

INCA GSR Package Specification

1. Dedicated Software for GSR

- Complies to ASTM standard E1588, with report of full quantitative analysis

GSR Classification Scheme

- Includes classes for the main unique and indicative GSR types for Pb and Pb free ammunitions
- Class scheme may be used as supplied or modified
- Match index option to ensure single classification of particles

Dedicated software for re-acquiring data from any selected particle

- Automatic relocation of particle
- User selectable acquisition conditions
- Option to collect SE and/or BSE image
- Reacquire spectrum and reclassify particle
- Saved data is included in data tables and statistical analysis
- Original data is deleted or rejected to prevent double counting
- Saved particles are marked for particle confirmation

Area Filters

- Select individual samples or groups of samples from a batch run for data review and processing

User Definable Rank scheme

- Ranking of classes or groups of classes
- Ranks can be given either a number or a name

Data review options

- Particle classification summary
- Marked particle list
- System stability data
- Scatter plot – including class map
- Stage mimic
- Ternary plot with option of up to 4 elements or oxides at each corner

GSR Report Templates

- Confirmed particle
- Multiple particle report – spectrum and image
- Class distribution plot
- System stability report
- Marked particle list

Compliant with **INCA**Energy system driven by mics/x-stream hardware. Requires MPO communication to microscope column and motorized sample stage

2. Calibration and Verification Standards

- Detection threshold set-up standard (C, Co, Rh, Au)
- Particle detection verification sample

Oxford Instruments Analytical

UK

Halifax Road, High Wycombe
Bucks, HP12 3SE England
Tel: +44 (0) 1494 442255
Fax: +44 (0) 1494 461033
Email: analytical@oxinst.co.uk

Australia

Sydney, N.S.W. 1715
Tel: +61 2 9484 6108
Fax: +61 2 9484 1667
Email: sales@oxinst.com.au

China

Beijing
Tel: +86 (10) 6518 8160/1/2
Fax: +86 (10) 6518 8155
Email: info@oxford-instruments.com.cn

France

Saclay, Cedex
Tel: +33 (0) 1 69 85 25 24
Fax: +33 (0) 1 69 41 86 80
Email: analytical-info@oxford-instruments.fr

Germany

Wiesbaden
Tel: +49 (0) 6122 937 176
Fax: +49 (0) 6122 937 178
Email: analytical@oxford.de

Japan

Tokyo
Tel: +81 (0) 3 5245 3591
Fax: +81 (0) 3 5245 4466/4477
Email: oikkma@oxinst.co.jp

Latin America

Clearwater FL
Tel: +1 727 538 7702
Fax +1 727 538 4205
Email: oxford@gate.net

Scandinavia

Link Nordiska AB
Lidingö, Sweden
Tel: +46 8 590 725 50
Fax: +46 8 590 725 58
Email: info@linknord.se
Web: www.linknord.se

Singapore

Tel: +65 6337 6848
Fax: +65 6337 6286
Email: analytical.sales@oxford-instruments.com.sg

USA

Concord MA
Tel: +1 978 369 9933
Toll Free: +1 800 447 4717
Fax: +1 978 369 8287
Email: info@ma.oxinst.com

www.oxford-instruments.com

PATENTS
EP 0325383
EP 0302716
US 4931650
GB 2192091
US 5170229
US 5357110
JP 2557692
JP 2581597
EU 0568351



CERTIFICATE NUMBER FM29142

Oxford Instruments, at High Wycombe, UK, operates Quality Management Systems approved to the requirements of BS EN ISO 9001. This publication is the copyright of Oxford Instruments Analytical Limited and provides outline information only which (unless agreed by the company in writing) may not be used, applied or reproduced for any purpose or form part of any order or contract or be regarded as a representation relating to the products or services concerned. Oxford Instruments' policy is one of continued improvement. The company reserves the right to alter without notice the specification, design or conditions of supply of any product or service.

© Oxford Instruments Analytical Limited, 2003. All rights reserved. Printed in England.
part number: OIA/O87/A/0703

