MAC Standards 2024

Reference Standards For X-ray Microanalysis

January 2024

About Us

Micro-Analysis Consultants Ltd.

Micro-Analysis Consultants Limited "**MAC**" for short was formed in April 1981 by Graham "George" Taylor and two associates, manufacturing reference and calibration standards for electron microscopy users worldwide. With a comprehensive background within Transmission and Scanning Electron Microscopy as well as Microprobe analysis, Graham was able to guide MAC to becoming an established market leader within this field.

Grahams son, Robert "Rob" Taylor, joined the company in 2005 and became Managing Director in 2007 after Graham sadly passed away.

Sharing the same values as his late father, Rob has maintained the high level of standards which have been associated with MAC, as well as maintaining the flexibility to work with clients to ensure that they are able to obtain standards which reflect their requirements.

The production of standards for X-ray Microanalysis is a skilled and time consuming operation and all of our staff take great pride and care during the production process to ensure a quality product.

All the materials used in our standards are only ever sourced from leading manufacturers/suppliers and are fully tested for suitability prior to being offered for selection. Our range of materials are embedded into our range of mounts, polished and Carbon coated *(if required)* in our own modern factory. Each Standard produced has its own unique serial number allocated to it, and comes with a booklet containing a location map of the materials in the mount along with copies of the appropriate certificates of analysis.

We are able to trace all of our standards back over the last 40+ years to the first one produced by us and still provide customers with copies of certificates and layout plans. Some of the Standards we produced back in 1981 are still regularly returned for refurbishment.

In September of 1997 we gained accreditation to ISO 9001 which has been successfully maintained every renewal. Our ISO 9001 is registered with UKAS (certificate number 8960) and monitored annually by National Quality Assurance Ltd. (NQA) to ensure compliance.

With a dedicated team, our attention to detail and great customer service, we have gained a reputation for unsurpassed technical and quality excellence. Whilst we have an uncompromising approach to quality, we also appreciate the importance of realistic delivery times and economical prices.

We have access to over 1,000 different materials which include Rare Earths, Synthetic Compounds, Pure Materials, Natural Minerals and Certified Steels/Alloys. In instances where a required material is not listed, every endeavour will be made to try and source it.

Universal Elements Reference Standards

Universal Elements Standards

Our range of Universal Elements Reference Standards have been thoughtfully designed and manufactured to incorporate an extensive selection of elements from across the periodic table.

With input from leading manufacturers, respected professionals, analysts and Electron Microscopy users worldwide, these standards provide you with a comprehensive catalogue of reference materials.

The Universal Standards are manufactured in either a 25mm or 32mm diameter brass mount depending on your requirements.

Our standards are used worldwide by:

- OEM Engineers in the setup and servicing of equipment
- Testing Laboratories
- Research & Development Laboratories
- Universities, Colleges and Schools
- Geological Societies
- Police Forensic Science Departments
- Government Agencies

Supplied in a specially designed storage/transportation case that contains:

- The standard—protected by an additional specially designed case
- A full electronic booklet on a USB, containing:
  - The standard plan/layout
  - Certificates of analysis or conformance for each material
  - Details on storage and care of your standards
  - Certificate of final inspection & recommended re-polishing date
- A replaceable silica gel capsule for protection whilst in transit
- A credit card sized quick reference guide

A copy of the electronic booklet is also accessible from our cloud storage.

Universal 55 Reference Standard

55 material samples, covering 56 elements from the periodic table.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

This Standard Contains Moisture/Air Sensitive Materials.

Available to Order As:

***UNI55-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***UNI55-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Universal 45 Reference Standard

45 material samples, covering 51 elements from the periodic table.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

Available to Order As:

***UNI45-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

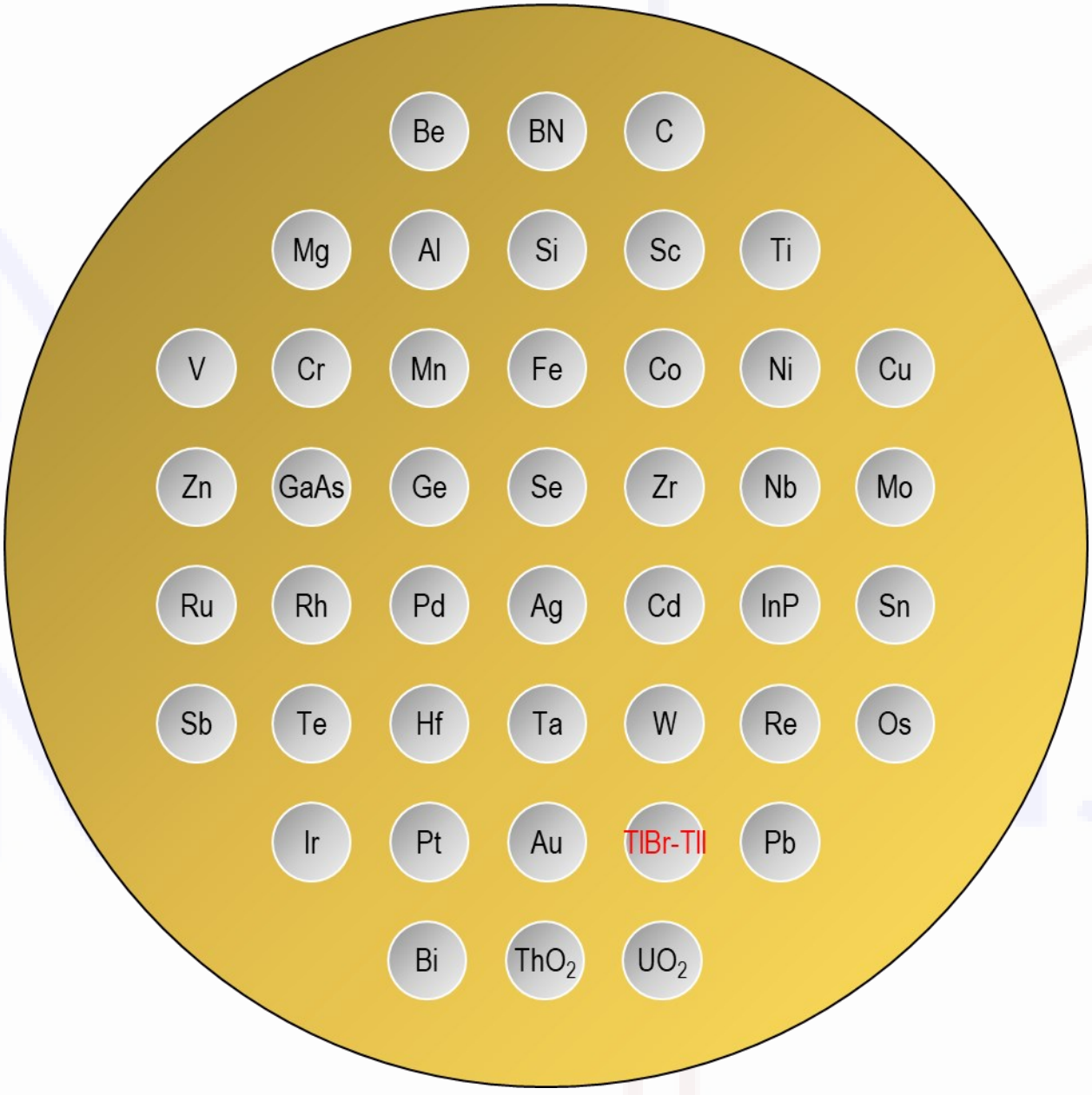
***UNI45-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Universal 44 Metals Reference Standard

44 material samples, covering 50 elements from the periodic table.

Available with optional 150µm Molybdenum Faraday Cup.

This Standard Contains Moisture/Air Sensitive Materials.



Available to Order As:

MET44-32, *32mm Ø x 5mm Brass mount, polished and Carbon coated*

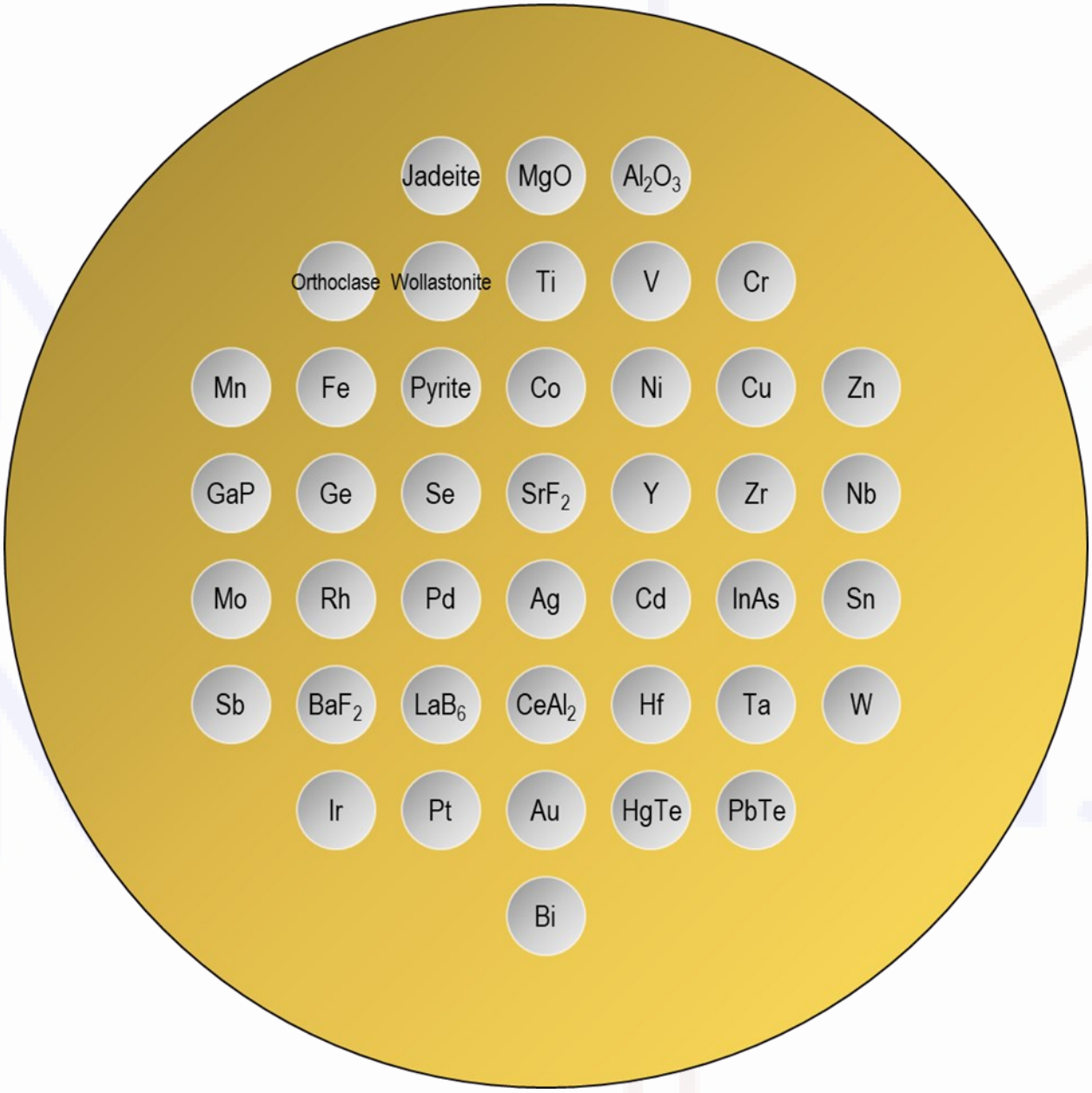
MET44-32FC, *32mm Ø x 5mm Brass mount, polished and Carbon coated. WITH FARADAY CUP*

MET44-25, *25mm Ø x 5mm Brass mount, polished and Carbon coated*

MET44-25FC, *25mm Ø x 5mm Brass mount, polished and Carbon coated. WITH FARADAY CUP*

Universal 42 Reference Standard

42 material samples, covering 48 elements from the periodic table.



