jpg	Ge52.4 survey.jpg	Ge 52.4 LMM.jpg
Specimen or Calibration Spectrum:	specimen	specimen	specimen	specimen
Parameter Set # Used	2 - e-beam	3 - e-beam	4 - e-beam	1 - e-beam
Spectrum Date	2014-10-10	2014-10-10	2014-08-01	2014-08-01
Species/ Transitions:	Si KL23L23	O KL23L23	Ge/Si MNN/LMM, Ge LMM, Si KLL	Ge LMM
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abcissa Starting Value (eV):	1605	490	50	650
Abcissa Increment Value:	0.2	0.2	2	2
Ordinate Label:	Intensity	Intensity	Intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec
Number of Data Channels:	100	200	875	277
Number of Scans:	100	50	10	3

Field Name	Spectrum 9	Spectrum 10	Spectrum 11	Spectrum 12
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	0.2	0.2	2	2
Total Signal Accumulation Time (sec):	504	502	396	60
Total Elapsed Time (sec):	802	638	723	120
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 13	Spectrum 14	Spectrum 15	Spectrum 16
Spectrum #	13	14	15	16
This spectrum is from which Part B Specimen?	4 - Si47.6Ge52.4 alloy	4 - Si47.6Ge52.4 alloy	4 - Si47.6Ge52.4 alloy	4 - Si47.6Ge52.4 alloy
Suggested Publication Status:	Print in SSS	Print in SSS	Print in SSS	Database Only
Spectrum Data File Name	Si KLL 52.4.txt	Ge narrow 52.4.txt	Si narrow 52.4.txt	OKLL Ge52.4.txt
Data File Comment:				
Spectrum Figure Image File Name	Si 52.4 KLL.jpg	Ge52.4 narrow.jpg	Si 52.4 narrow.jpg	Graph18.jpg
Specimen or Calibration Spectrum:	specimen	specimen	specimen	specimen
Parameter Set # Used	1 - e-beam	2 - e-beam	2 - e-beam	3 - e-beam
Spectrum Date	2014-08-01	2014-10-10	2014-10-10	2014-10-10
Species/ Transitions:	Si KLL	Ge L3M45M45	Si KL23L23	O KL23L23
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abcissa Starting Value (eV):	1300	1140	1605	490
Abcissa Increment Value:	0.5	0.2	0.2	0.2
Ordinate Label:	Intensity	Intensity	Intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec
Number of Data Channels:	700	50	100	200
Number of Scans:	50	100	100	50

Field Name	Spectrum 13	Spectrum 14	Spectrum 15	Spectrum 16
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	0.5	0.2	0.2	0.2
Total Signal Accumulation Time (sec):	1750	254	504	502
Total Elapsed Time (sec):	2210	496	802	638
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 17	Spectrum 18	Spectrum 19	Spectrum 20
Spectrum #	17	18	19	20
This spectrum is from which Part B Specimen?	2 - Silicon	2 - Silicon	2 - Silicon	2 - Silicon
Suggested Publication Status:	Print in SSS	Print in SSS	Print in SSS	Database Only
Spectrum Data File Name	Si 100 survey.txt	Si KLL 100.txt	Si narrow 100.txt	OKLL Si100.txt
Data File Comment:				
Spectrum Figure Image File Name	Si 100 survey.jpg	Si 100 KLL.jpg	Si100 narrow.jpg	Graph20.jpg
Specimen or Calibration Spectrum:	specimen	specimen	specimen	specimen
Parameter Set # Used	4 - e-beam	1 - e-beam	2 - e-beam	3 - e-beam
Spectrum Date	2014-08-01	2014-08-01	2014-10-10	2014-10-10
Species/ Transitions:	Si LMM, Si KLL	Si KLL	Si KL23L23	O KL23L23
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abcissa Starting Value (eV):	50	1300	1605	490
Abcissa Increment Value:	2	0.5	0.2	0.2
Ordinate Label:	Intensity	Intensity	Intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec
Number of Data Channels:	875	700	100	200
Number of Scans:	10	50	50	50

