LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900204-v2 *Advanced LIGO* April 30, 2009

iLIGO Witness Plate Analysis: Imaging run #2

Cheryl Vorvick

Distribution of this document:
LIGO Scientific Collaboration

This is an internal working note
of the LIGO Project.

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In 2008 a proposal was submitted by Cheryl Vorvick and Garilynn Billingsley to the Environmental Molecular Science Laboratory (EMSL) at Pacific Northwest National Laboratory (PNNL), to use their Scanning Electron Microscope (SEM). The purpose of the proposal (#30487) was to identify defects in an iLIGO witness plate, in hopes of identifying the source. This is part of an ongoing coating evaluation program by members of the Core Optics Components (COC) group.

A witness plate (2ITM02, 2ITM04) was shipped to EMSL, where the top surface was coated with platinum, in preparation of SEM imaging. The SEM has the capability to cut through the coating layers on the optic using a Gallium ion beam, creating a trench where the individual coating layers are revealed. The SEM then images these layers from a 52 degree angle, and from that measures thicknesses. In this imaging run #2, we were also able to get X ray fluorescence data.

We are looking for defects that are 10 to 100 um in length. Identifying specific defects has proven to be difficult, and so this is the main thrust of a proposal to extend the work another year.

This document has 4 SEM images and then X ray fluorescence analysis of the coating layers. These were collected by Dr. Lawmaking Saraf, Senior Research Scientist at EMSL.


2/13/2009
9:06:56 AM
det
TLD
HFW
213 µm
mag
1 200 x
WD
4.3 mm
50 µm
Witness Plate 1" Fused Silica

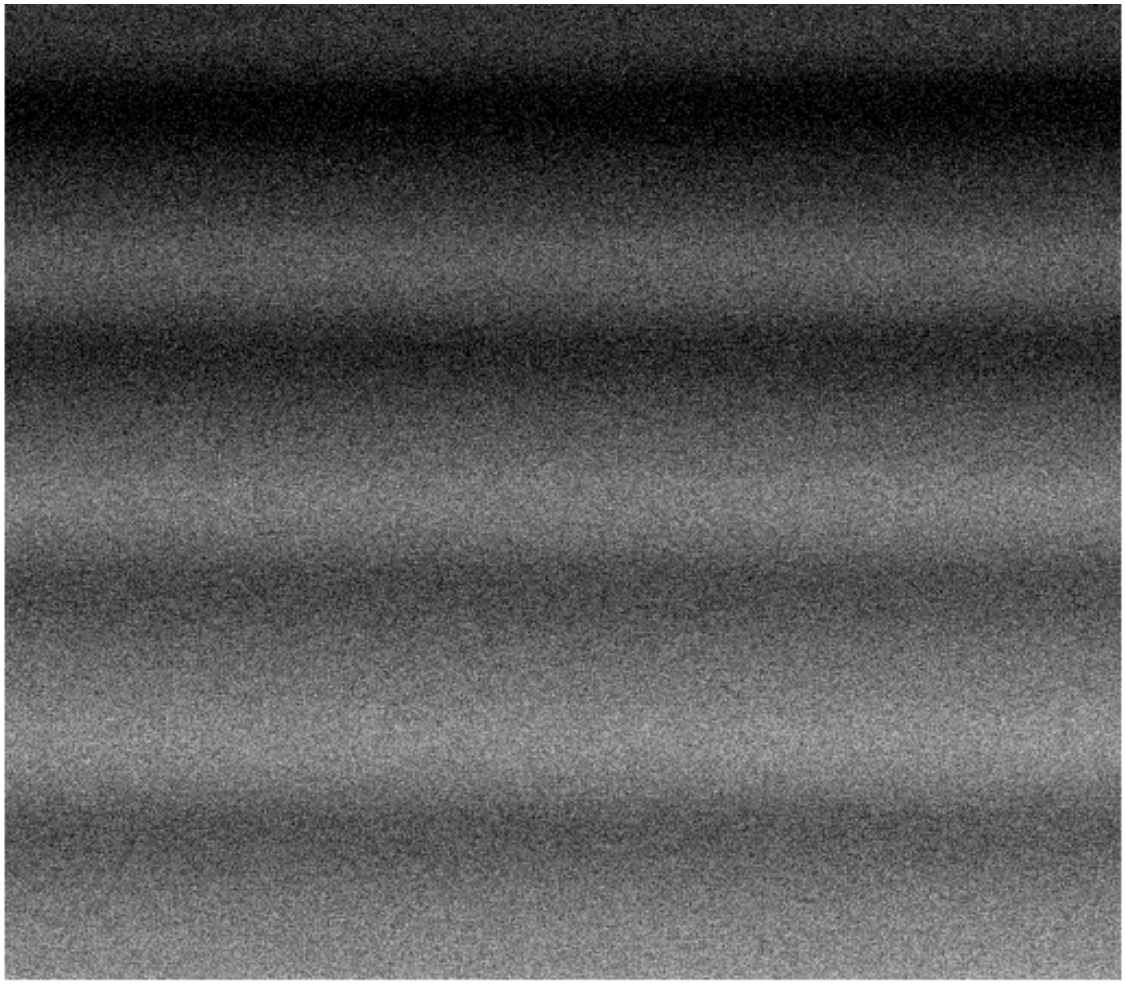
	2/13/2009	det	HFW	mag □	WD	50 µm
	9:44:30 AM	TLD	128 µm	2 000 x	4.5 mm	Witness Plate 1" Fused Silica

	2/13/2009	det	HFW	mag ☐	WD	500 nm
	9:55:34 AM	TLD	1.71 µm	150 000 x	4.5 mm	Witness Plate 1" Fused Silica