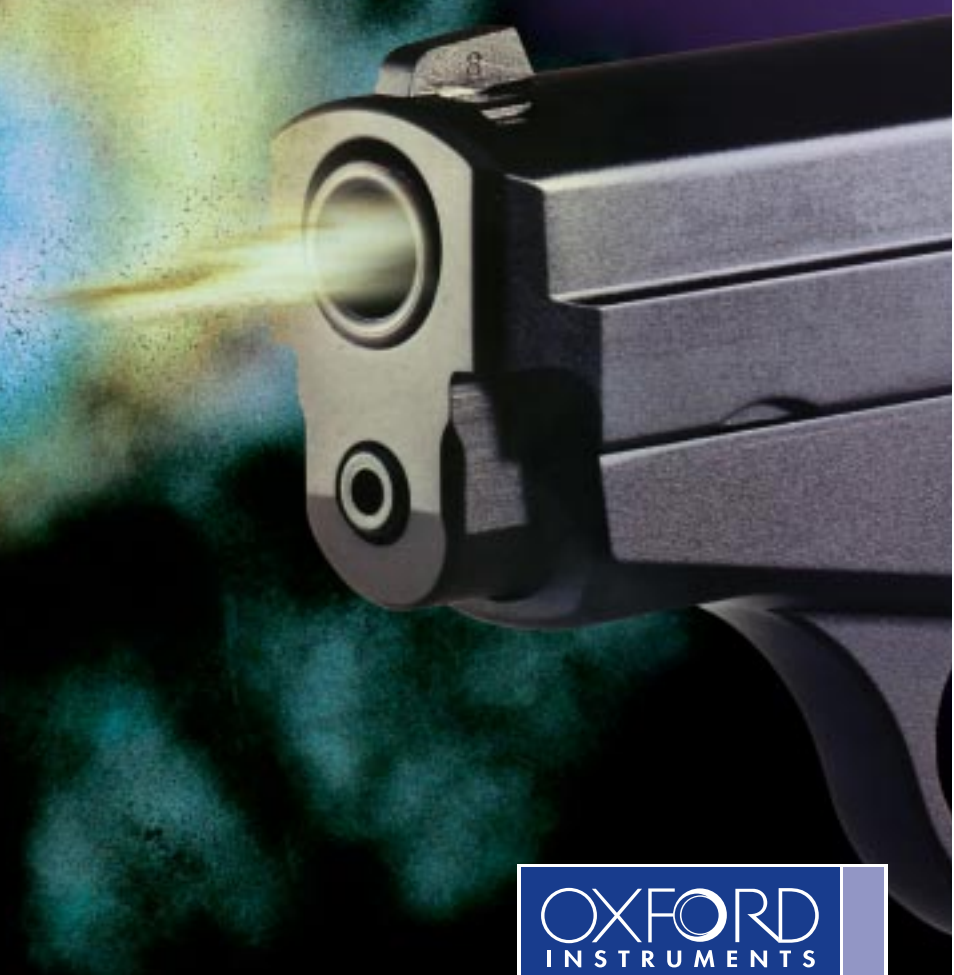
OXFORD
INSTRUMENTS

INCA

GSR

INCA GSR

Gun Shot Residue

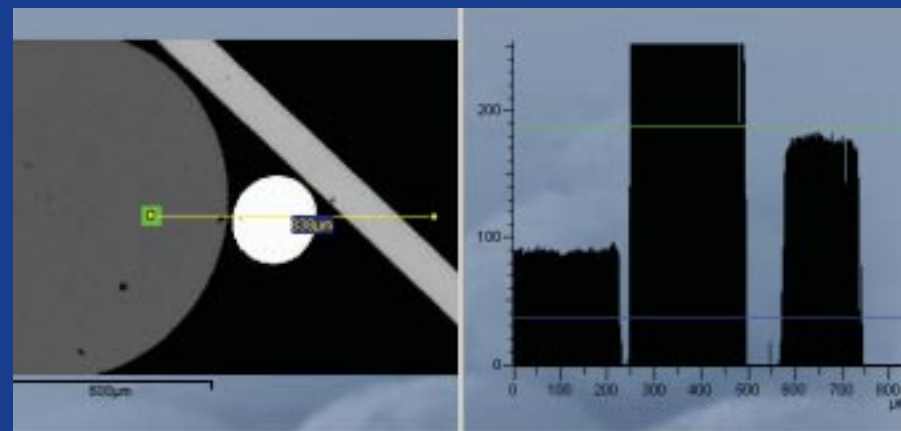
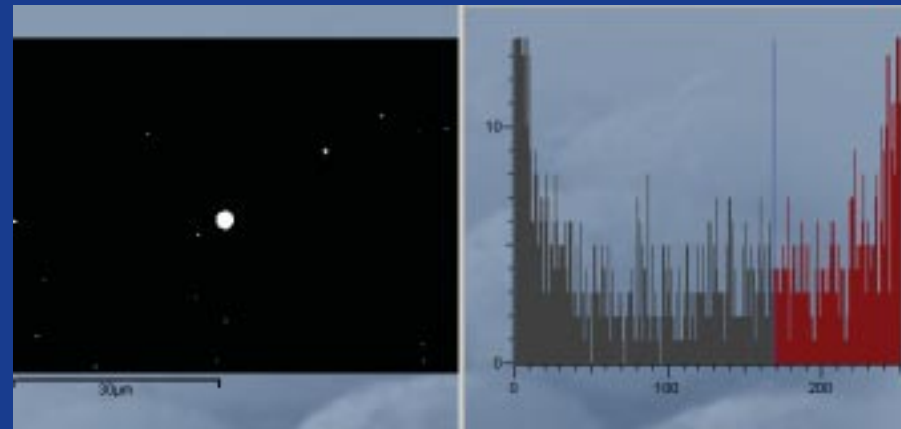


OXFORD
INSTRUMENTS

INCA GSR

Introduction INCA GSR is a dedicated solution for automated detection and analysis of Gun Shot Residue using the scanning electron microscope. This product has been designed in conjunction with leading forensic scientists to meet the requirements of GSR particle detection and characterization.