Available to Order As:

***UNI42-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***UNI42-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

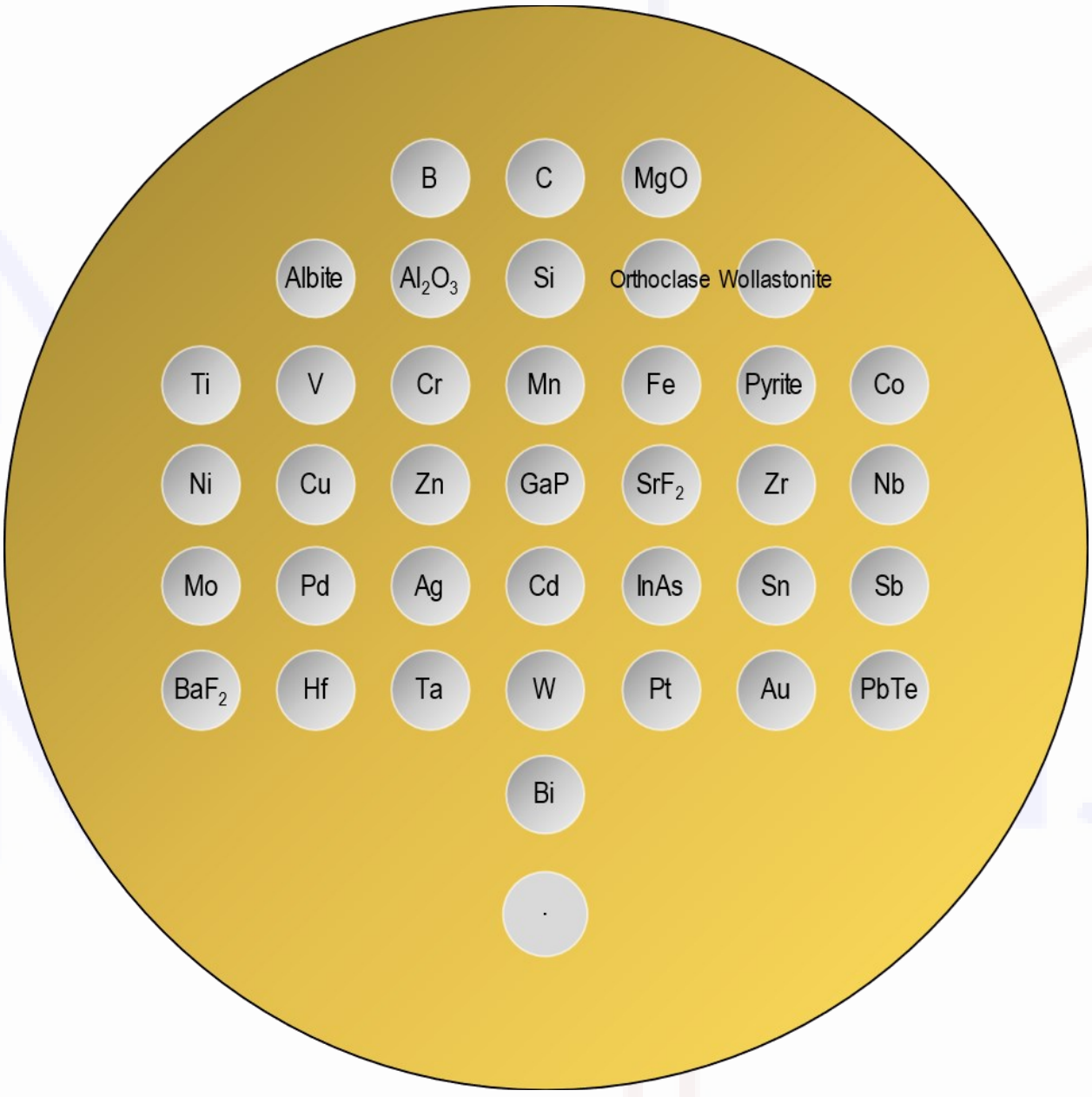
www.micro-analysis.com

Universal 42 Reference Standard—UNI42-##

Universal 37 Reference Standard

37 material samples, covering 42 elements from the periodic table.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.



Available to Order As:

***UNI37-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

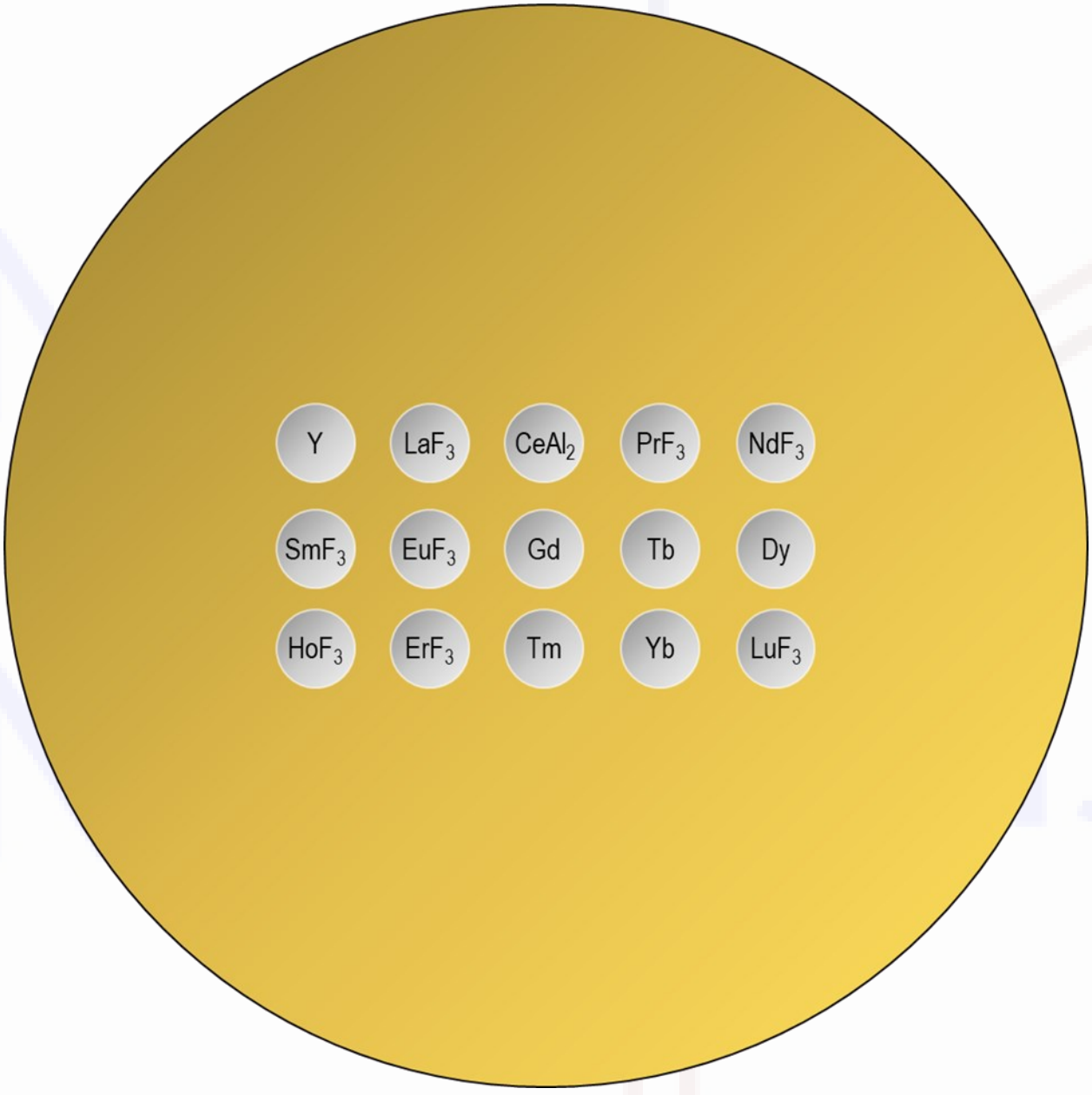
***UNI37-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Rare Earth Elements (REE) Reference Standard

15 material samples, covering 17 elements from the periodic table.

(15 REE's including Y and La plus F and Al).

Available with optional 150µm Molybdenum Faraday Cup.



Available to Order As:

***REE15-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***REE15-32FC**, 32mm Ø x 5mm Brass mount, polished and Carbon coated. WITH FARADAY CUP*

***REE15-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

***REE15-25FC**, 25mm Ø x 5mm Brass mount, polished and Carbon coated. WITH FARADAY CUP*

www.micro-analysis.com

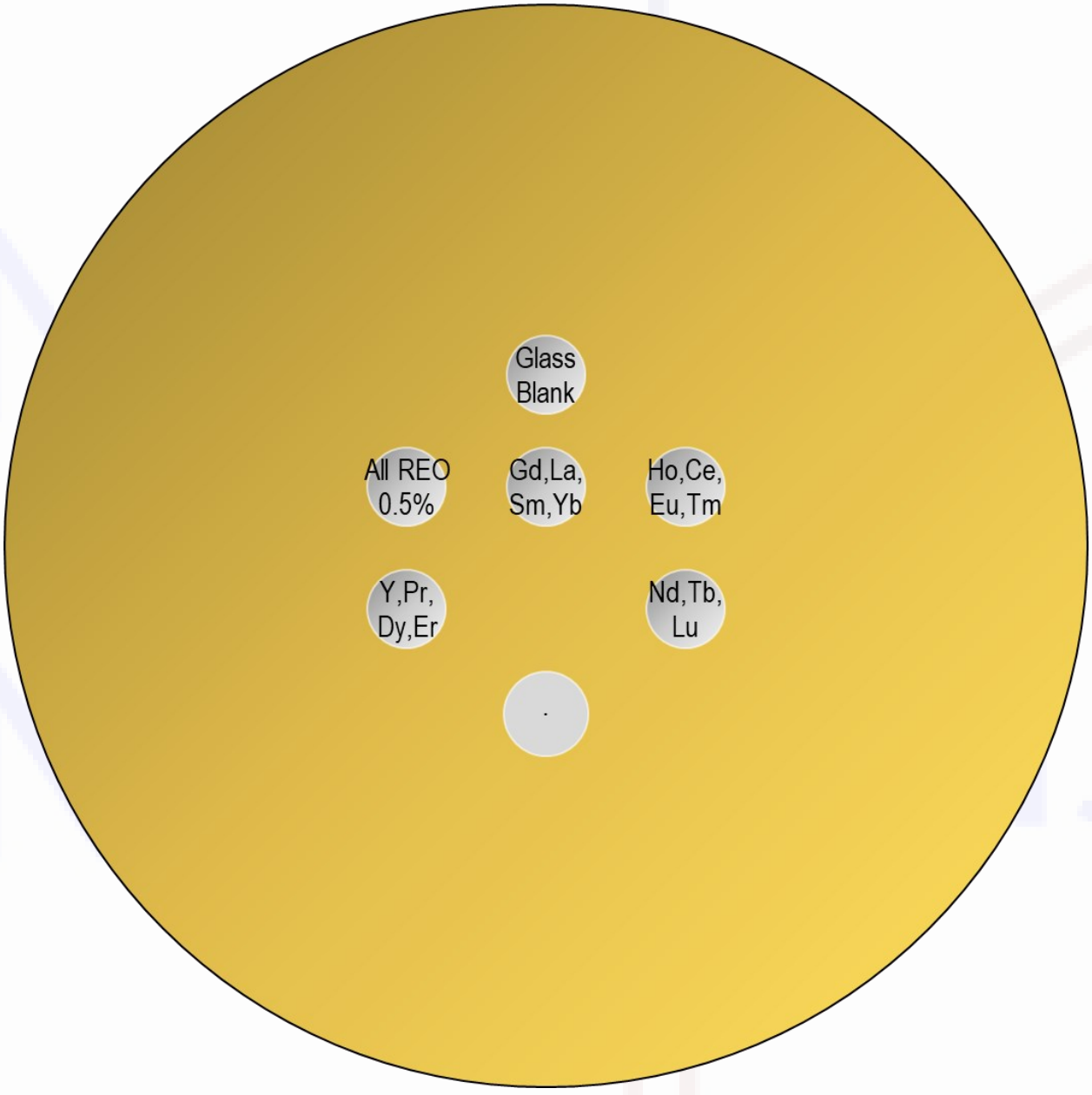
Rare Earth Elements Reference Standard—REE15-##

Rare Earth Oxides (REO) Reference Standard

Containing a set of REO Glasses.

(1x All REO's at 0.5% each, 3x REO's at 4% each, 1x REE free Glass).

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.



Available to Order As:

***REM6-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***REM6-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

www.micro-analysis.com

Rare Earth Oxides Reference Standard–REM6-##

Light Elements Reference Standard

Brass mount containing 8 light element materials covering atomic numbers 3, 4, 5, 6, 7, 8, 9 and 11 embedded using a conductive matrix (no Carbon coat).

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

Available to Order As:

***LES8-32**, 32mm Ø x 5mm Brass Mount and Polished. No Carbon Coat Applied.*

***LES8-25**, 25mm Ø x 5mm Brass Mount and Polished. No Carbon Coat Applied.*

Low Carbon Analysis Reference Standard

Brass mount containing 10 certified steel/alloy samples and 5 high purity elements.

Embedded using a conductive matrix (no Carbon coat).