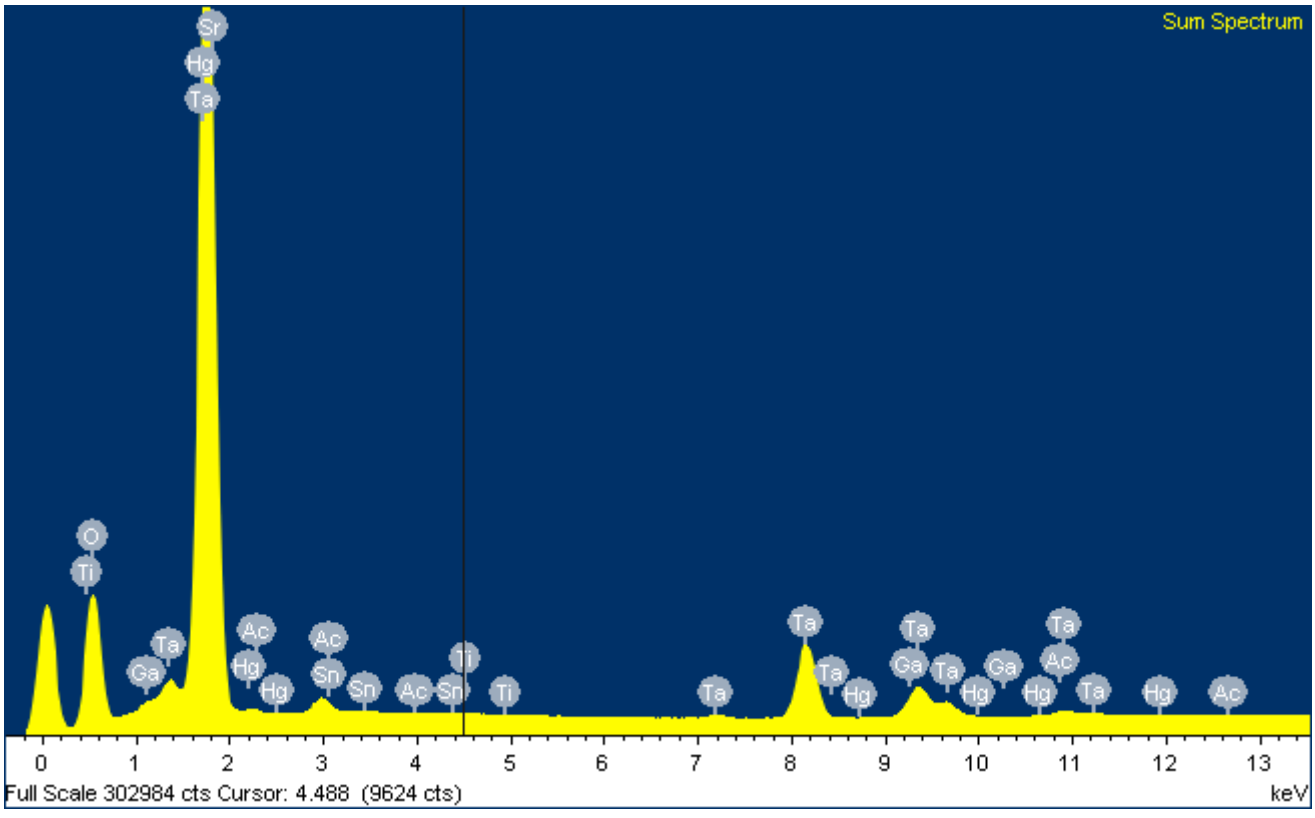
	2/20/2009	det	HFW	mag ☐	WD	10 µm
	11:45:04 AM	TLD	25.6 µm	10 000 x	4.6 mm	witness plate