The software is based around the unique INCA Energy platform and the new INCA Feature particle analysis system. INCA GSR now offers all the important answers for accurate, fast and reliable analysis.



Logical Analysis Set-Up

INCA GSR creates an analysis recipe through a series of logical steps using the INCA GSR Navigator. The recipe is stored for quick set-up of routine analysis, saving time and ensuring consistency.

- Detection criteria, threshold levels, analysis parameters and termination conditions are all stored in the recipe
- Sample areas are defined with the aid of a stage mimic. The positions are stored and recalled for future use.

Reliable GSR Particle Detection

The particle detection algorithm designed for INCA GSR combines speed and accuracy. So all your particles will be correctly detected in the minimum possible time for maximum productivity

- A four component imaging standard consisting of C, Co, Rh and Au is included with the system. Using this standard the backscatter detector is accurately configured to detect all types of ammunition.

Accurate GSR Quantification & Classification

With INCA GSR there is no need to make any assumption about the elements present in your sample. The high stability of the EDS hardware used means that all peaks are correctly identified automatically using the INCA AutoID algorithm. Therefore you can be sure accurate results are achieved for every particle. Using accurate quantification you can achieve accurate classification.

INCA GSR is supplied with a tailored GSR classification scheme which can be used as supplied or modified as required, giving you a flexible and accessible tool.

- Reprocessing and reclassification of collected data is quick and easy with no need to reanalyze the sample.

GSR Particle Review for Correct Particle Confirmation

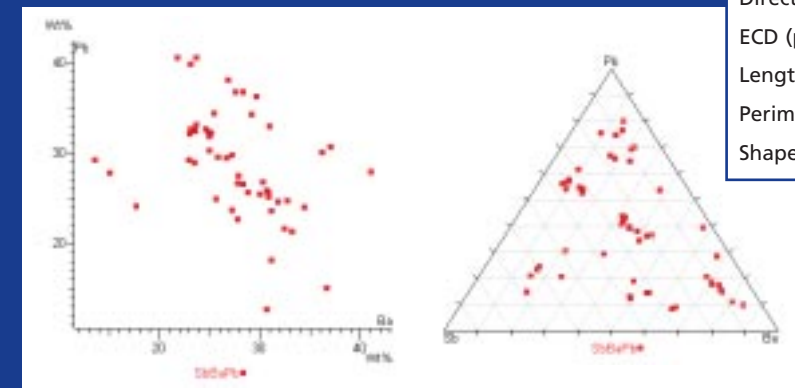
At the press of a button, particles of interest are automatically relocated under the microscope beam. A dedicated reacquire step is used to confirm the nature of the particle ensuring correct identification of unique particles.

- Data reacquired for manual confirmation is saved in the database and included in the statistical analysis.

Comprehensive Data Analysis

The tools available for data analysis provide a fast overview of any data set, giving you confidence in the validity of your analysis.

- Data can be plotted on the basis of an individual class or groups of classes.
- The graphs and tables in INCA GSR are easily exported in standard formats.