Field Name	Spectrum 17	Spectrum 18	Spectrum 19	Spectrum 20
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	2	0.5	0.2	0.2
Total Signal Accumulation Time (sec):	396	1750	504	502
Total Elapsed Time (sec):	723	2210	802	638
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 21	Spectrum 22	Spectrum 23	Spectrum 24
Spectrum #	21	22	23	24
This spectrum is from which Part B Specimen?	5 - Gold	5 - Gold	6 - Silver	7 - Copper
Suggested Publication Status:	Database Only	Database Only	Database Only	Database Only
Spectrum Data File Name	Au NVV.txt	Au MNN.txt	Ag MNN.txt	Cu MVV.txt
Data File Comment:				
Spectrum Figure Image File Name				
Specimen or Calibration Spectrum:	calibration	calibration	calibration	calibration
Parameter Set # Used	1 - e-beam	1 - e-beam	1 - e-beam	1 - e-beam
Spectrum Date	2014-08-15	2014-08-15	2014-08-15	2014-08-15
Species/ Transitions:	Au NVV	Au MNN	Ag MNN	Cu MVV
Spectral Region Comment:				
Abscissa Label	kinetic energy	kinetic energy	kinetic energy	kinetic energy
Abcissa Starting Value (eV):	50	1960	335	45
Abcissa Increment Value:	0.1	0.5	0.2	0.2
Ordinate Label:	Intensity	Intensity	Intensity	Intensity
Ordinate Units:	counts/sec	counts/sec	counts/sec	counts/sec
Number of Data Channels:	500	180	200	150
Number of Scans:	50	50	50	50

Field Name	Spectrum 21	Spectrum 22	Spectrum 23	Spectrum 24
Signal Mode:	pulse	pulse	pulse	pulse
Detector Width (eV):	0.1	0.5	0.2	0.2
Total Signal Accumulation Time (sec):	500	450	500	360
Total Elapsed Time (sec):	660	950	660	540
Is 'raw data' signal intensity corrected? (Yes/No):	No	No	No	No
Signal Intensity Correction Comment:				
Signal Modulation Method:	none	none	none	none
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

Field Name	Spectrum 25			
Spectrum #	25			
This spectrum is from which Part B Specimen?	7 - Copper			
Suggested Publication Status:	Database Only			
Spectrum Data File Name	Cu LVV.txt			
Data File Comment:				
Spectrum Figure Image File Name				
Specimen or Calibration Spectrum:	calibration			
Parameter Set # Used	1 - e-beam			
Spectrum Date	2014-08-15			
Species/ Transitions:	Cu LVV			
Spectral Region Comment:				
Abscissa Label	kinetic energy			
Abscissa Starting Value (eV):	890			
Abscissa Increment Value:	0.5			
Ordinate Label:	Intensity			
Ordinate Units:	counts/sec			
Number of Data Channels:	100			
Number of Scans:	50			

Field Name	Spectrum 25			
Signal Mode:	pulse			
Detector Width (eV):	0.5			
Total Signal Accumulation Time (sec):	240			
Total Elapsed Time (sec):	480			
Is 'raw data' signal intensity corrected? (Yes/No):	No			
Signal Intensity Correction Comment:				
Signal Modulation Method:	none			
Peak-to-peak amplitude of Modulation (eV):				
Modulation Frequency of Reference Signal (Hz):				
Time Constant of Lock-in Amplifier Used (sec):				

SECTION H - ANALYSIS METHODS

H-1. Energy Scale Correction: No energy scale correction has been applied

H-2. Recommended Energy-Scale Shift:

H-3. Intensity Scale Correction:

H-4. Peak Shape and Background Methods: A linear background subtraction was performed over the range 650-1205 eV for germanium and 1300-1650 eV for silicon to measure the peak intensities for quantification. For the higher resolution peaks, a peak background is not reported as the energy scale does not include sufficient elastic background contribution.

H-5. Quantitation Method: A graph of silicon intensity vs germanium intensity was plotted, a deviation from a linear relationship between the pure material intensities was noted indicating a matrix factor. This was calculated as 0.9 for Si in Ge. Using $X_a/X_b = F_{ab}((I_a/I_{apure}) / (I_b/I_{bpure}))$

SECTION I - Units for Spectral Features Quantitative fields

I-1. Peak Amplitude Method: **peak height**

I-2. Peak Amplitude Units: **counts/sec**

I-3. Concentration Units: **atomic percent**

I-4. Comments to Spectral Features Table: **Peak height measured after a linear background subtraction, as described in section H4.**