Project 1

20/02/2009 15:25:02

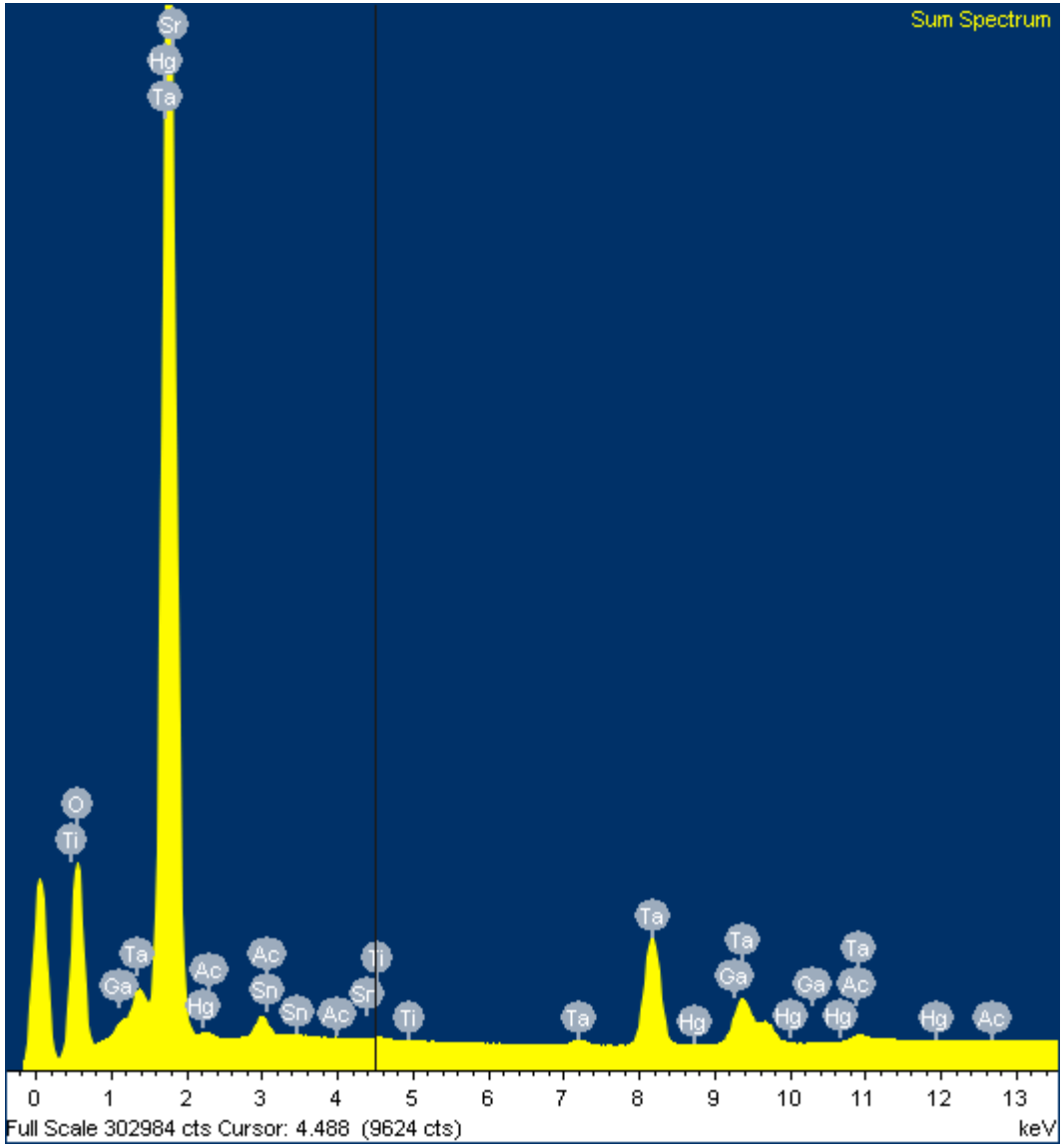


Electron Image 1



Project 1

20/02/2009 15:25:26



Label : Sum Spectrum

Collected : 20-Feb-2009 03:23 PM

Livetime (s) : 521.83

Real time (s) : 0.00

Detector : Silicon

Window : SATW

Tilt (deg) : 55.0

Elevation (deg) : 35.0

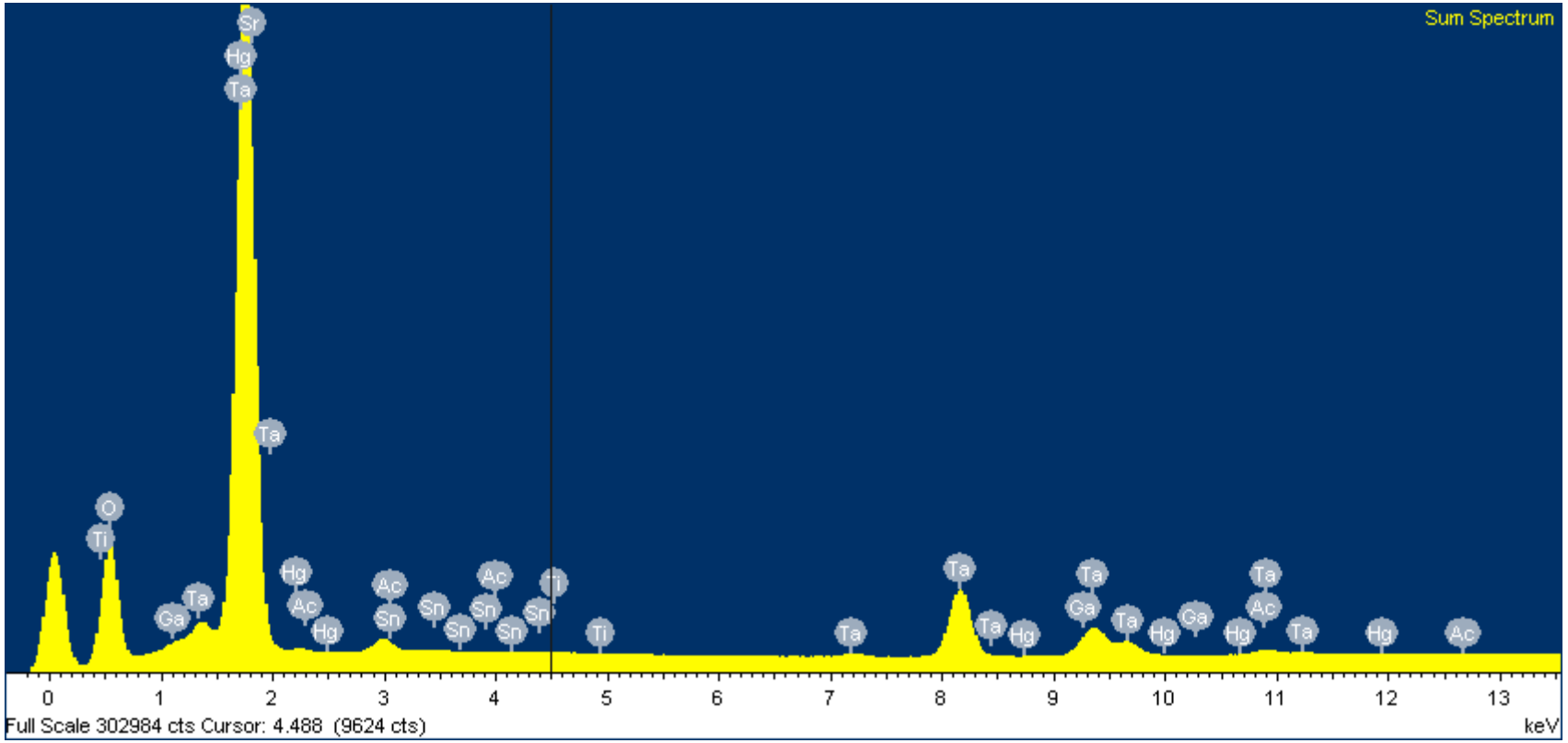
Azimuth (deg) : 0.0

Magnification : 100000 X

Variable Vacuum SEM Options:

Comment:

INCA



Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

Sr SrF2 1-Jun-1999 12:00 AM

Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

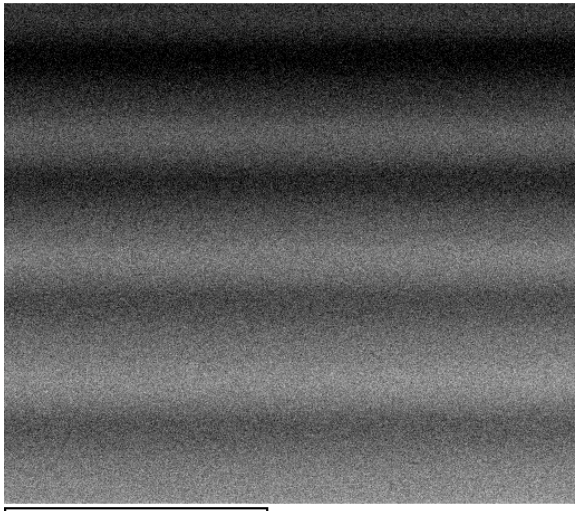
Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM

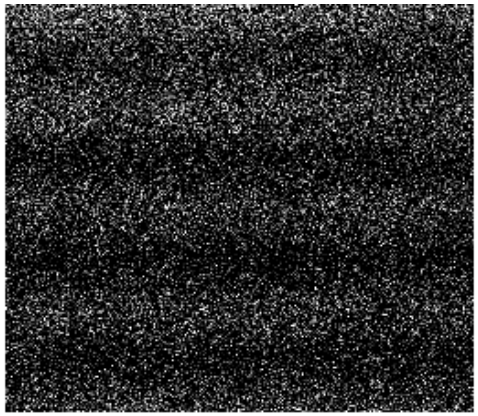
Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	263.73	1.2194	15.90	0.06	65.81
Ti K	1.57	0.9184	0.13	0.02	0.17
Ga K	12.62	1.0545	0.88	0.09	0.84
Sr L	66.86	0.6559	7.49	0.07	5.66
Sn L	2.45	0.8286	0.22	0.05	0.12
Ta M	927.05	0.9424	72.30	0.12	26.47
Hg M	5.39	0.7620	0.52	0.04	0.17
Ac M	28.73	0.8231	2.57	0.05	0.75
Totals			100.00		

Project 1

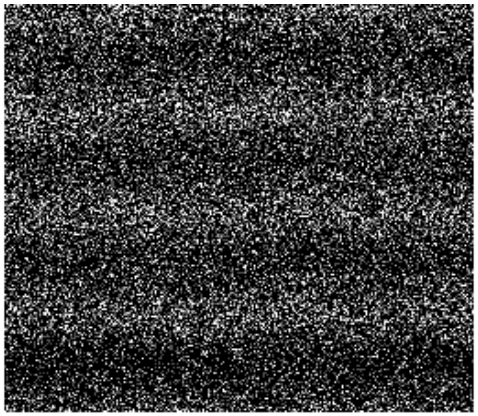
20/02/2009 15:29:08



Electron Image 1

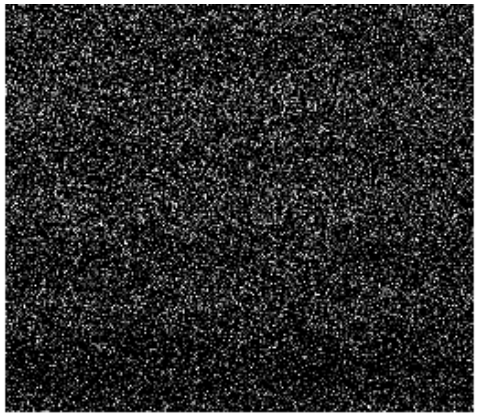


O Ka1

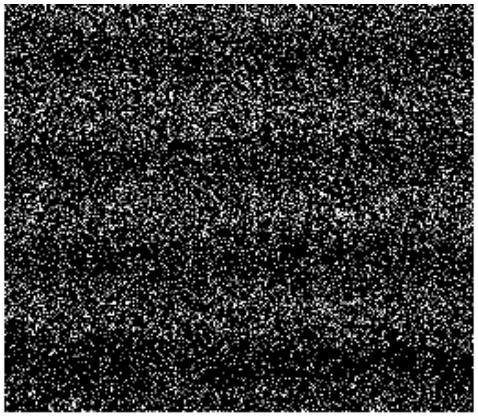


Sr Ka1

Comment:



Ta La1



Ac La1

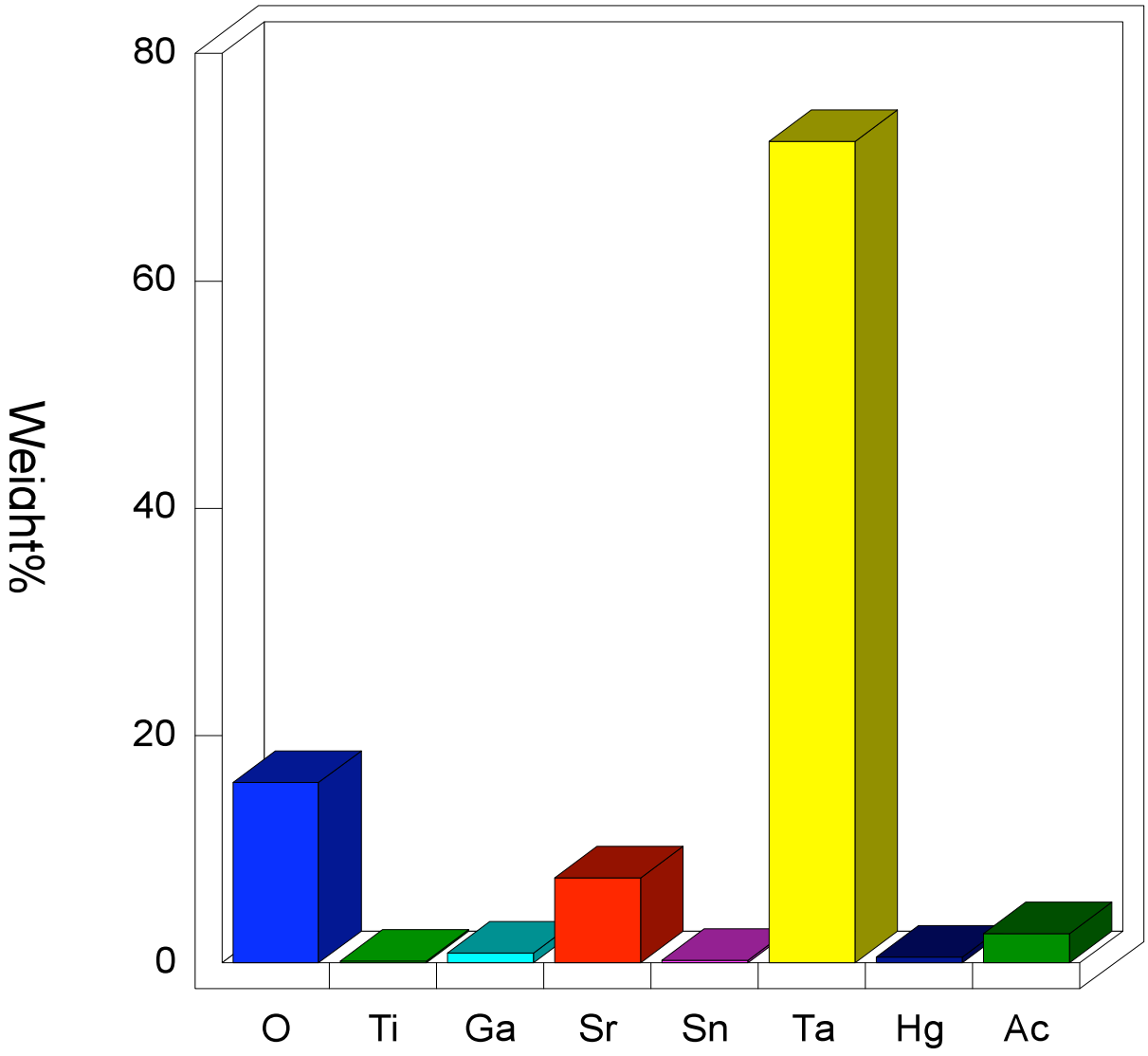
inca

Project 1

20/02/2009 15:30:02

Project: Project 1 Owner: customerservice	Sample: Sample 1 Type: Default

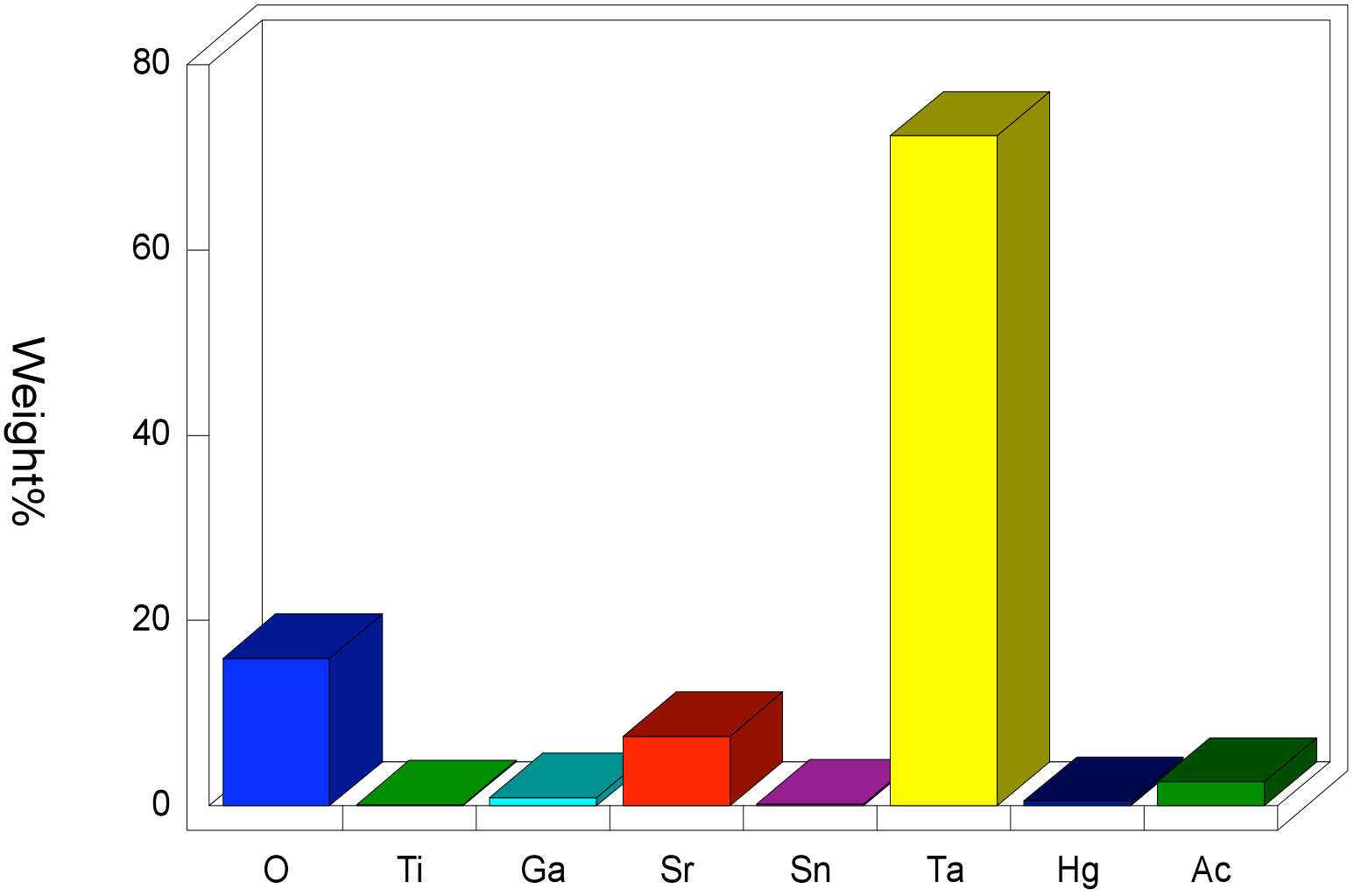