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

Available to Order As:

***LCA15-32**, 32mm Ø x 5mm Brass Mount and Polished. No Carbon Coat Applied.*

***LCA15-25**, 25mm Ø x 5mm Brass Mount and Polished. No Carbon Coat Applied.*

Single Element Reference Standards & Quant. Verification Reference Standards

Available High Purity Single Elements:

Be	B	C	Mg	Al	Si	Sc	Ti	V	Cr
Mn	Fe	Co	Ni	Cu	Zn	Ge	As	Se	Y
Zr	Nb	Mo	Ru	Rh	Pd	Ag	Cd	In	Sn
Sb	Te	Gd	Tb	Dy	Ho	Tm	Yb	Hf	Ta
W	Re	Os	Ir	Pt	Au	Pb	Bi		

Available Materials Suitable for quick Quant. Verification:

Material	Generic Formula
Almandine	$Fe^{+2}{}_3Al_2(SiO_4)_3$
Spessartine	$Mn^{+2}{}_3Al_2(SiO_4)_3$
BR4L Glass	SiO_2 35%, BaO 24.7%, PbO 18.7%, ZnO 4.98%, B_2O_3 4.25%, CaO 4.77%, TiO_2 2.33%, K_2O 1.85%, Na_2O 1.08%, Al_2O_3 0.7%, As_2O_3 0.31%, SrO 0.22%, Sb_2O_3 0.2%, Fe_2O_3 0.02%
AISI 316 Stainless Steel BS 316D (Certified)	Fe 68.1%, Cr 16.76%, Ni 10.38%, Mo 2.05%, Mn 1.4%
Waspaloy BS 199A (Certified)	Ni 57.8%, Cr 19.25%, Co 13.47%, Mo 3.99%, Ti 3.07%, Al 1.26%, Fe 1.05%

Ordering Information

Brass

Pin Stub

Hitachi M4

##-Std *– Embedded into a 5mm Ø x 5mm brass mount. **

##-Pin *– Embedded into a standard Aluminium 12.5mm Ø pin stub.*

##-M4 *– Embedded into a 15mm Ø Aluminium Hitachi M4 threaded mount. **

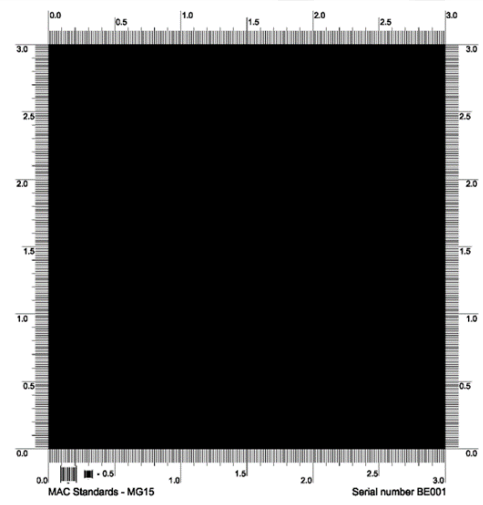
*= Element or material name.*

**Attached to a standard pin stub using a carbon tab for transportation.*

Can be used either as attached or removed from the stub.

Silicon Magnification Specimen

MAC MG15-T, 1µm Pitch Silicon Magnification Calibration Specimen



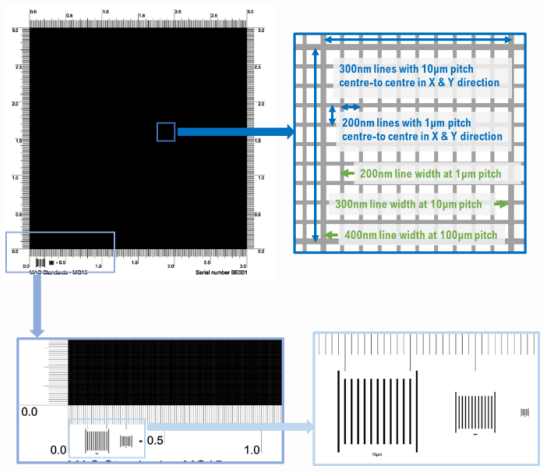
The MAC MG15-T magnification specimen is a 4mm x 4mm Boron doped, ultra-flat Silicon substrate with a 3mm x 3mm useable area. Consisting of:

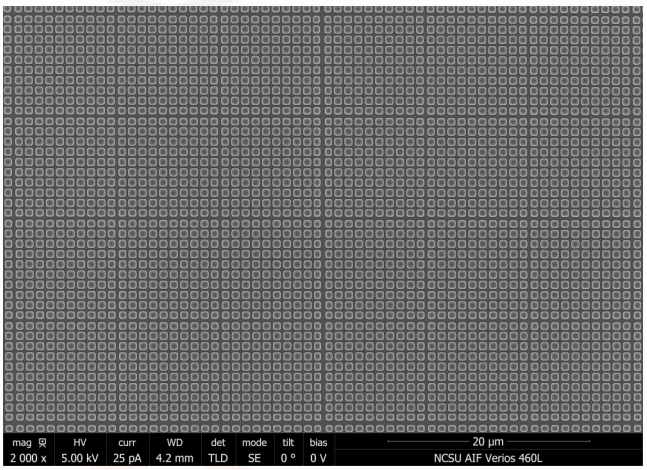
- 1µm pitch grid with additional grid pitch lines at 10µm and 100µm
- Additional calibration lines for 1µm, 5µm and 10µm below the main grid
- X and Y scale, major edge fiducial markers for grid positioning at 0.5mm intervals and minor at 0.1mm intervals

Intended for use with SEM, FESEM, FIB, AUGER, SIMS and reflected light microscopy, useful for checking image calibration and distortion in the 100x to 10,000 magnification range.

Specification

Substrate:		525µm ±20µm thick Boron-doped ultra-flat silicon substrate with <100> orientation
Conductivity:		5-10 ohm-cm
Grid Pitch/ Precision		1µm ± 0.025µm | 10µm ± 0.025µm | 100µm ± 0.25µm | Perpendicularity better than 0.01°
Line type/depth		342nm ± 15nm deep etched lines
Line Width	*Grid*	218nm ± 10nm for 1µm pitch | 342nm ± 15nm for 10µm pitch | 451nm ± 20nm for 100µm pitch
	Additional	2.5µm ± 5% for 10µm pitch | 1.25µm ± 5% for 5µm pitch | 250nm ± 5% for 1µm pitch
Identification		Etched specimen ID with unique serial number
Certification		Wafer level certification traceable to a NIST standard
Expiry date		None





Available to Order As:

MG15-Pin, *Mounted onto a standard 12.5mm Ø Aluminium Pin Stub.*

MG15-M4, *Mounted onto a 15mm Ø Hitachi M4 Aluminium Stub.*

Mounted Silicon Magnification Specimen—MG15-##

Universal Multi-Element Reference Standards

Universal Multi-Element Reference Standards

Our range of Universal multi-element Reference Standards have been designed and manufactured with a number of them focusing on specialised areas.

With input from leading manufacturers, respected professionals, analysts and Electron Microscopy users worldwide, these standards provide you with a comprehensive catalogue of reference materials.

The Universal Standards are manufactured in either a 25mm or 32mm diameter brass mount depending on your requirements.

Our standards are used worldwide by:

- OEM Engineers in the setup and servicing of equipment
- Testing Laboratories
- Research & Development Laboratories
- Universities, Colleges and Schools
- Geological Societies
- Police Forensic Science Departments
- Government Agencies

Supplied in a specially designed storage/transportation case that contains:

- The standard—protected by an additional specially designed case
- A full electronic booklet on a USB, containing:
  - The standard plan/layout
  - Certificates of analysis or conformance for each material
  - Details on storage and care of your standards
  - Certificate of final inspection & recommended re-polishing date
- A replaceable silica gel capsule for protection whilst in transit
- A credit card sized quick reference guide

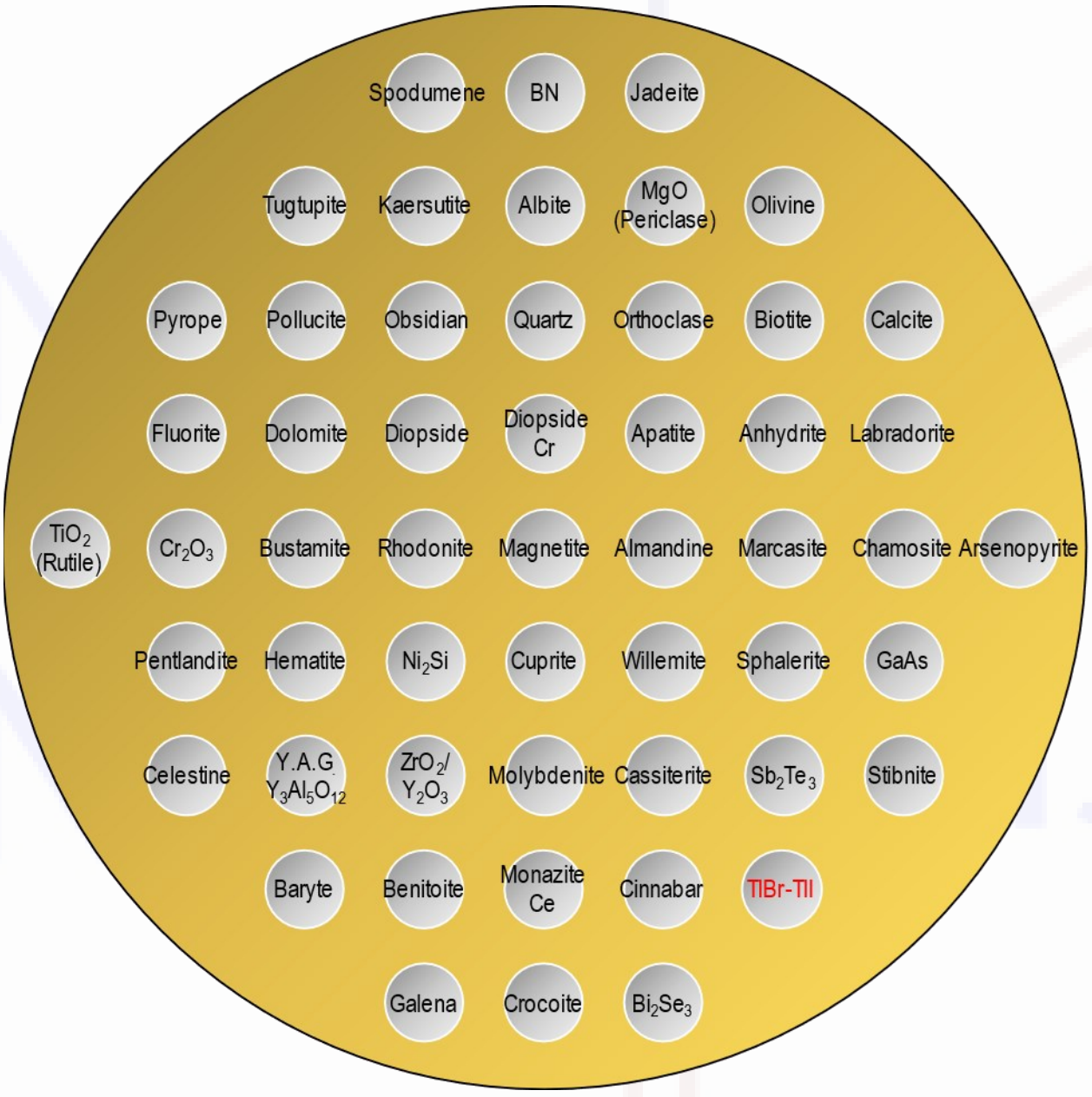
A copy of the electronic booklet is also accessible from our cloud storage.

Minerals 53 Reference Standard

53 mineral/synthetic samples.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

This Standard Contains Moisture/Air Sensitive Materials.



Available to Order As:

***MIN53-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***MIN53-32FC**, 32mm Ø x 5mm Brass mount, polished and Carbon coated. WITH FARADAY CUP*