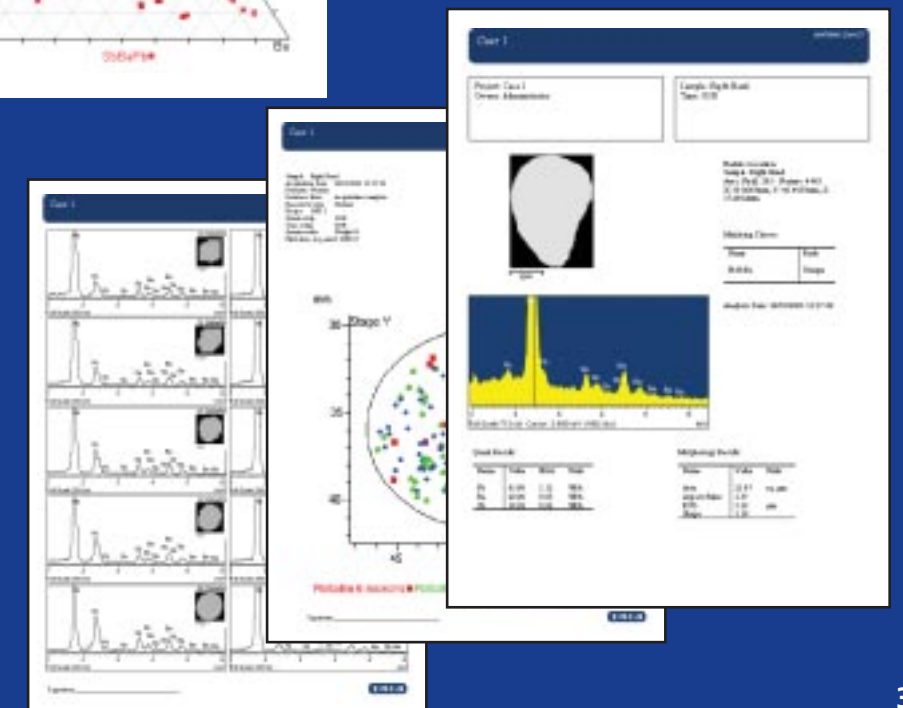
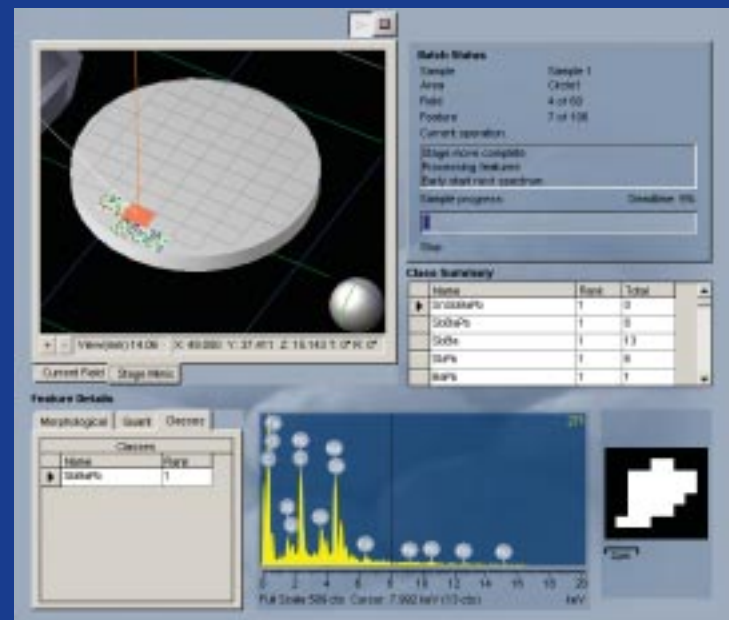
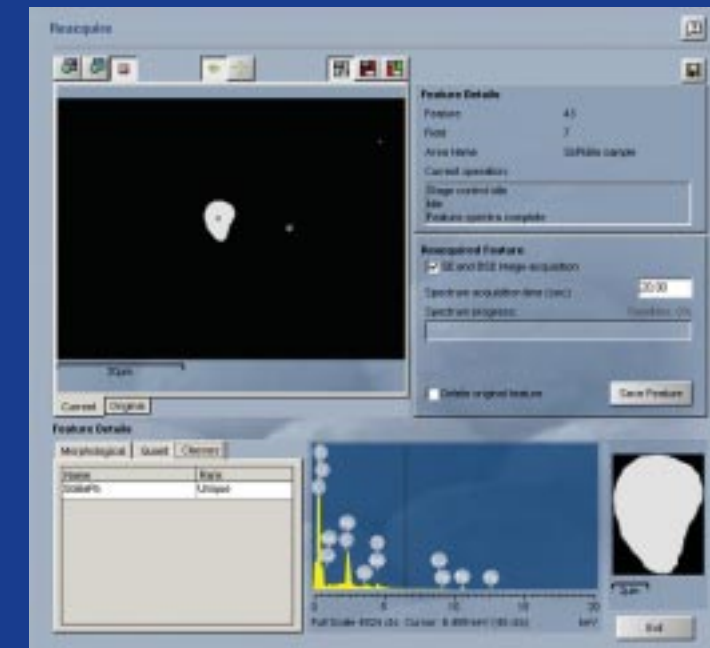


Measure	Count	Min	Max	Mean	St Dev
Sb (Wt%)	43	10.53	33.94	24.14	5.7
Pb (Wt%)	43	21.79	54.64	39.42	8.7
O (Wt%)	43	14.11	61.93	35.44	12.74
Area (sq.µm)	43	0.39	42.56	7.56	9.32
Aspect Ratio	43	1.07	2.95	1.48	0.34
Breadth (µm)	43	0.44	6.82	2.49	1.47
Direction (deg)	43	14.11	170.69	42.78	34.81
ECD (µm)	43	0.7	7.36	2.7	1.54
Length (µm)	43	0.98	8.5	3.43	1.67
Perimeter	43	2.26	23.84	8.94	4.89
Shape	43	0.98	2.05	1.15	0.19

GSR Reporting

Specially designed report templates are provided for reporting GSR data. In addition the report template editor allows you to easily create tailored reports.

- Reporting the data you need in the format you want is easy.
- All reports can be exported to Microsoft® Word at the press of a button.