Table of Spectral Features

Seq #	Spectrum #	Element	Peak Transition	Peak Energy (eV)	Peak FWHM	Peak Amplitude	Sensitivity Factor	Concentration	Peak Assignment	Peak Assignment Comment
1	2383	Ge	LMM	1146.0	-	46226	-	100	Ge	Average intensity from 8 points 27746
2	2392	Ge	L ₃ M _{4,5}	1145	-	-	-	100	Ge	Pure germanium
3	2393	O	KL _{2,3} L _{2,3}	511.6	-	510	-	Trace	GeO ₂	Surface oxide
4	2385	Ge	LMM	1146.0	-	48701	-	77.5	Ge-Si alloy	Average intensity from 8 points 18056
5	2394	Ge	L ₃ M _{4,5}	1145.3	-	-	-	77.5	Ge in Si _{22.5} Ge _{77.5} alloy	Alloy germanium
6	2386	Si	KLL	1618.0	-	5915	-	22.5	Ge-Si alloy	Average intensity from 8 points 2976
7	2395	Si	KL _{2,3} L _{2,3}	1615.5	-	-	-	22.5	Si in Si _{22.5} Ge _{77.5} alloy	Alloy silicon
8	2396	O	KL _{2,3} L _{2,3}	510.0	-	609	-	trace	Si _{22.5} Ge _{77.5} alloy oxide	Surface oxide
9	2388	Ge	LMM	1146.0	-	30146	-	52.4	Ge-Si alloy	Average intensity from 8 points 12690

Seq #	Spectrum #	Element	Peak Transition	Peak Energy (eV)	Peak FWHM	Peak Amplitude	Sensitivity Factor	Concentration	Peak Assignment	Peak Assignment Comment
10	2397	Ge	L ₃ M _{4,5}	1145.2	-	-	-	52.4	Ge in Si47.6Ge 52.4	Alloy germanium
11	2389	Si	KLL	1617.5	-	11732	-	47.6	Ge-Si alloy	Average intensity from 8 points 5791
12	2398	Si	KL _{2,3} L _{2,3}	1615.5	-	-	-	~47.6	Si in Si47.6Ge 52.4 alloy	Alloy silicon
13	2399	O	KL _{2,3} L _{2,3}	510.0	-	830	-	trace	O in Si47.6Ge 52.4 oxide	Surface oxide
14	2391	Si	KLL	1618.0	-	23630	-	100	Pure Si	Average intensity from 8 points 13356
15	2400	Si	KL _{2,3} L _{2,3}	1615.5	-	-	-	100	Si	Pure silicon
16	2401	O	KL _{2,3} L _{2,3}	510.0	-	1100	-	trace	O in SiO ₂	Surface oxide

FIGURE IMAGE FILES

This submission has 20 spectrum records with associated image files.

Spectrum No 1: [*Ge100 survey.jpg*](#)
Spectrum No 2: [*Ge100 LMM.jpg*](#)
Spectrum No 3: [*Ge100 narrow.jpg*](#)
Spectrum No 4: [*Graph12.jpg*](#)
Spectrum No 5: [*Ge77.5 survey.jpg*](#)
Spectrum No 6: [*Ge 77.5 LMM.jpg*](#)
Spectrum No 7: [*Si 77.5 KLL.jpg*](#)
Spectrum No 8: [*Ge77.5 narrow.jpg*](#)
Spectrum No 9: [*Si 77.5 narrow.jpg*](#)
Spectrum No 10: [*Graph15.jpg*](#)
Spectrum No 11: [*Ge52.4 survey.jpg*](#)
Spectrum No 12: [*Ge 52.4 LMM.jpg*](#)
Spectrum No 13: [*Si 52.4 KLL.jpg*](#)
Spectrum No 14: [*Ge52.4 narrow.jpg*](#)
Spectrum No 15: [*Si 52.4 narrow.jpg*](#)
Spectrum No 16: [*Graph18.jpg*](#)
Spectrum No 17: [*Si 100 survey.jpg*](#)
Spectrum No 18: [*Si 100 KLL.jpg*](#)
Spectrum No 19: [*Si100 narrow.jpg*](#)
Spectrum No 20: [*Graph20.jpg*](#)

Ge100 survey.jpg

Ge100 LMM.jpg

Ge100 narrow.jpg

Graph12.jpg

Ge77.5 survey.jpg

Ge 77.5 LMM.jpg

Si 77.5 KLL.jpg

Ge77.5 narrow.jpg

Si 77.5 narrow.jpg

Graph15.jpg

Ge52.4 survey.jpg

Ge 52.4 LMM.jpg

Si 52.4 KLL.jpg

Ge52.4 narrow.jpg

Si 52.4 narrow.jpg

Graph18.jpg

Si 100 survey.jpg

Si 100 KLL.jpg

Si100 narrow.jpg

Graph20.jpg