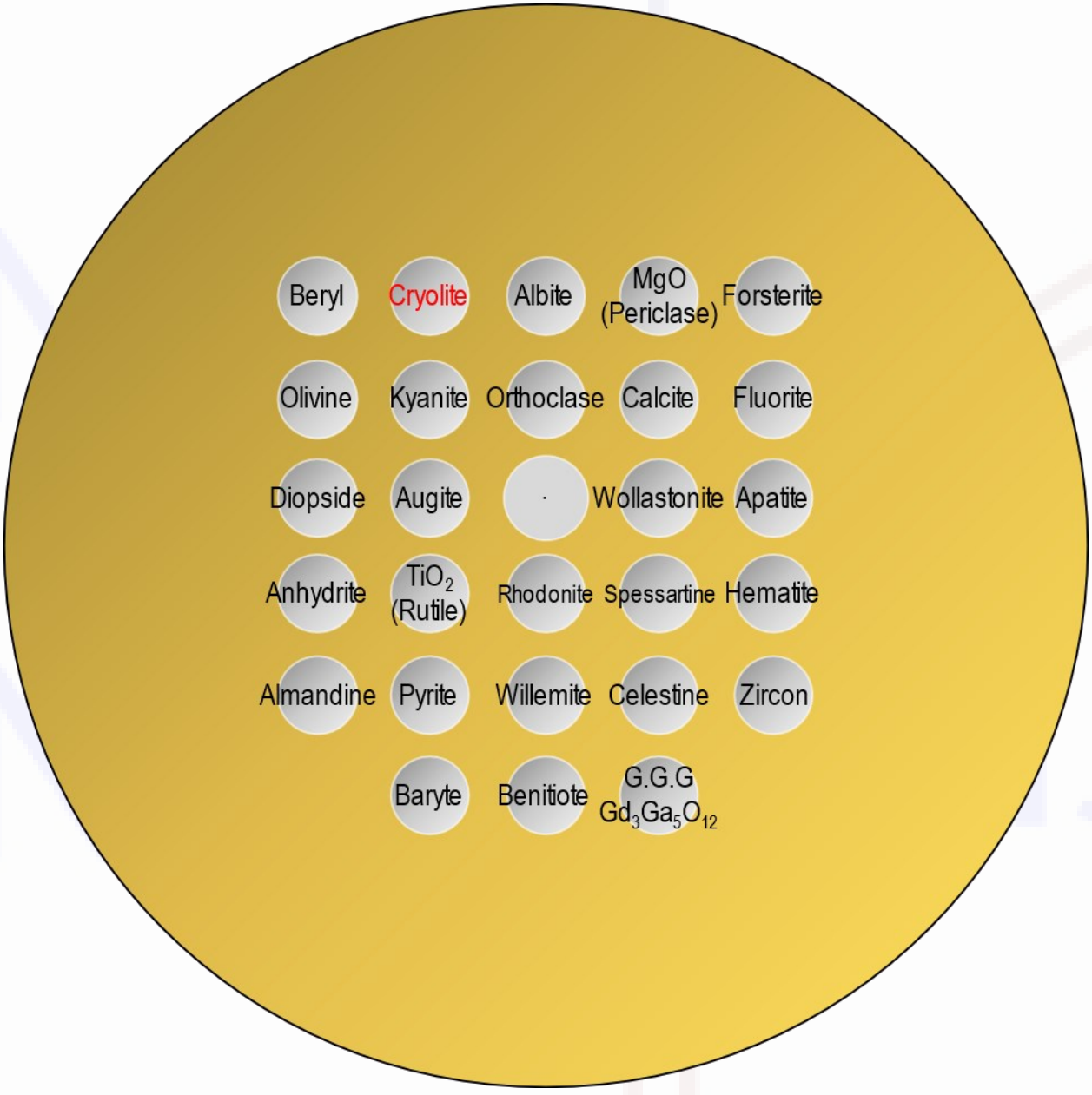
***MIN53-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Minerals 27 Reference Standard

53 mineral/synthetic samples.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

This Standard Contains Moisture/Air Sensitive Materials.



Available to Order As:

***MIN27-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

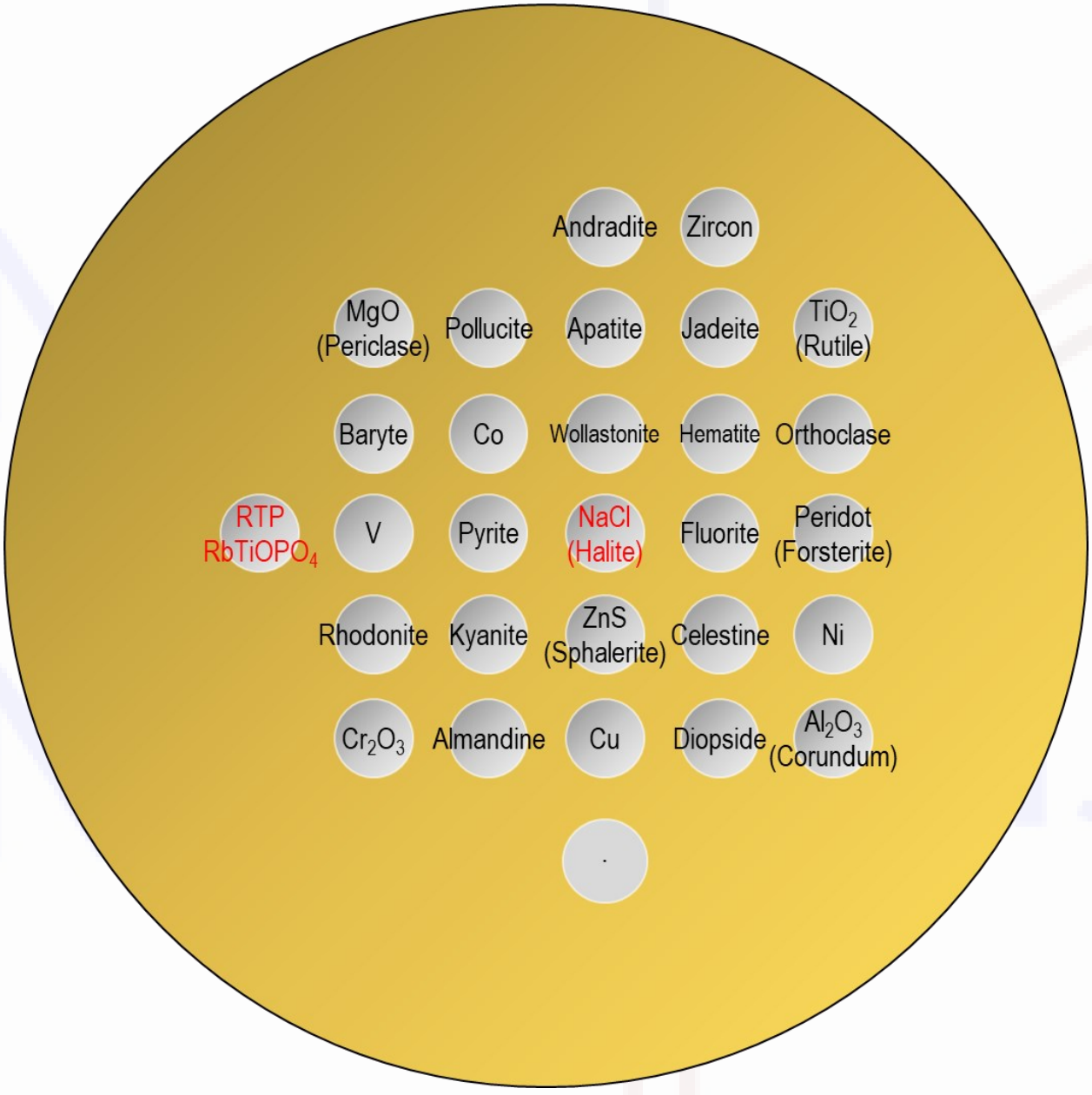
***MIN27-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Geological MkII Reference Standard

28 mineral/synthetic /pure samples.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

This Standard Contains Moisture/Air Sensitive Materials.



Available to Order As:

***GGL28-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***GGL28-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

Biological Reference Standard

18 mineral/synthetic /pure samples.

A 150µm Molybdenum Faraday Cup is also included for measuring the stability of the electron beam.

This Standard Contains Moisture/Air Sensitive Materials.

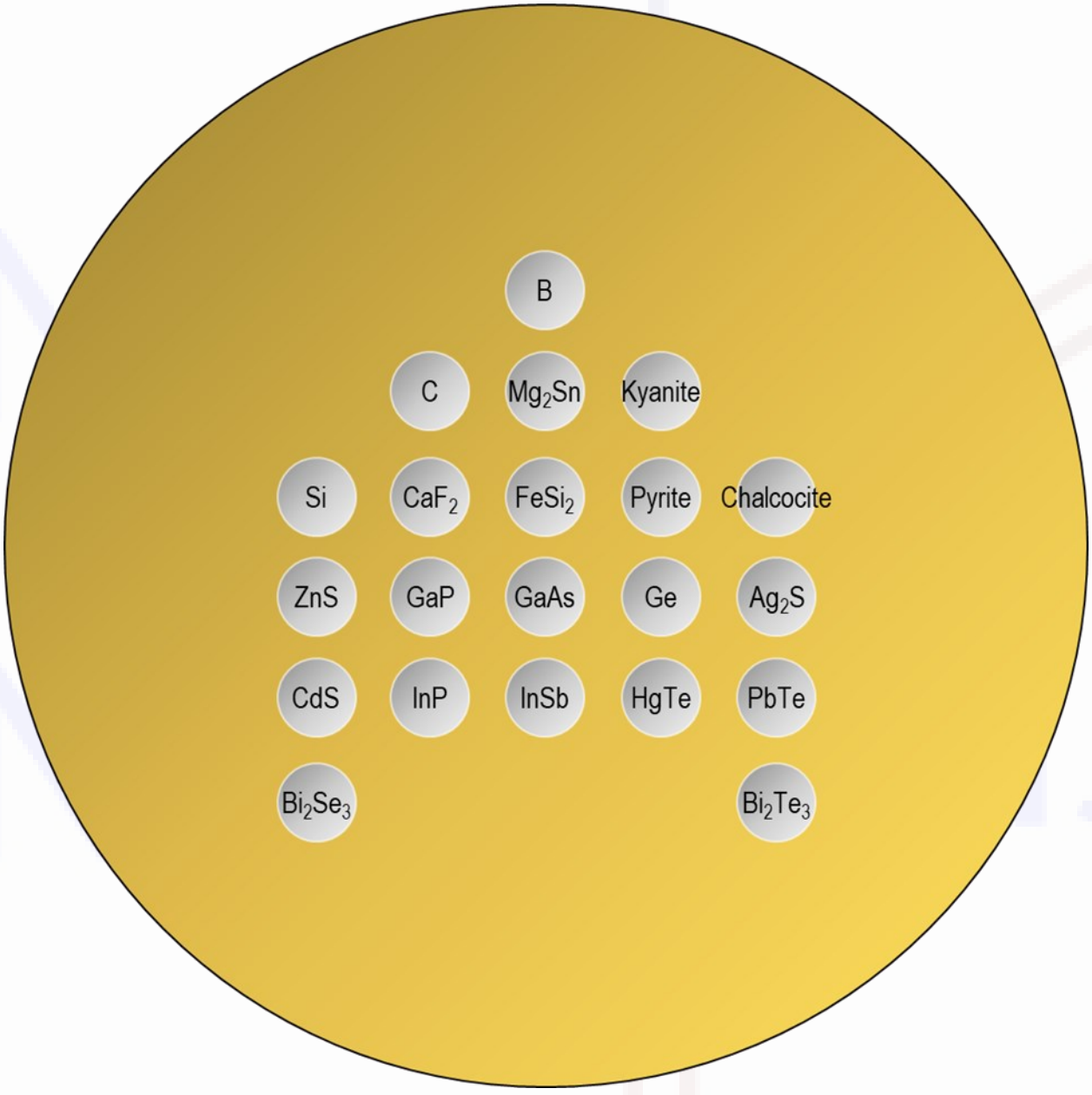
Available to Order As:

BGL18-32, *32mm Ø x 5mm Brass mount, polished and Carbon coated*

BGL18-25, *25mm Ø x 5mm Brass mount, polished and Carbon coated*

Semiconductor Reference Standard

21 mineral/synthetic /pure samples.



Available to Order As:

***SCR21-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

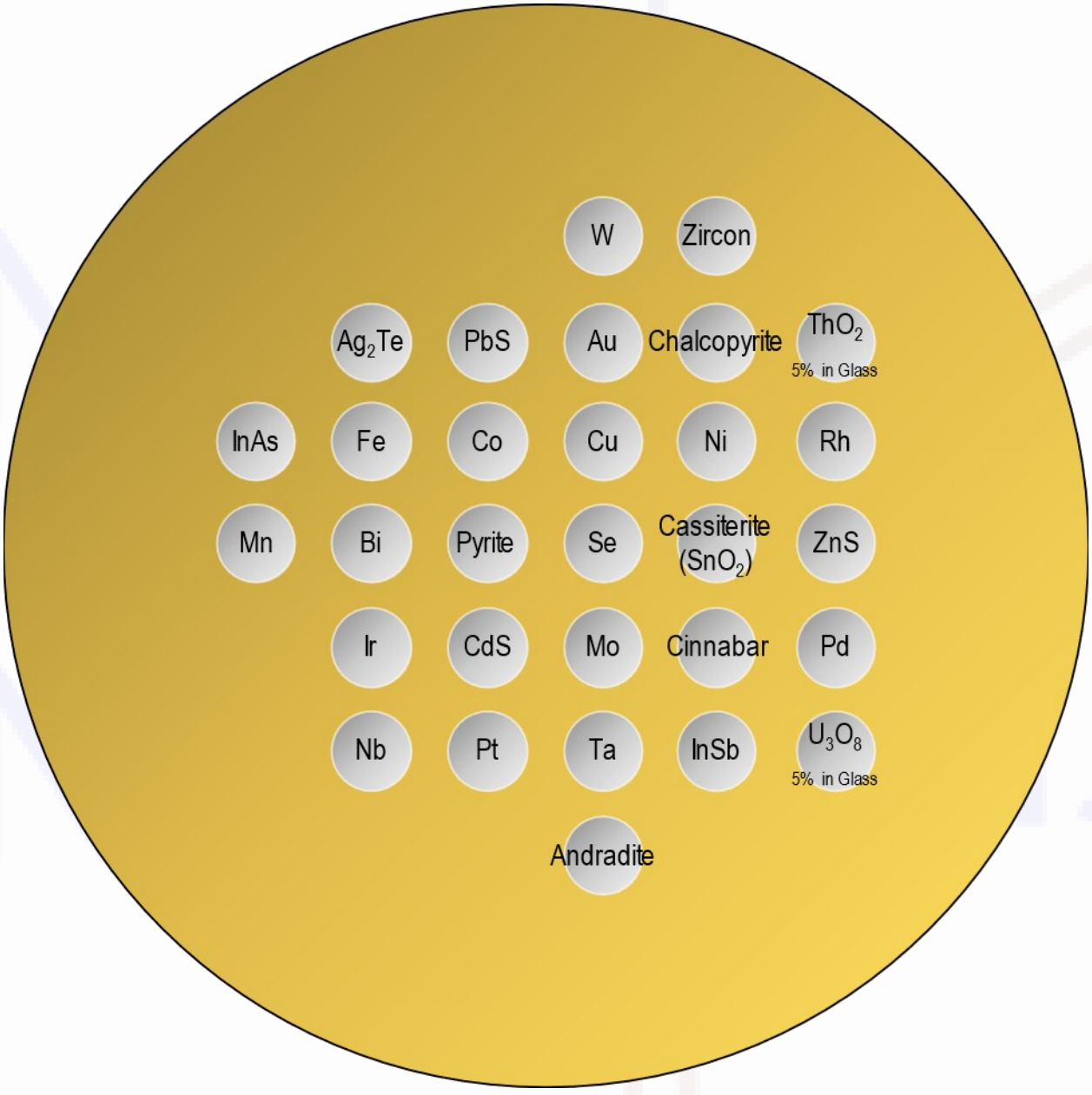
***SCR21-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

www.micro-analysis.com

Semiconductor Reference Standard—SCR21-##

Sulphide-Heavy Metals Reference Standard

21 mineral/synthetic/pure samples.