Application information

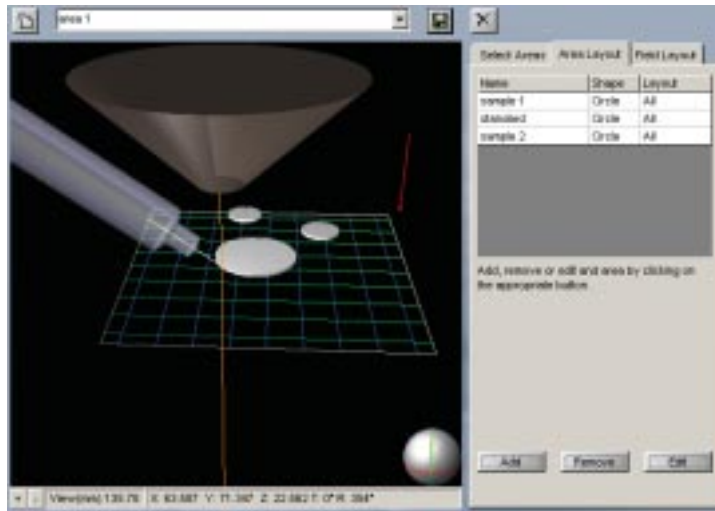


Figure 1 Stage mimic, with three areas defined for analysis



Figure 2 Selection of particle detection criteria

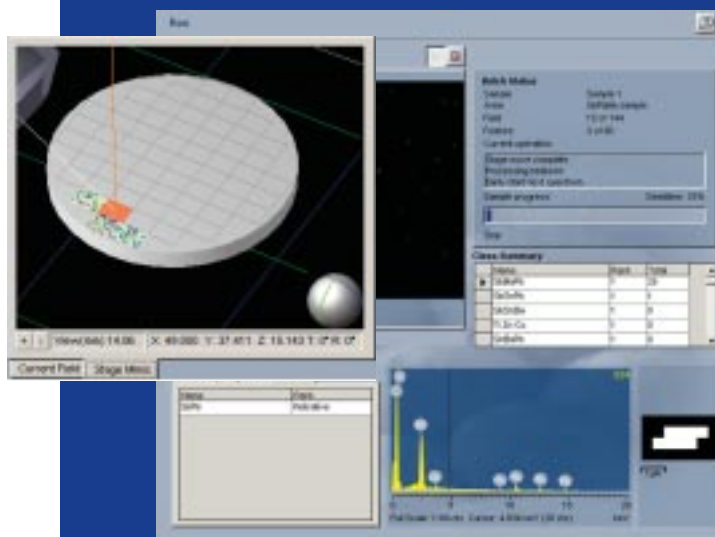


Figure 3 Data displayed as analysis progresses

The powerful tools available in the **INCA GSR** package are described in the following section: A real GSR sample* prepared in a clean environment is used to illustrate these features.

INCA GSR performs an automated search, detects particles of interest and measures the morphology and chemistry of these particles. Particle detection relies on the backscatter contrast between the sampling substrate and the GSR particles, which typically have a higher mean atomic number.

GSR Analysis

INCA GSR offers straightforward set up and high flexibility for analysis. The set-up involves:

- Defining areas for analysis.
- Defining detection criteria.

Area Layout

Defining and relocating sample areas is easy using the stage mimic, Figure 1. Once a layout is defined it can be saved for future use. By defining the position of imaging and beam current compensation standards, the system can monitor microscope/system stability throughout the analysis run.

Detection Criteria

- Analysis is achieved by dividing the sample into rectangular fields of equal area, which are analyzed in turn. Field size is calculated automatically by selecting either the magnification or the minimum particle size required, Figure 2. At any magnification the minimum detectable particle size can be decreased by increasing the resolution of the image.
- The grey level scale of the electron image is set-up using the sample or an imaging standard with a suitable grey level range (e.g. Mn-Rh). A threshold window is used to determine the acceptance criteria for particle detection.

The algorithm used to identify and measure the particles uses a two pass imaging technique. This combines accurate particle detection with a fast recognition of blank fields. The first image pass scans the entire field at a user defined dwell time, usually fast. The image is thresholded and if no particles are detected the second pass is skipped. If particles are detected then a second scan pass is made but only the detected particles are scanned. This second pass is usually made at a longer dwell time to accurately identify the position and morphology of each particle.

Automated Analysis

Morphological and chemical data is collected from the detected particles. During the analysis an image and spectrum is displayed for each particle, Figure 3. This data is automatically saved as the run progresses. During the run detected particles are plotted on the stage mimic, which can be viewed at any time.

Quantification and Classification

INCA GSR uses AutoID to identify the elements present in each spectrum. This ensures that all the elements present in a particle are identified and quantified. It is possible to select deconvolution elements to correct for matrix and coating elements.

The system uses a supplied GSR classification scheme, Figure 4, or a scheme created by the user. The default scheme may be used as supplied or modified by the user. Alternatively the user can create their own class schemes. Classification of the particles is done automatically during the analysis, and all data can be re-classified at any stage after the run to account for any changes in the classification scheme.

Reacquiring Data and Particle Confirmation

On completion of the run all the data for each particle can be instantly reviewed, Figure 5. The data can be reviewed by class or selection of classes. Although several sample areas may have been analyzed, individual or groups of areas can be selected for data review. Particles may be deleted or rejected and particles of interest may be marked.

Any selected particle can be relocated under the microscope beam automatically. The reacquire data option is then used to collect more detailed data for manual particle confirmation, Figure 6.

The user can select optimum microscope conditions and spectrum live time for analysis. A secondary electron image can be collected in addition to the backscattered image. Reacquired data is saved and the particle placed in the marked class, and the original data placed in the rejected class. This ensures that all the data for a particle is available but that the particle is only included once in the analysis.