Quantitative results



Comment:

inca

Quantitative results



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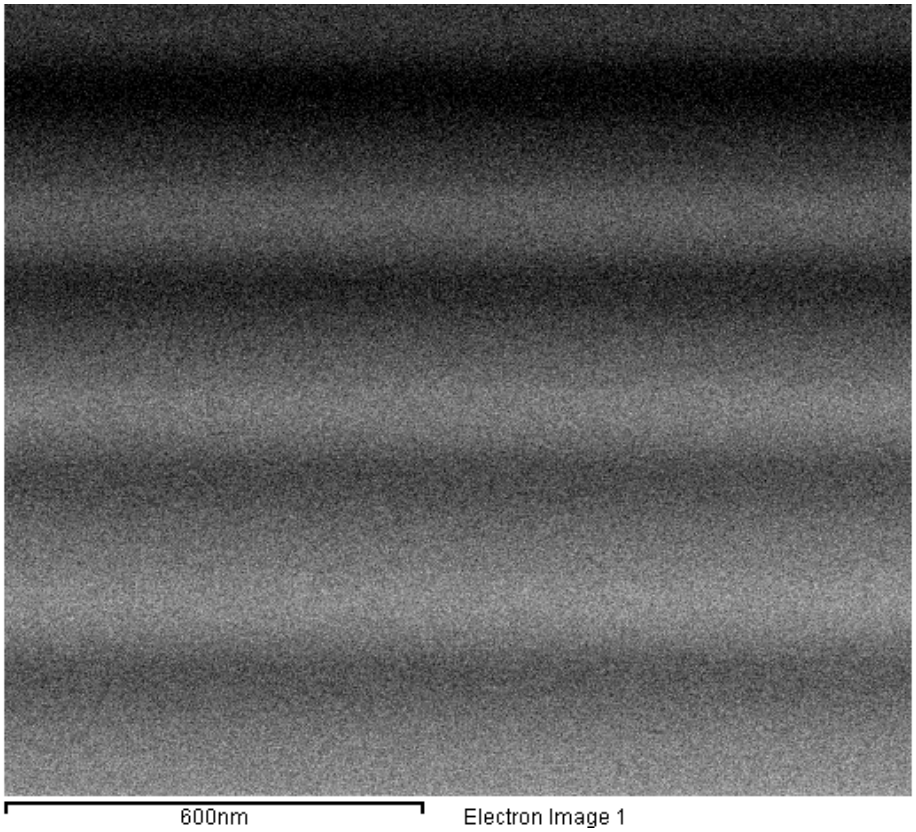
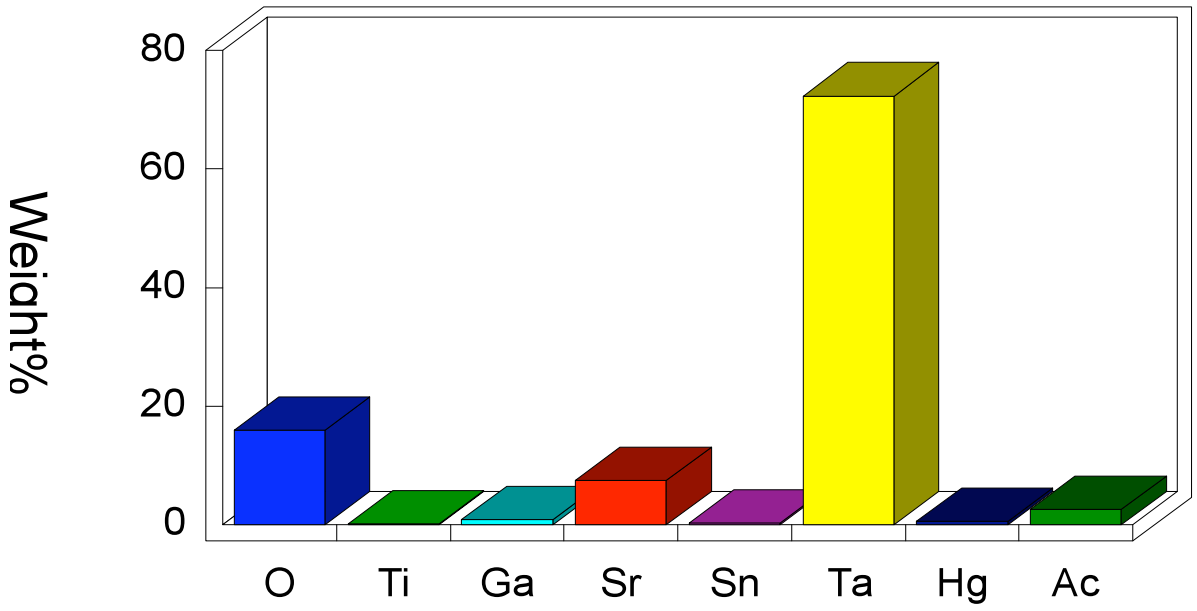