Available to Order As:

***SMH30-32**, 32mm Ø x 5mm Brass mount, polished and Carbon coated*

***SMH30-25**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

www.micro-analysis.com

Sulphide-Heavy Metals Reference Standard—SMH30-##

Quality Control Test Standards

Quality Control Test Standards

Our range of Quality Control Test Standards (QCT) have been thoughtfully designed and manufactured to help aid the user in checking and monitoring the performance and accuracy of their EDX/WDX-SEM equipment and to help identify any potential problems that may effect the quality of the analysis results they are achieving.

Our standards are used worldwide by:

- OEM Engineers in the setup and servicing of equipment
- Testing Laboratories
- Research & Development Laboratories
- Universities, Colleges and Schools
- Geological Societies
- Police Forensic Science Departments
- Government Agencies

All of the QCT standards we manufacture can be customised by the customer if an alternative material or accessory is preferred or required. If we do not have the material you need from the 1,000+ materials we hold in stock, we will do our best to source it for you.

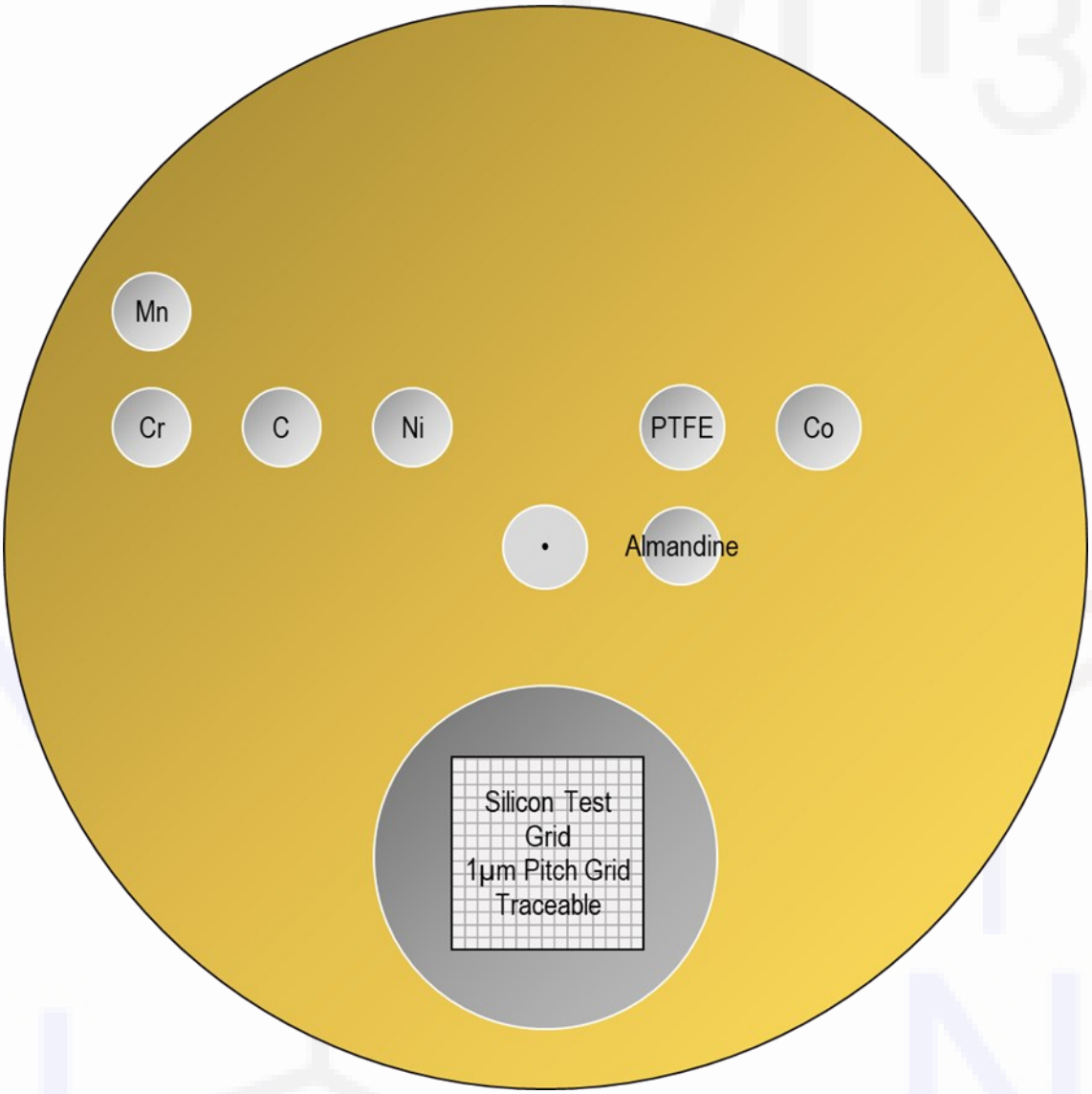
Supplied in a specially designed storage/transportation case that contains:

- The standard—protected by an additional specially designed case
- A full electronic booklet on a USB, containing:
  - The standard plan/layout
  - Certificates of analysis or conformance for each material
  - Details on storage and care of your standards
  - Certificate of final inspection & recommended re-polishing date
- A replaceable silica gel capsule for protection whilst in transit
- A credit card sized quick reference guide

A copy of the electronic booklet is also accessible from our cloud storage.

Quality Control Test Standards

Basic EDS Quality Control Test Standard



This Standard contains the following:

•	Manganese	used for	Detector resolution (FWHM)
•	Chromium	used for	Detector sensitivity / contamination
•	Carbon	used for	Beam measurement & energy calibration (Low)
•	Nickel	used for	Detector sensitivity / contamination
•	Cobalt	used for	Beam measurement & energy calibration
•	Almandine (mineral)	used for	Quant. verification
•	150 µm Faraday cup	used for	Beam current stability
•	Silicon Test Grid	used for	Magnification calibration & image distortion

A version of this standard is also available with a certified AISI316 Stainless Steel as the Quant verification material instead of Almandine

Available to Order As:

***EDX-CAL**, 25mm Ø x 5mm Brass mount, polished and Carbon coated—With Almandine*

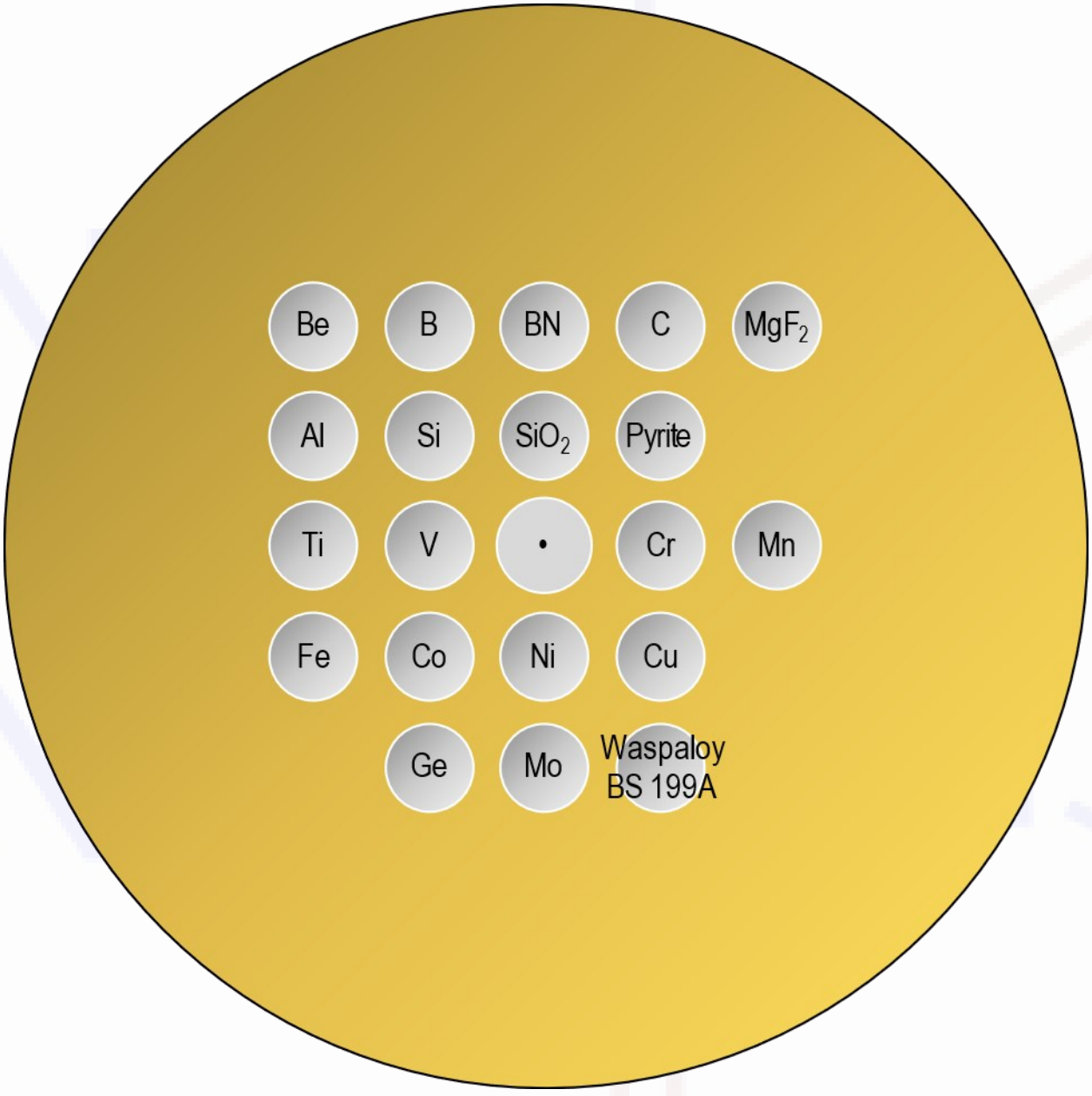
***EDX-CAL316**, 25mm Ø x 5mm Brass mount, polished and Carbon coated—With AISI316 S/S*

www.micro-analysis.com

Basic EDS Quality Control Test Standard—EDX-CAL

WDS Quality Control Test Standard

21 mineral/synthetic /pure/alloy samples which has been specifically designed to help calibrate any WDX system.