Class	Rank	Features	% total features	Feature area (sq.µm)	% total area
SnSbBaPb	Unique	0	0	0.00E+00	0
SbBaPb	Unique	82	1.8	1.81E+03	0.001
SbSnPb	Unique	0	0	0.00E+00	0
SbSnBa	Unique	0	0	0.00E+00	0
TiZnCu	Unique	89	2	1.98E+03	0.0011
SnBaPb	Unique	0	0	0.00E+00	0
TiZnSn	Unique	0	0	0.00E+00	0
SbBa	Indicative	64	1.4	7.46E+02	0.0004
SbPb	Indicative	77	1.7	6.97E+02	0.0004
BaPb	Indicative	41	0.9	9.63E+01	0.0001
SbSn	Indicative	3	0.1	2.16E+00	0
Sr	Indicative	1	0	2.75E+01	0
TiZn	Indicative	993	22.3	7.31E+04	0.0416
Sb	Environmental	57	1.3	2.52E+02	0.0001
CuZn	Environmental	147	3.3	3.44E+03	0.002
Ni	Environmental	27	0.6	1.76E+02	0.0001
Pb	Environmental	473	10.6	1.76E+03	0.001
Sn	Environmental	1	0	5.89E+01	0
Au	Environmental	0	0	0.00E+00	0
Lighter flint	Environmental	3	0.1	3.93E+01	0
Fe	Environmental	204	4.6	2.01E+04	0.0115
Cu	Environmental	102	2.3	1.01E+04	0.0057

Figure 4 GSR Class Scheme

Figure 5 Review data showing field of view, spectrum, chemical and morphological analysis

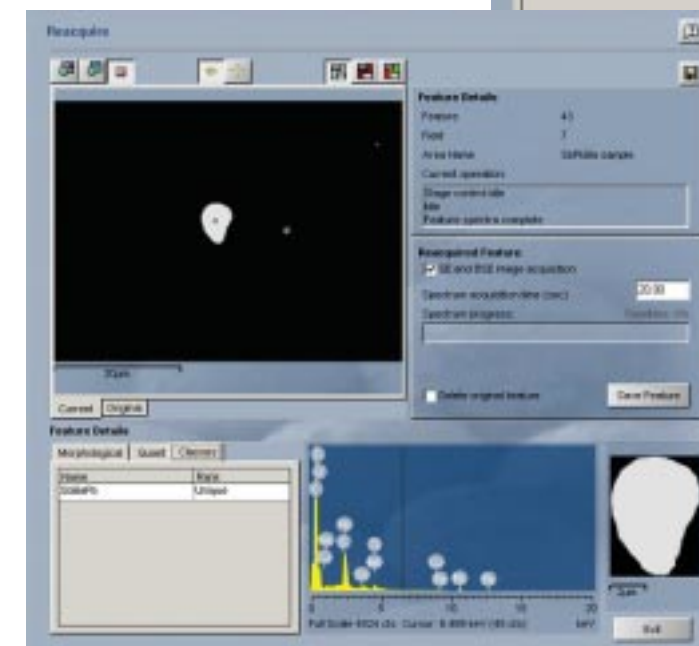
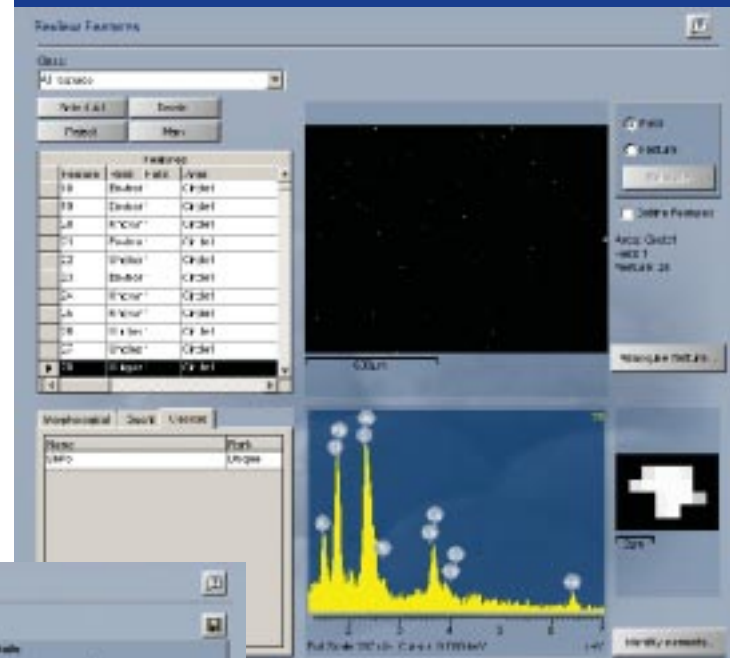


Figure 6 Re-acquire data step

INCA GSR

Detailed Data Analysis

The tools available in **INCA**GSR are designed for detailed data analysis and for checking the validity of classification schemes.

Examples include ternary diagrams and histograms. In Figure 7 a ternary diagram has been used to study the relationship between chemistry and particle size. In Figure 8 a histogram is used to illustrate the shape of the TiZnCu particles.