Quantitative results



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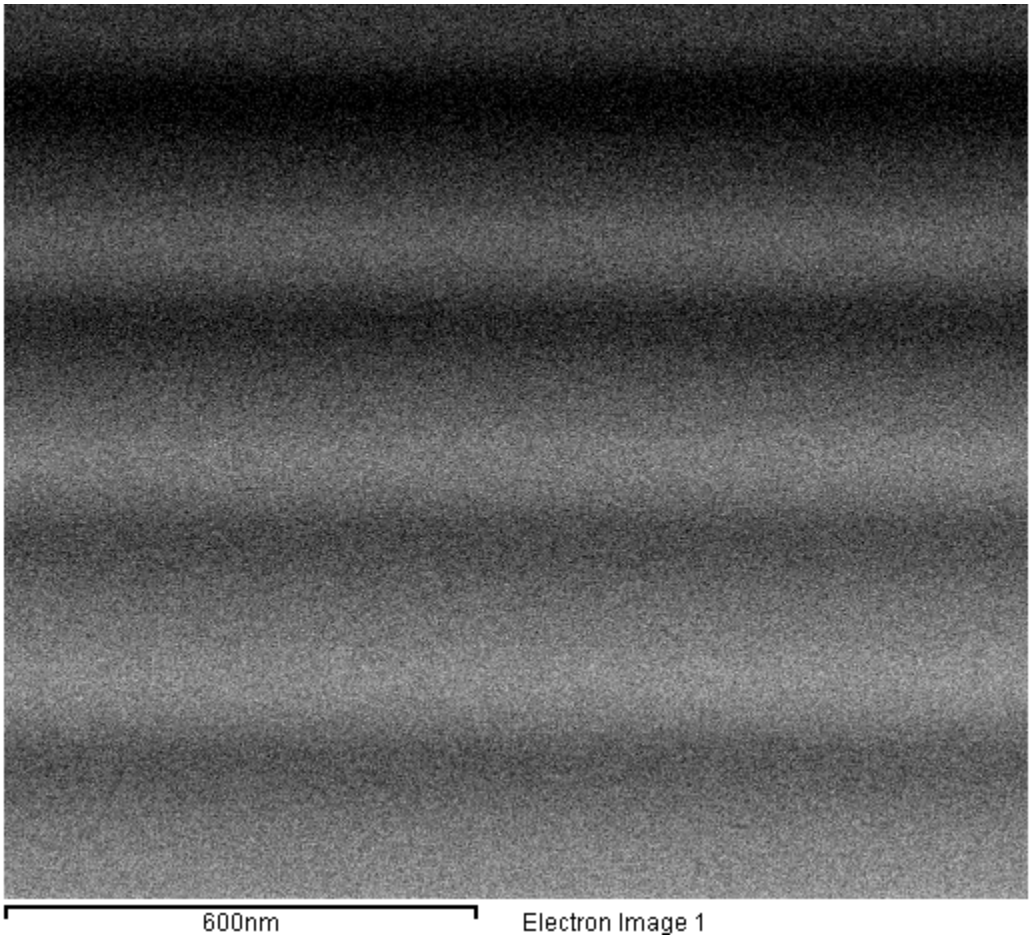


Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

Sr SrF2 1-Jun-1999 12:00 AM

Comment:

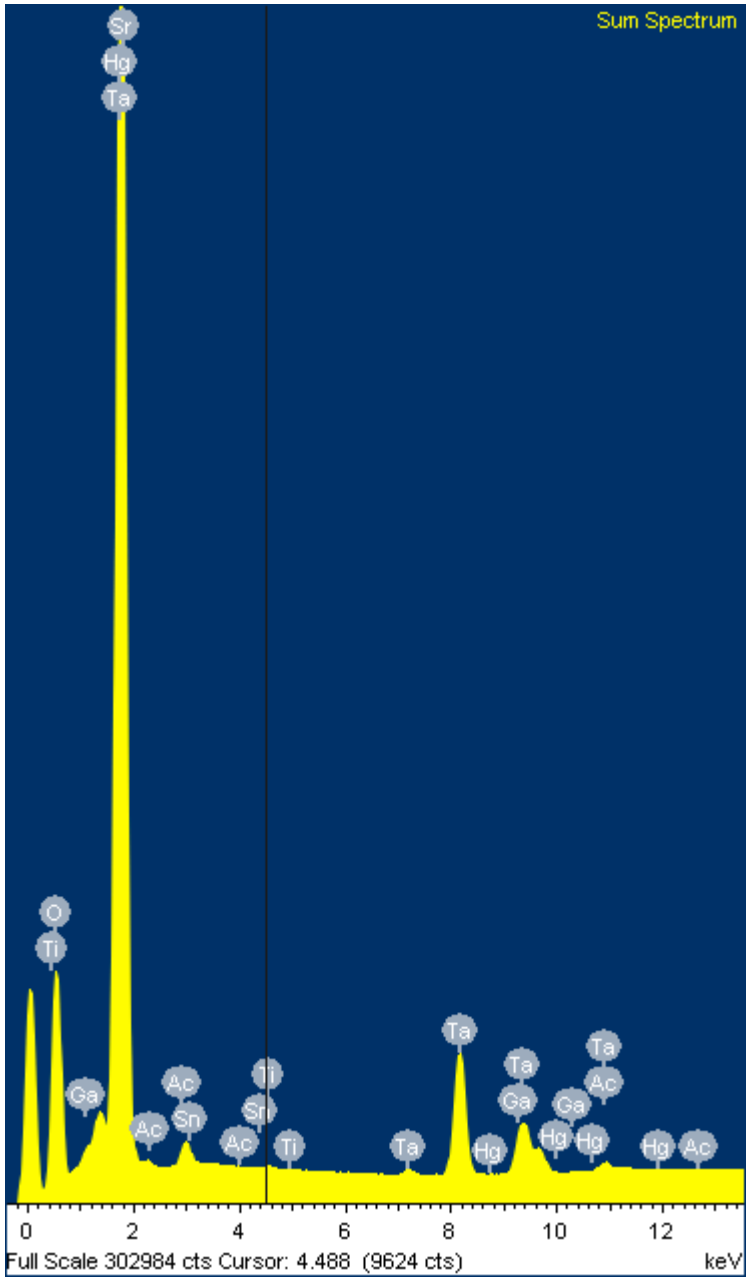
Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

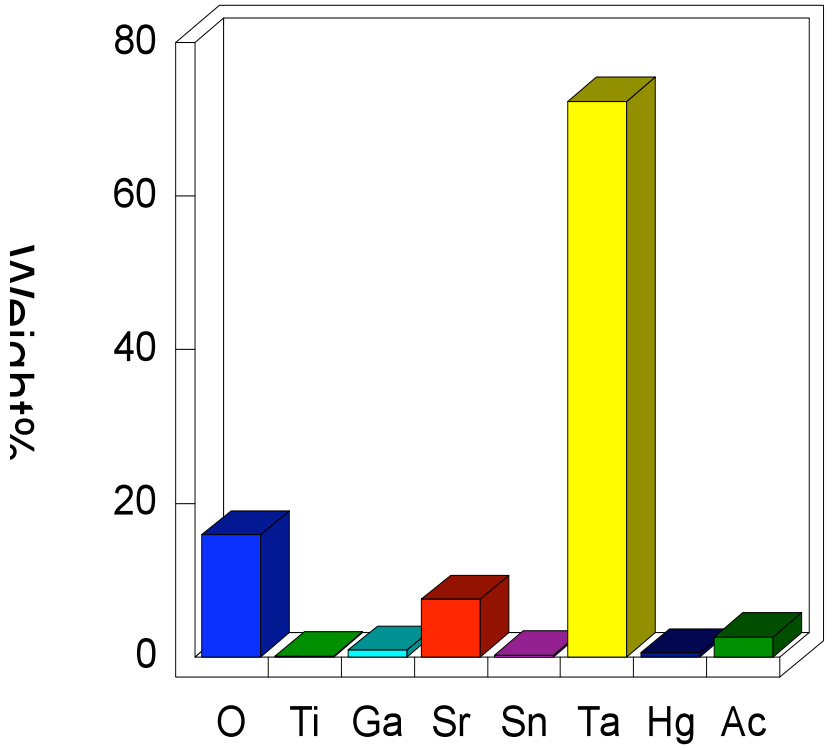
Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM

Element	Weight%	Atomic%
O K	15.90	65.81
Ti K	0.13	0.17
Ga K	0.88	0.84
Sr L	7.49	5.66
Sn L	0.22	0.12
Ta M	72.30	26.47
Hg M	0.52	0.17
Ac M	2.57	0.75
Totals	100.00	



Quantitative results



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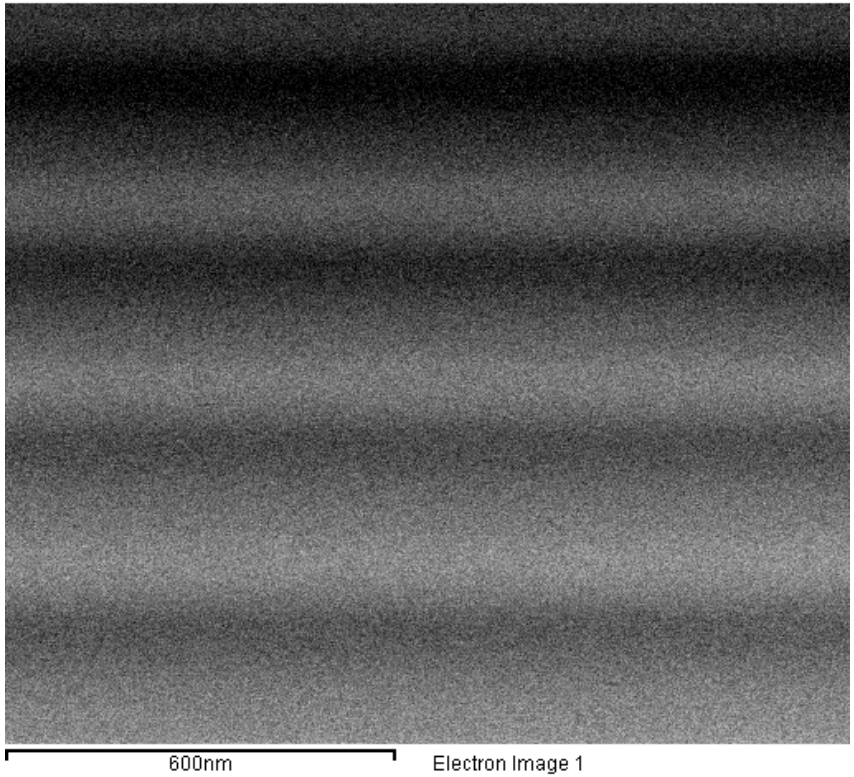
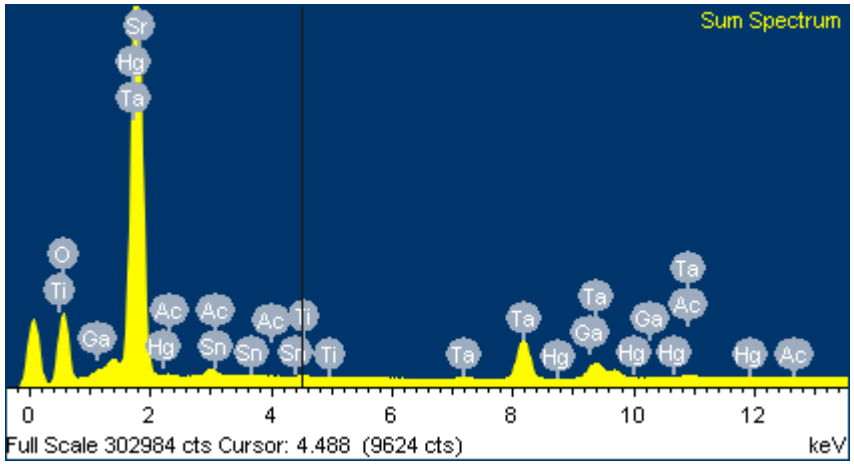
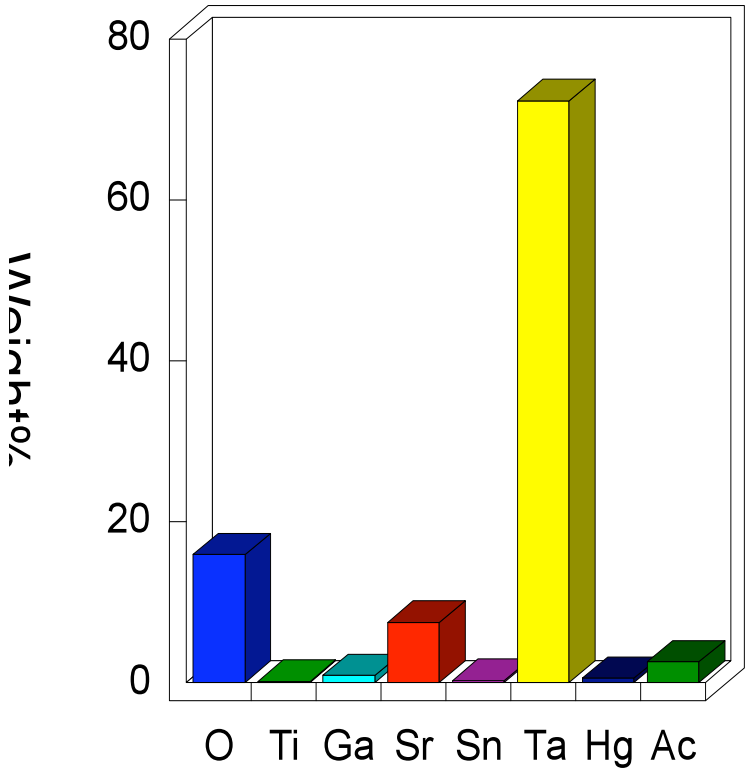




Quantitative results



Comment:

Project 1

20/02/2009 15:31:23

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

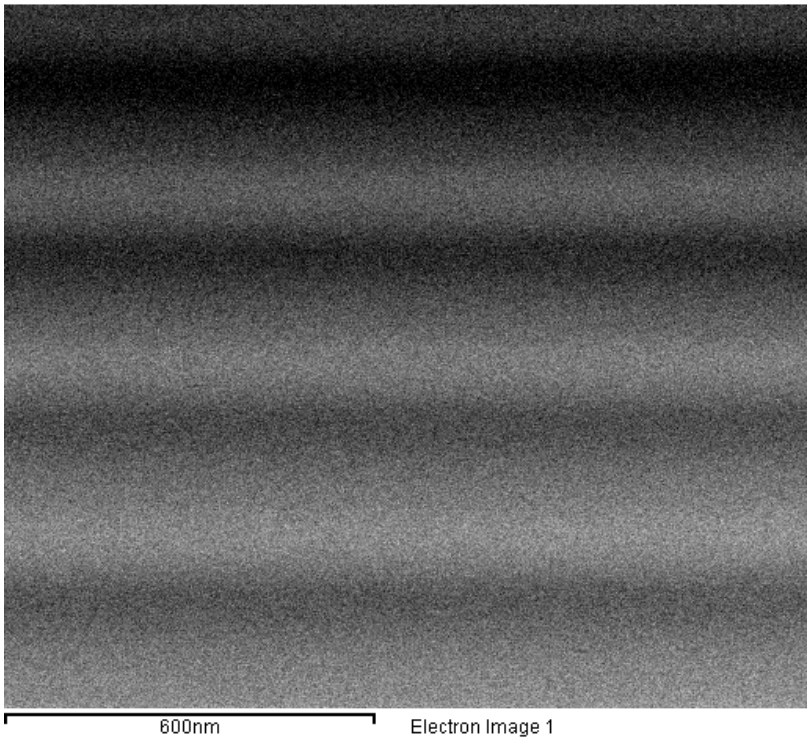
Sr SrF2 1-Jun-1999 12:00 AM

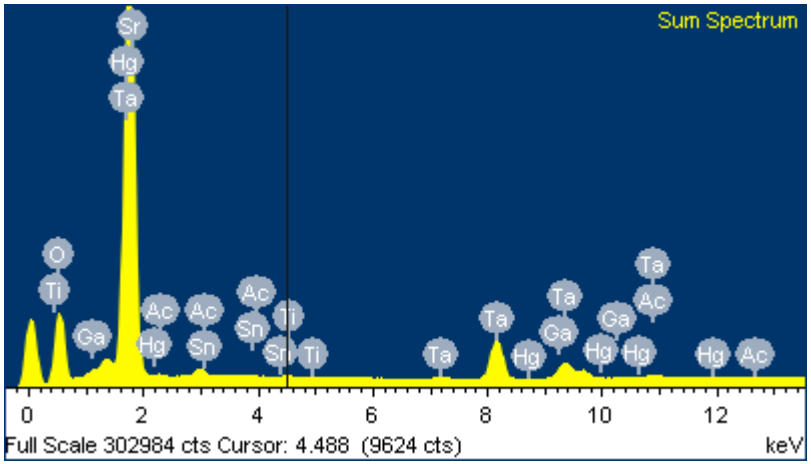
Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM





Element	Weight%	Atomic%
O K	15.90	65.81
Ti K	0.13	0.17

Comment:

Ga K	0.88	0.84
Sr L	7.49	5.66
Sn L	0.22	0.12
Ta M	72.30	26.47
Hg M	0.52	0.17
Ac M	2.57	0.75
Totals	100.00	

Project 1

20/02/2009 15:31:31

Project: Project 1

Owner: customerservice

Sample: Sample 1

Type: Default

Label : Sum Spectrum

Collected : 20-Feb-2009 03:23 PM

Livetime (s) : 521.83

Real time (s) : 0.00

Detector : Silicon

Window : SATW

Tilt (deg) : 55.0

Elevation (deg) : 35.0

Sample is unpolished X-ray corrections may be approximate.

Sample is uncoated

There is a mismatch between at least one of the angles

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

Sr SrF2 1-Jun-1999 12:00 AM

Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	263.73	1.2194	15.90	0.06	65.81
Ti K	1.57	0.9184	0.13	0.02	0.17
Ga K	12.62	1.0545	0.88	0.09	0.84
Sr L	66.86	0.6559	7.49	0.07	5.66
Sn L	2.45	0.8286	0.22	0.05	0.12
Ta M	927.05	0.9424	72.30	0.12	26.47
Hg M	5.39	0.7620	0.52	0.04	0.17
Ac M	28.73	0.8231	2.57	0.05	0.75
Totals			100.00		

Project 1

20/02/2009 15:31:41

Project: Project 1

Owner: customerservice

Sample: Sample 1

Type: Default

Label : Sum Spectrum

Collected : 20-Feb-2009 03:23 PM

Livetime (s) : 521.83

Real time (s) : 0.00

Detector : Silicon

Window : SATW

Tilt (deg) : 55.0

Elevation (deg) : 35.0

Azimuth (deg) : 0.0

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Sample is unpolished X-ray corrections may be approximate.

Sample is uncoated

There is a mismatch between at least one of the angles

(azimuth, tilt, elevation) used in the optimization

and those of the current spectrumThe element used for optimization was Copper

Detector efficiency : Calculation

INCA

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

Sr SrF2 1-Jun-1999 12:00 AM

Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	263.73	1.2194	15.90	0.06	65.81
Ti K	1.57	0.9184	0.13	0.02	0.17
Ga K	12.62	1.0545	0.88	0.09	0.84
Sr L	66.86	0.6559	7.49	0.07	5.66
Sn L	2.45	0.8286	0.22	0.05	0.12
Ta M	927.05	0.9424	72.30	0.12	26.47
Hg M	5.39	0.7620	0.52	0.04	0.17
Ac M	28.73	0.8231	2.57	0.05	0.75
Totals			100.00		

Project 1

20/02/2009 15:32:02

Project: Project 1

Owner: customerservice

Sample: Sample 1

Type: Default

Spectrum Label: Sum Spectrum

Livetime 521.8 s

Acquisition geometry (degrees):

Tilt = 55.0

Azimuth = 0.0

Elevation = 35.0

Sample is unpolished X-ray corrections may be approximate.

Sample is uncoated

There is a mismatch between at least one of the angles

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

O SiO2 1-Jun-1999 12:00 AM

Ti Ti 1-Jun-1999 12:00 AM

Ga GaP 1-Jun-1999 12:00 AM

Sr SrF2 1-Jun-1999 12:00 AM

Sn Sn 1-Jun-1999 12:00 AM

Ta Ta 1-Jun-1999 12:00 AM

Hg HgTe 1-Jun-1999 12:00 AM

Ac Not defined 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
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Ti K	1.57	0.9184	0.13	0.02	0.17
Ga K	12.62	1.0545	0.88	0.09	0.84
Sr L	66.86	0.6559	7.49	0.07	5.66
Sn L	2.45	0.8286	0.22	0.05	0.12
Ta M	927.05	0.9424	72.30	0.12	26.47
Hg M	5.39	0.7620	0.52	0.04	0.17
Ac M	28.73	0.8231	2.57	0.05	0.75
Totals			100.00		