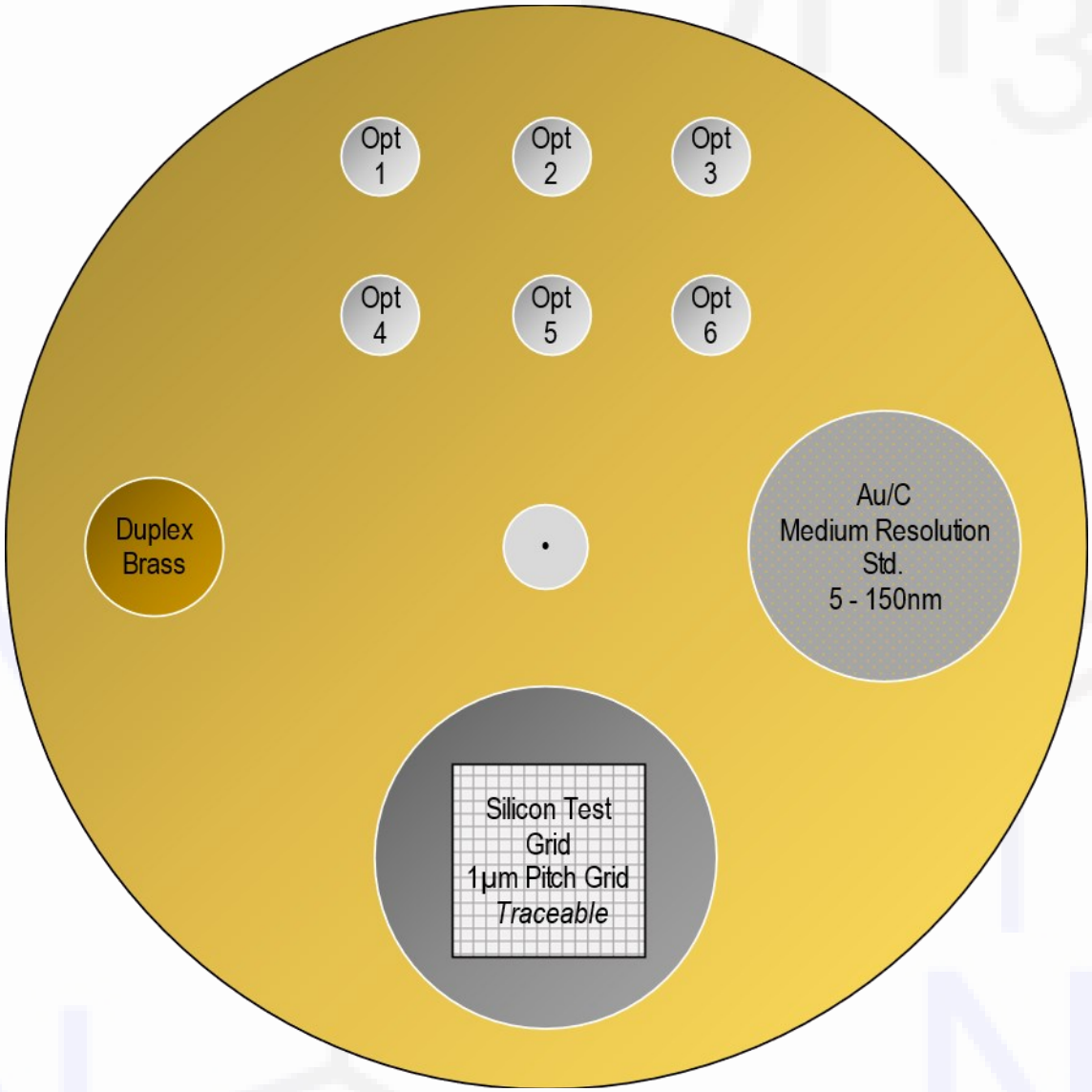


Available to Order As:

***WDX-CAL**, 25mm Ø x 5mm Brass mount, polished and Carbon coated*

www.micro-analysis.com

Quality Control Test Standard-A



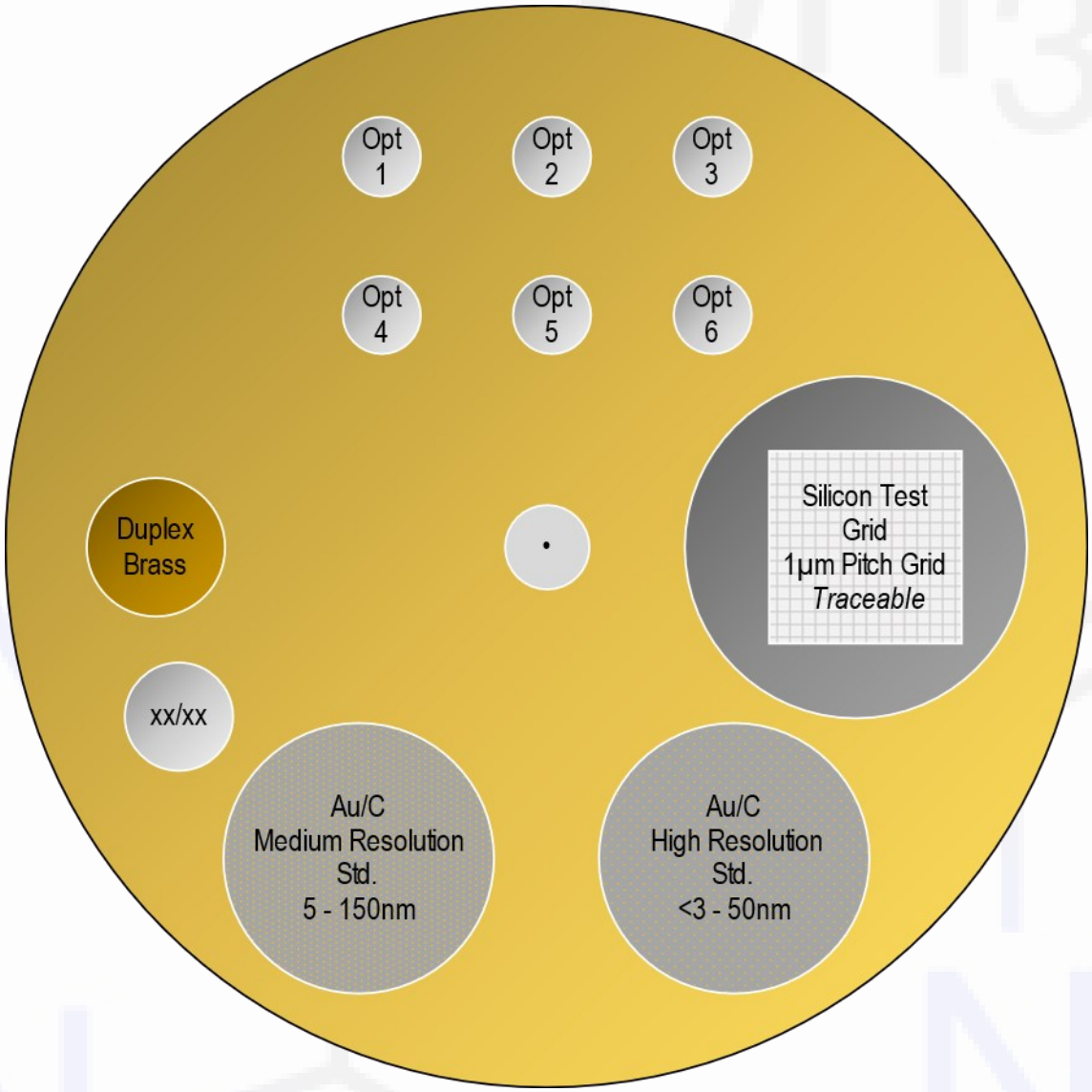
This Standard contains the following:

- Opt 1 – Material to be selected by the customer from our recommended list
- Opt 2 – Material to be selected by the customer from our recommended list
- Opt 3 – Material to be selected by the customer from our recommended list
- Opt 4 – Material to be selected by the customer from our recommended list
- Opt 5 – Material to be selected by the customer from our recommended list
- Opt 6 – Material to be selected by the customer from our recommended list
- BSE Duplex Brass used for Backscattered Detector (BSE) resolution
- Au/C BSE specimen used for SEM BSE resolution, 5 – 150nm particles
- 150 µm Faraday cup used for Beam current stability
- Silicon Test Grid used for Magnification calibration & image distortion

Available to Order As:

QCT-A, *32mm Ø x 8mm Brass mount, polished and Carbon coated.*

Quality Control Test Standard (Enhanced)-B



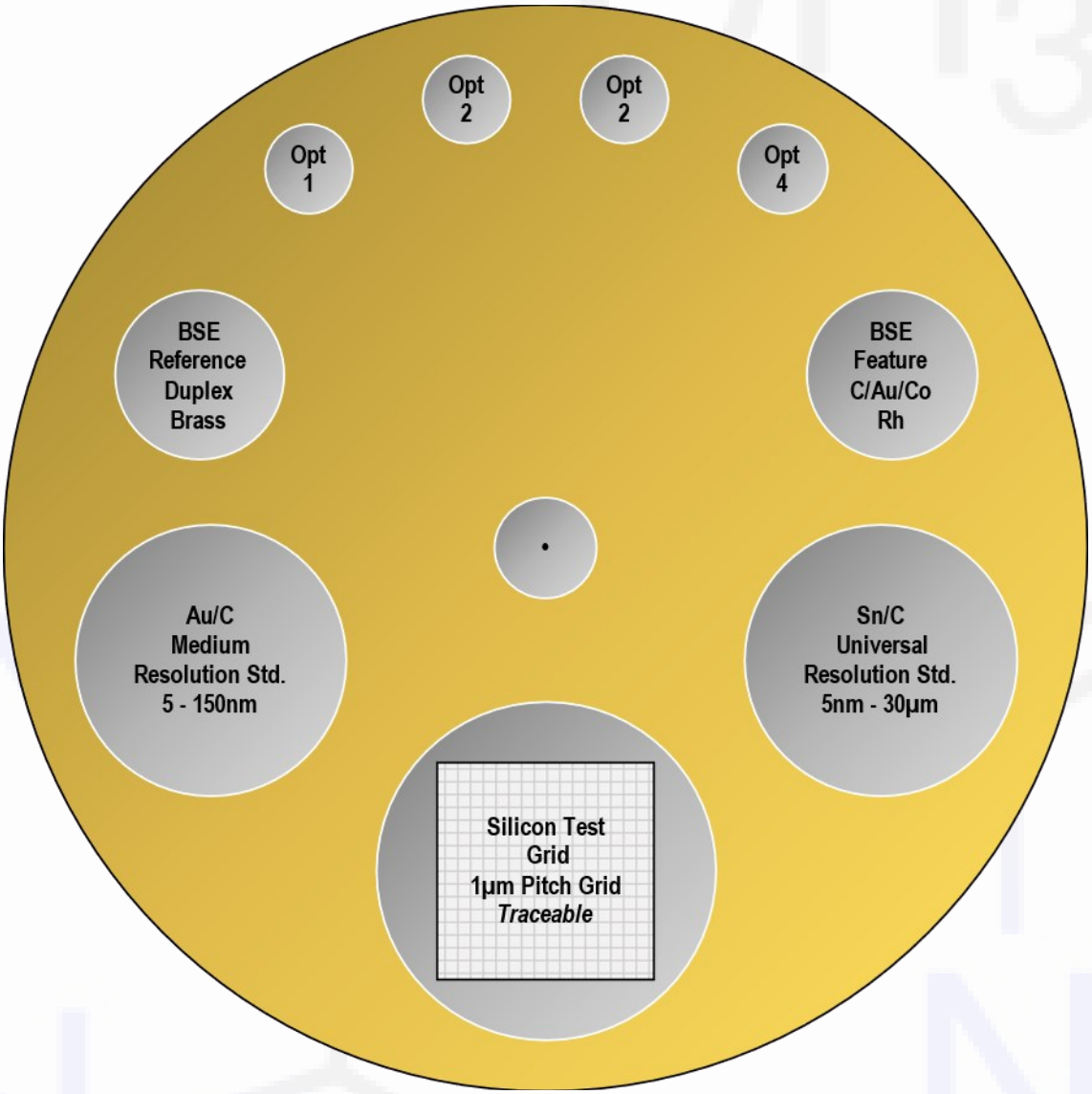
This Standard contains the following:

- Opt 1 – Material to be selected by the customer from our recommended list
- Opt 2 – Material to be selected by the customer from our recommended list
- Opt 3 – Material to be selected by the customer from our recommended list
- Opt 4 – Material to be selected by the customer from our recommended list
- Opt 5 – Material to be selected by the customer from our recommended list
- Opt 6 – Material to be selected by the customer from our recommended list
- xx/xx – Dual Atomic BSE Standard, selected by the customer from our options list
- BSE Duplex Brass used for Backscattered Detector (BSE) resolution
- Au/C BSE specimen used for SEM BSE resolution, 5 – 150nm particles
- Au/C BSE specimen used for SEM BSE resolution, <3 – 50nm particles
- 150 µm Faraday cup used for Beam current stability
- Silicon Test Grid used for Magnification calibration & image distortion

Available to Order As:

QCT-B, *32mm Ø x 8mm Brass mount, polished and Carbon coated.*

Quality Control Test Standard (Calibration)