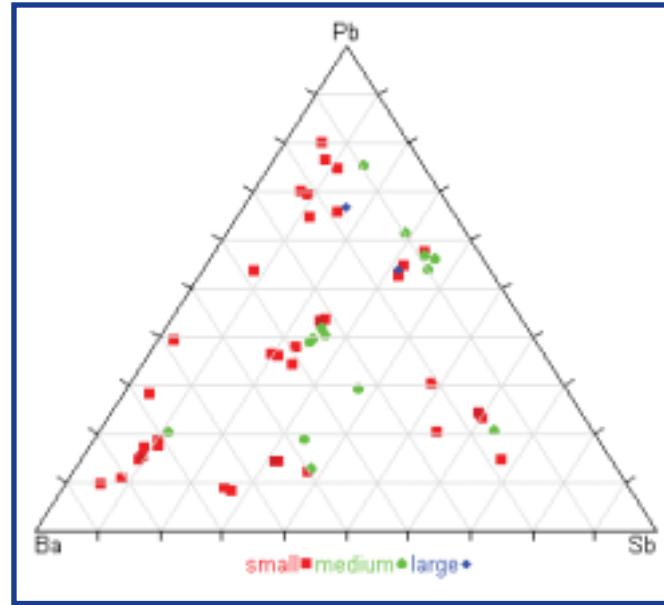
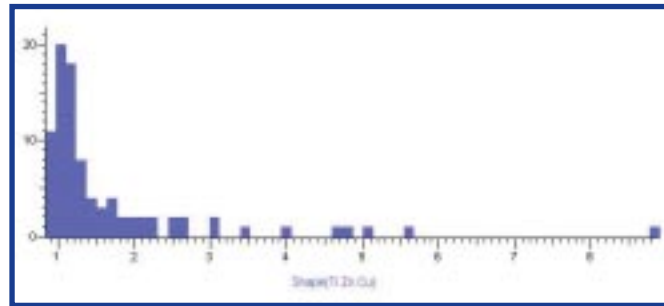


Figure 7
Ternary plot of Ba, Sb and Pb

Figure 8
Histogram showing the shape distribution of unique TiZnCu particles



Exporting and Reporting Data

Specific GSR report templates are included in **INCA**GSR. In addition the Report Template Editor gives flexibility to design or modify report templates as required. The data tables within **INCA**GSR can be exported either to Microsoft® Excel or as a tsv file. This includes the database containing all the data, the class and rank summary data and the tables of statistics.

Further Analysis of GSR particles

Using the integrated tools available within **INCA**Energy a more detailed examination of the particles detected can be made. These tools include SmartMap, for X-ray mapping, phase mapping and spectrum reconstruction. To illustrate compositional variation within the particles a unique GSR particle was relocated and a SmartMap was collected over a selected area of the particle surface, Figure 9. The maps show discrete Pb and Sn rich phases, which appear to be embedded in the particle surface. Cameo+ imaging which gives X-ray energies real visible light colours can be used to map the distribution of phases on rough surfaces. Pb-rich phases on the surface of the GSR particle can be quickly located using this technique (Figure 10).

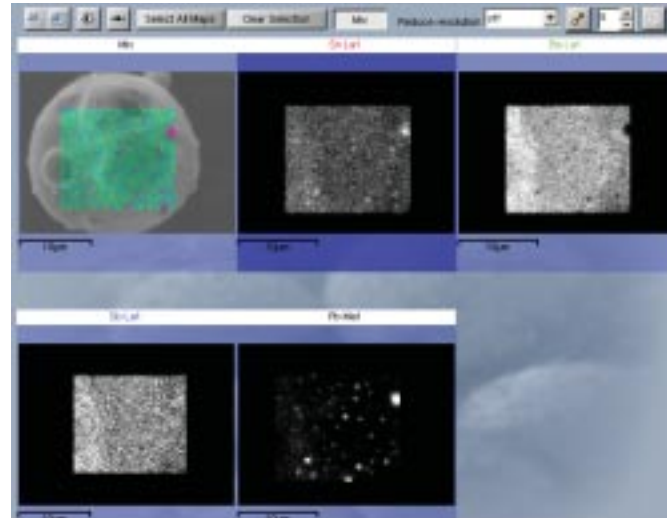


Figure 9 Element mapping of a GSR particle

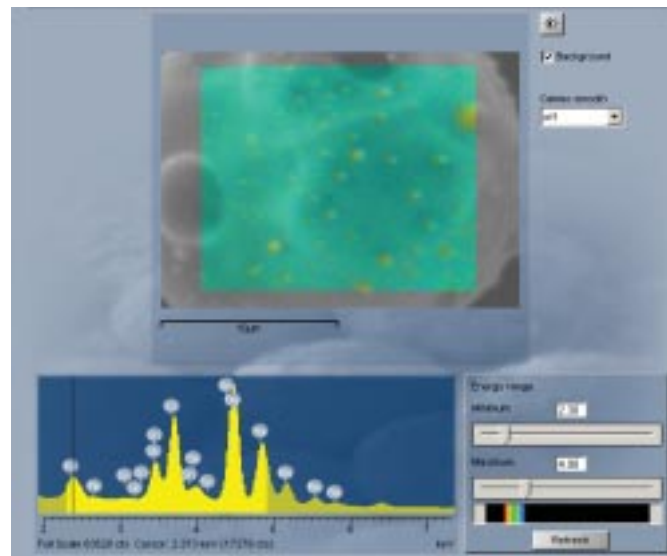


Figure 10 Cameo image of a GSR particle

Speed of INCA GSR

The speed of GSR systems is normally defined using a blank field test. This tests the time required to analyze an area with no particles, using a defined minimum particle size. A typical result for **INCA**GSR is:

Surface Area	100sq mm
Minimum particle size	0.5 (4 pixels)
Magnification	512
No of fields	365
Time (minutes)	45

The time to analyze 1000 particles over a similar area was measured at 95 minutes.

GSR System Validation

The reliability of an automated particle detection system should be checked periodically using a certified standard to show the system is detecting particles reliably. This check ensures that the stage and beam are properly calibrated, so that particles are not lost in gaps between fields or double counted in overlapped fields. It also validates the detection and analysis settings to ensure all particles will be found. Standards designed for the validation of automated particle analysis systems are commercially available. The standard* used here is

specifically designed for validating GSR analysis and contains 43 Pb/Sb particles on a silicon chip. The particles are randomly distributed but are at known locations, given on the sample map. There are three distinct particle sizes approximately 6µm, 2.5µm and 1.2µm in diameter. The standard also contains additional particles of Pb, Cu and Fe. Therefore this standard can be used to check particle detection and morphological measurement accuracy. Using **INCA**GSR all 43 PbSb particles were accurately detected and measured. Figure 11 shows a plot of particle location from the software that corresponds exactly to the true location of the particles.

Summary

INCAGSR offers a fast and powerful solution for all GSR analysis. The system is easy to set-up, but includes the flexibility to tailor for individual requirements. The use of AutoID gives the added confidence all constituent elements will be detected. Handling large quantities of data the system allows full re-quantification and reclassification without the need to reacquire the data. Tools have been designed for the special needs of GSR users including particle classification, manual particle confirmation, data analysis and reporting.

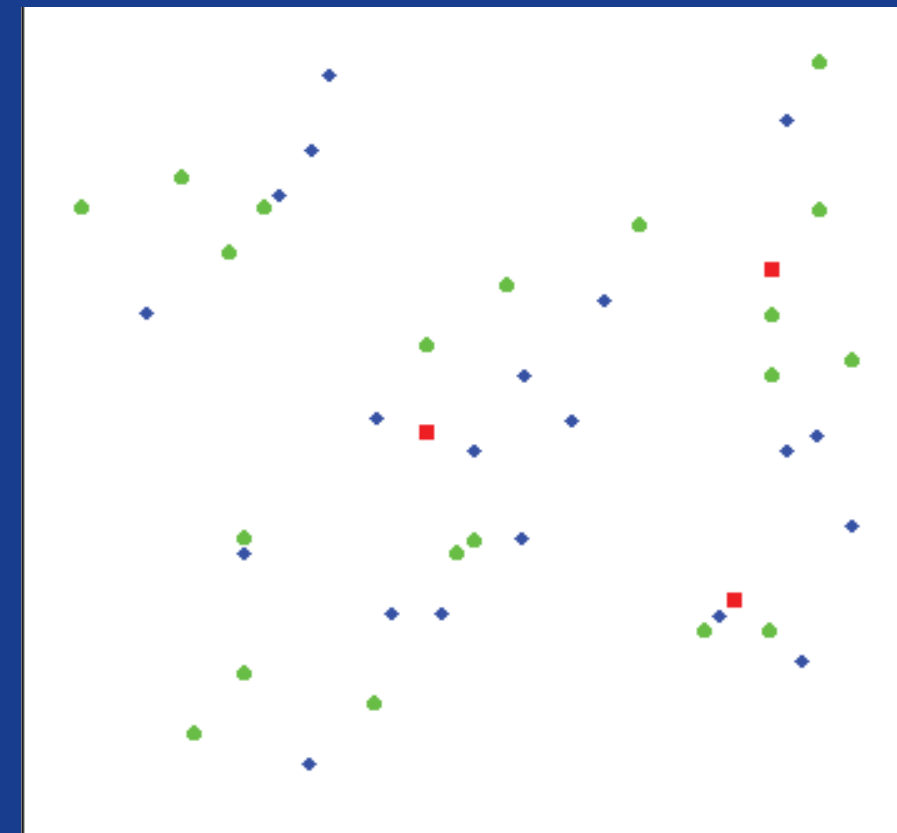


Figure 11
43 PbSb particles
detected by **INCA**GSR

PbSb 6 microns ■
PbSb 2.5 microns ●
PbSb 1.2 microns ◆

*Standard supplied by PLANO W. Plannet GmbH