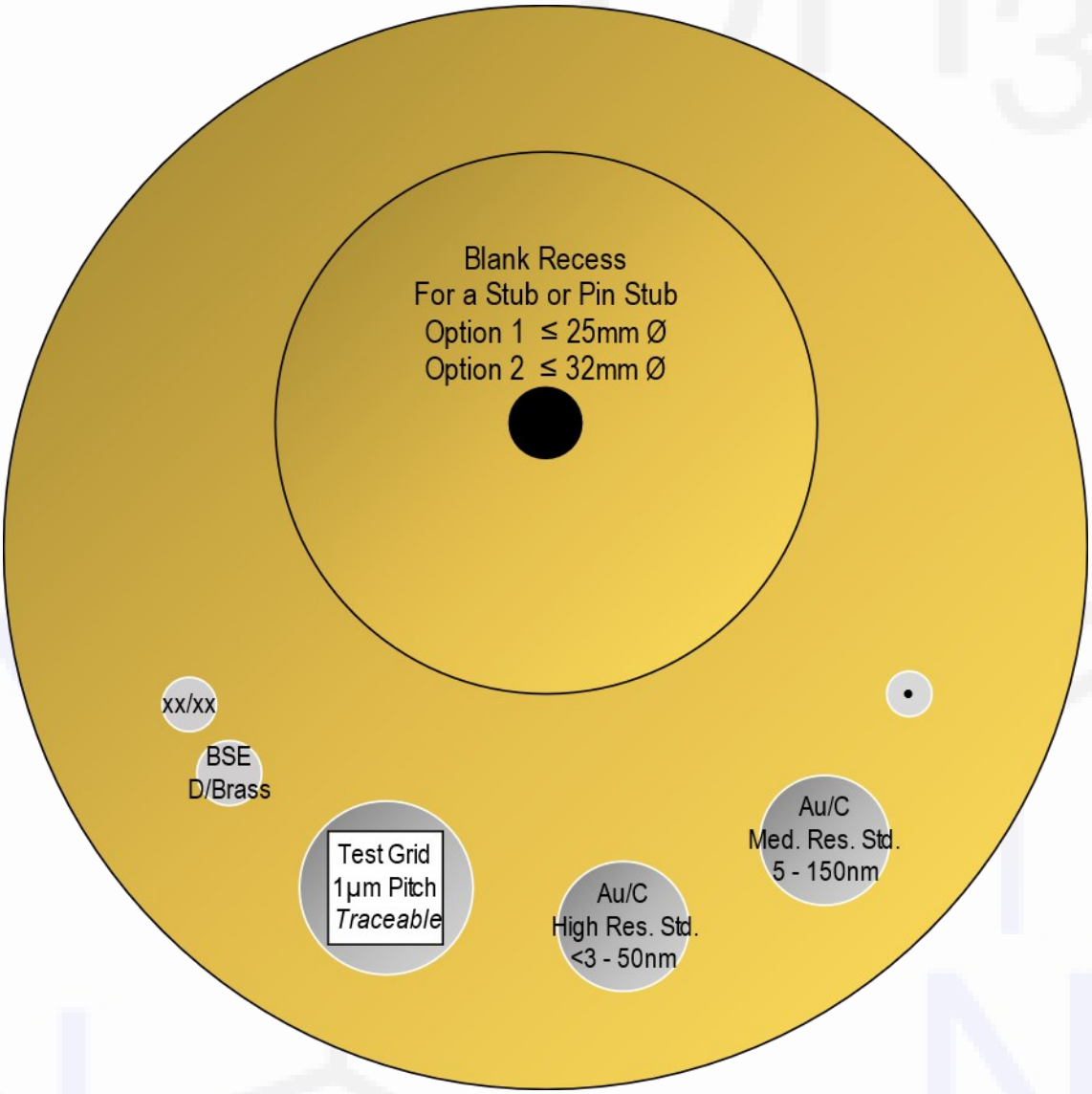
This Standard contains the following:

- Opt 1 – Material to be selected by the customer from our recommended list
- Opt 2 – Material to be selected by the customer from our recommended list
- Opt 3 – Material to be selected by the customer from our recommended list
- Opt 4 – Material to be selected by the customer from our recommended list
- BSE Feature Std – 4 high purity elements covering low, med. and high grey scales
- BSE Duplex Brass used for Backscattered Detector (BSE) resolution
- Au/C BSE specimen used for SEM BSE resolution, 5 – 150nm particles
- Sn/C BSE specimen used for SEM BSE resolution, 5nm-30µm particles
- 150 µm Faraday cup used for Beam current stability
- Silicon Test Grid used for Magnification calibration & image distortion

Available to Order As:

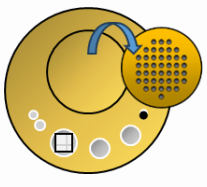
QCT-CAL, *32mm Ø x 8mm Brass mount, polished and Carbon coated.*

Quality Control Test Standard (Calibration)



This Standard contains the following:

- Recess to allow either a stub or pin to be inserted into the mount (select size required)
- xx/xx – Dual Atomic BSE Standard, selected by the customer from our options list
- Duplex Brass used for Backscattered Detector (BSE) resolution
- Au/C BSE specimen used for SEM BSE resolution, 5 – 150nm particles
- Au/C BSE specimen used for SEM BSE resolution, <3 – 50nm particles
- 150 µm Faraday cup used for Beam current stability
- Silicon Test Grid used for Magnification calibration & image distortion



Available to Order As

QCT-C32, *Brass Mount, 49mm Ø x 8mm (thick) to accept a stub or pin mount >32mm Ø*

QCT-C25, *Brass Mount, 49mm Ø x 8mm (thick) to accept a stub or pin mount >25mm Ø*

Selectable Materials for the QCTA and QCTB Standards

High Purity Materials Recommended for Energy Calibration

Si	**Sc**	**Ti**	**V**	**Cr**	**Mn**
Fe	**Co**	**Ni**	**Cu**	**Zn**	

X-ray peaks often involve multiple lines therefore in order to achieve accurate calibration, a large peak with well-known line energies and intensities is required.

We recommend that for energy calibration a pure element is used; Si, Co, Ni or Cu are the most common.

High Purity Materials Recommended for Beam Measurement

C	**Si**	**Ti**	**V**	**Cr**	**Mn**
Fe	**Co**	**Ni**	**Cu**	**Zn**	

Pure Co resists oxidation and polishes well and is therefore the most suitable choice to monitor beam current when you want to obtain accurate un-normalized or "absolute" estimates of composition. However, below 15kV, Co K-line is weakly excited and it is preferable to choose another pure element for monitoring.

If the beam measurement material is oxidized, contaminated or has a rough surface, then this will have a direct effect on the analysis results. When using very low accelerating voltages, a pure carbon standard (ideally glassy carbon) can be used for beam calibration. The resolution must be sufficient to leave background regions either side of the carbon peak, so that the peak is clearly separated from the triggered noise peak (near zero keV) and any oxygen peak near 0.5 keV. Furthermore, the voltage must be sufficient to excite an adequately large C K-line emission.

Most EDX software allows calibration using the zero strobe peak and a known element. If the software on your system does not allow this then calibration is recommended using an Al+Cu sample. These two 1mm wires are embedded side by side in a single hole. For low accelerating voltages a Al/C sample would be used.

Selectable Materials for the QCT Standards

Recommended Materials for Checking Energy Resolution

Mn	Cu	C	F

Resolution is quoted as the width of the peak at half its maximum height (FWHM). The lower the number the better the resolution of the detector and therefore the better it will be at resolving peaks due to closely spaced X-ray lines.

Many manufacturers test the performance of an EDS detector using Fe55. This is convenient as it can be achieved without the need of mounting the detector on an SEM.

The resolution of a detector is traditionally specified for the Manganese Kα X-rays at 5.895 KeV as this is the energy of the most intense X-ray line emitted by the Fe55 source.

Mn Kα energy is most commonly used to specify EDS resolution as the peaks are well separated. However, much more serious overlaps occur below 3keV and the resolution performance at low energies is critical to good performance for all elements. Mn (FWHM) is a very insensitive measure to characterize the noise of a detector and predict the resolution at low energy. Therefore, to characterize the resolution of a detector at low energy, the resolution is also quoted for another line, typically Fluorine Kα.

The resolution of the C Kα peak measured using pure Carbon is very useful due to its sensitivity to noise and incomplete charge collection. A low value guaranteed here means excellent detector resolution for all energies.

Recommended Material for Checking Detector Performance Changes

Ni	Cr

A gradual decrease in low energy sensitivity over time will result in a decrease in the height of peaks at low energy. This can be checked by monitoring the relative height of K and L lines from a transition metal element. The ratio of L to K line heights from pure nickel measured at 20kV is a common test. A more sensitive test for the presence of ice and water vapour on a detector window is to look at the L spectrum from pure Cr.

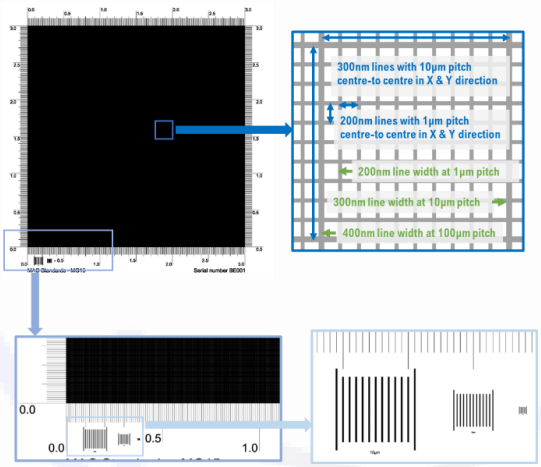
Miscellaneous Materials

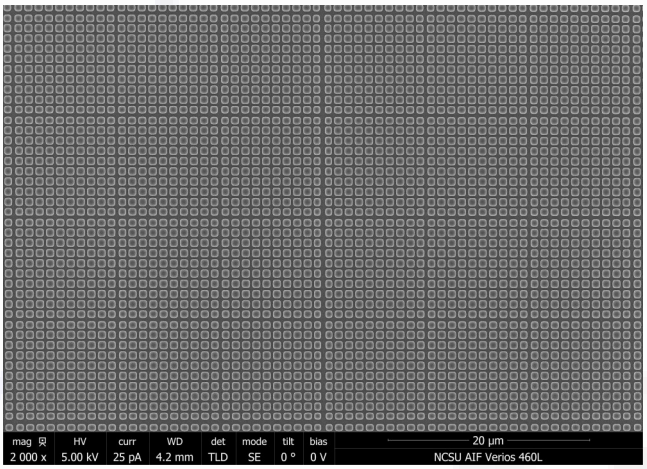
Be is often used for checking the low-end sensitivity of high-performance detectors.
BN is used for checking the low-end energy performance of thin window and windowless detectors.
SiO_2 is used to test the Oxygen sensitivity of the EDS.
Almandine is used to verify the quant. analysis achieved for oxides after calibration.
AISI 316 S/S is used to verify the quant. analysis achieved after calibration.

SEM Magnification Specimen Options

The default magnification specimen fitted into our QCT standards

MAC MG15-T Silicon Test Specimen





The MAC MG15-T magnification specimen is a 4mm x 4mm Boron doped, ultra-flat Silicon substrate with a 3mm x 3mm useable area.

Consisting of:

- 1µm pitch grid with additional grid pitch lines at 10µm and 100µm
- Additional calibration lines for 1µm, 5µm and 10µm below the main grid
- X and Y scale, major edge fiducial markers for grid positioning at 0.5mm intervals and minor at 0.1mm intervals

Intended for use with SEM, FESEM, FIB, AUGER, SIMS and reflected light microscopy, useful for checking image calibration and distortion in the 100x to 10,000 magnification range. Wafer level certification, traceable to a NIST standard.

Specification

Substrate:		525µm ±20µm thick Boron-doped ultra-flat silicon substrate with <100> orientation
Conductivity:		5-10 ohm-cm
Grid Pitch/ Precision		1µm ± 0.025µm | 10µm ± 0.025µm **|** 100µm ± 0.25µm **|** Perpendicularity better than 0.01º
Line type/depth		342nm ± 15nm deep etched lines
Line Width	*Grid*	218nm ± 10nm for 1µm pitch | 342nm ± 15nm for 10µm pitch | 451nm ± 20nm for 100µm pitch
	Additional	2.5µm ± 5% for 10µm pitch | 1.25µm ± 5% for 5µm pitch | 250nm ± 5% for 1µm pitch
Identification		Etched specimen ID with unique serial number
Certification		Wafer level certification traceable to a NIST standard
Expiry date		None

SEM Magnification Specimen Options

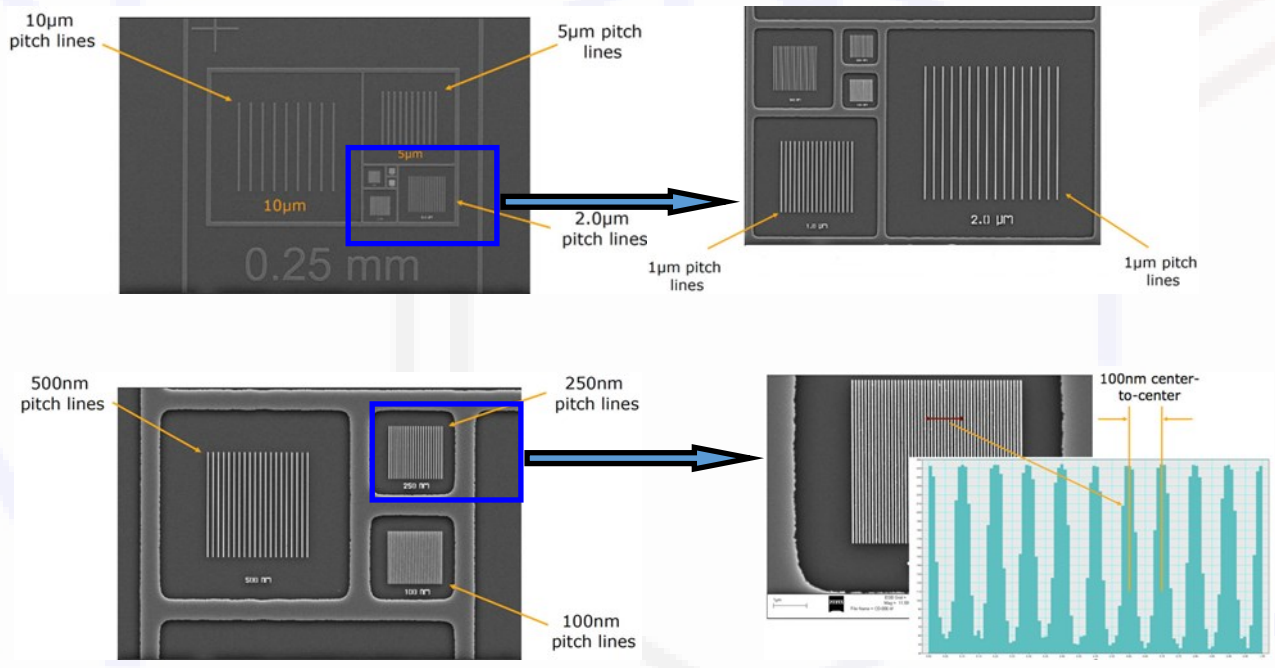
The default magnification Specimen fitted into our QCT standards can be modified to any of the following options, please note however that alternate options selected may affect the overall price of the standard.

CDMS—Critical Dimension Measurement Specimen

The MCS series are a fully featured Critical Dimension Specimen for calibration over a wide measurement range in SEM, table top SEM, FIB, Auger, Sims and Reflected Light Microscopy

2.5mm to 1µm
This version has a magnification range of approximately 10x to 20,000x

2.5mm to 0.1µm
This version has a magnification range of approximately 10x to 200,000x



Available to order as:

Wafer Level Certification

MG06—*2.5mm to 1µm NIST traceable and supplied with a global certificate of calibration using the average data measured for each production wafer.*

MG09—*2.5mm to 0.1µm NIST traceable and supplied with a global certificate of calibration using the average data measured for each production wafer.*

Individual Level Certification

MG07—*2.5mm to 1µm, NIST traceable and supplied with an individual certificate of calibration for higher accuracy.*

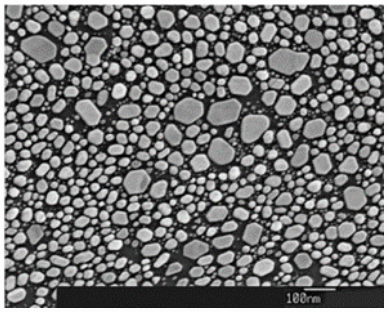
MG10—*2.5mm to 0.1µm, NIST traceable and supplied with an individual certificate of calibration for higher accuracy.*

SEM Resolution Specimen Options

Gold on Carbon Resolution Specimens

RS02—Au/C Medium Resolution Specimen, 5-150nm

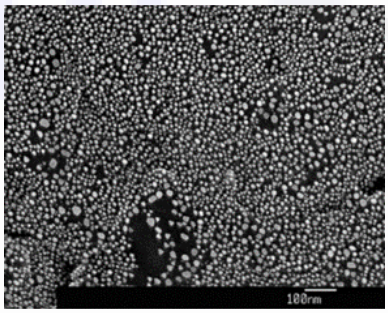
The default Resolution specimen fitted into our QCT-A, B, C and Cal standards



This specimen has a particle size range from approximately 5 - 150nm. Each specimen has a square grid pattern with large crystals in the centre of each grid square and very fine crystals at the edges of each grid (as illustrated). Medium and high resolution point separation tests may be performed on the same specimen. In addition, the larger crystals show facets which allow an assessment of the grey level reproduction available at high resolution.

RS03—Au/C High Resolution Specimen, <3-50nm

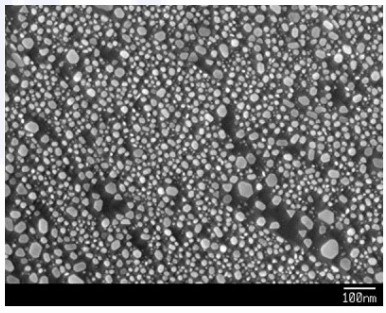
The default Resolution specimen fitted into our QCT- B, C and Cal standards



This specimen is particularly suitable for assessing the image quality of high resolution SEMs, such as those fitted with a field emission electron source. A magnification of at least x80,000 is required to clearly resolve the gold particles. Particle sizes range from <3 - 50nm.

RS04—Au/C Ultra High Resolution Specimen, <2-30nm

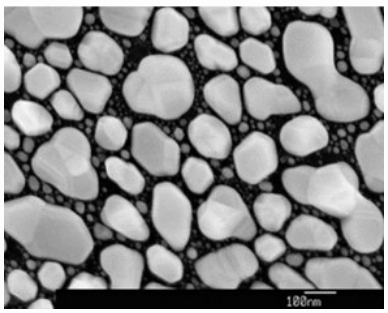
Optional Resolutions Specimen



Ultra high resolution test specimen with a particle size range from approximately <2 - 30nm
For ultra high resolution performance testing, this specimen has a smaller gold island particle size compared to the RS02 & RS03 specimens. They are suitable for testing at instrument magnifications of x50,000 and above. Particle size range from <2 - 30nm.

RS01—Au/C Low Voltage Resolution Specimen, <30-300nm

Optional Resolutions Specimen



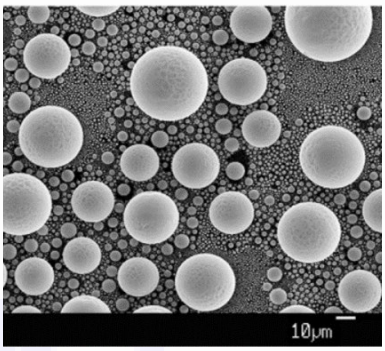
Standard gold or tin on carbon resolution specimens may not be suitable for operating at low accelerating voltages or for use with older instruments. This may be due to inferior resolution at low voltage or poor signal-to-noise ratio when operating at high scanning rates with small spot sizes. The larger gold islands give high contrast while retaining small gaps for resolution measurement, making this specimen easier to use at non-optimal operating conditions.

SEM Resolution Specimen Options

Tin on Carbon Resolution Specimens

RS05—Sn/C Universal Resolution Specimen, 5-30µm

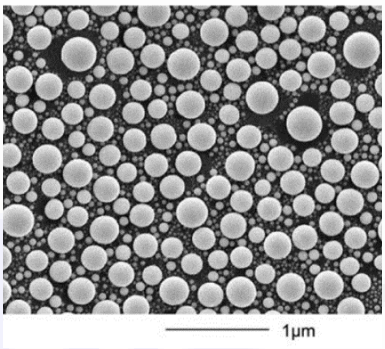
Optional Resolutions Specimen



This specimen provides a means of measuring resolution, astigmatism and image shift in scanning electron microscopes using a single specimen. The tin balls vary in size between 5 nm – 30 µm. This means that unlike some other test specimens, it can be imaged over a wide range of magnification, accelerating voltage and spot size. The relatively high atomic number of tin gives the spheres high contrast when compared to the carbon substrate. The ability to image the specimen at low magnification simplifies initial focussing at low accelerating voltages.

RS06—Sn/C Medium Resolution Specimen, 10-100nm

Optional Resolutions Specimen



An alternative test specimen for medium resolution evaluation and for the day-to-day visual checking of instrument performance is a tin on carbon specimen. This consists of a dispersion of tin spheres, within the size range 10 - 100nm, on a carbon substrate.
Ideal for astigmatism correction, it is also recommended for use in SEMs employed in the semiconductor industry, where the usual gold on carbon sample cannot be used because of the risk of gold poisoning.

BSE Reference Standards

Backscattered Electron (BSE) Reference Standards

Backscatter imaging is a second imaging modality available in the SEM.
Whilst SE-imaging reveals the surface topography of our sample, BSE imaging can provide information as to its composition. Elements with a high atomic number yield more backscatter electrons than elements with a low atomic number and hence appear brighter in the image.

Imaging a sample using BSE provides a Z-contrast image indicating differences in elemental composition. Samples for BSE imaging are imaged uncoated or coated with a layer of carbon to improve sample conductivity.

All of the BSE standards we manufacture can be customised by the customer if an alternative material or accessory is preferred or required. If we do not have the material you need from the 1,000+ materials we hold in stock, we will do our best to source it for you.

Supplied in a specially designed storage/transportation case that contains:

- The standard—protected by an additional specially designed case
- A full electronic booklet on a USB, containing:
  - The standard plan/layout
  - Certificates of analysis or conformance for each material
  - Details on storage and care of your standards
  - Certificate of final inspection & recommended re-polishing date
- A replaceable silica gel capsule for protection whilst in transit
- A credit card sized quick reference guide

A copy of the electronic booklet is also accessible from our cloud storage.

Backscattered Electron (BSE) Reference Standards

Dual Atomic Number Reference Standards

An electron microscope, when equipped with a Backscattered Electron Detector, has the capacity to produce images in which contrast is controlled by the differences in atomic numbers (Z) across the specimen.
These reference standards consists of two high purity elements that have an atomic number difference of 1, embedded side by side in a contrasting matrix into a 5mm Ø x 5mm brass mount.

Available to order as:

all embedded into a 5mm Ø x 5mm (thick) brass mount:

ANC-1314, Aluminium / Silicon

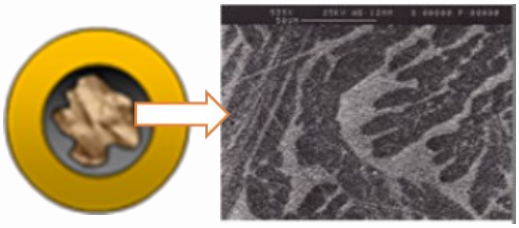
ANC-2829, Nickel / Copper

ANC-4647, Palladium / Silver

ANC-7879, Platinum / Gold

Duplex Brass Atomic Number Reference Standard

This standard allows checking the resolution and performance of the Backscattered Electron Detector. The resolution of a detector is usually quoted as 0.1 (Z) where the atomic number (Z) = 30. This is obtained in our standard by the mean atomic number between the phases of α/β Brass, being 0.1Z.



Phases of Duplex Brass:
Darker Phase Z = 29.37
Lighter Phase Z = 29.47

Available to order as:

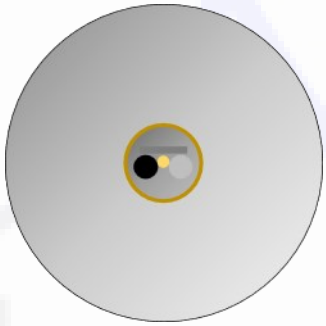
ANC-DBR, *Duplex Brass embedded into a brass mount, 5mm Ø x 5mm (thick)*

Backscattered Electron (BSE) Calibration Standards

Basic BSE Detector Test Standard

An electron microscope, when equipped with a Backscattered Electron Detector, has the capacity to produce images in which contrast is controlled by the differences in atomic numbers (Z) across the specimen. This reference specimen consists of four high purity elements that cover the low, medium, and high BSE grey scale. They are embedded in close proximity, in a contrasting matrix into a standard 12.7mm Ø pin stub.

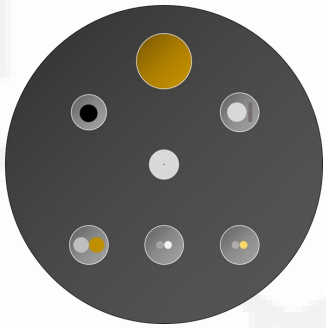
The Carbon and Cobalt samples can also be used for the Beam Measurement & Energy Calibration of the EDS/WDS Detector if fitted to the SEM.



Available to order as:

ANC-PAS, *Carbon / Cobalt / Gold / Rhodium, embedded into a standard 12.7mm Ø Pin stub.*

BSE Detector Calibration Standard



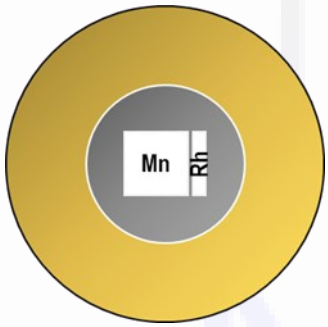
Duplex Brass	The resolution of a detector can usually be quoted as 0.1Z where the atomic number Z=30. This is obtained in our standard by the mean atomic number between the phases of α/β Brass, being 0.1Z.
Carbon	Beam measurement & energy calibration (low).
Aluminum/Silicon **Nickel/Copper** **Palladium/Silver** **Platinum/Gold**	Embedded in pairs (in close proximity) and have an atomic no. difference of 1Z, they can not only be used for checking the BSE detector across the full range of grey scales but can also be used as EDX/WDX energy beam and energy calibration standards.
150µm F-Cup	Electron beam stability.

Available to order as:

BSE-30C, *embedded into a Carbon disc, 30mm Ø x 5mm (thick).*

Backscattered Electron (BSE) GSR Standards

Manganese / Rhodium GSR Standard

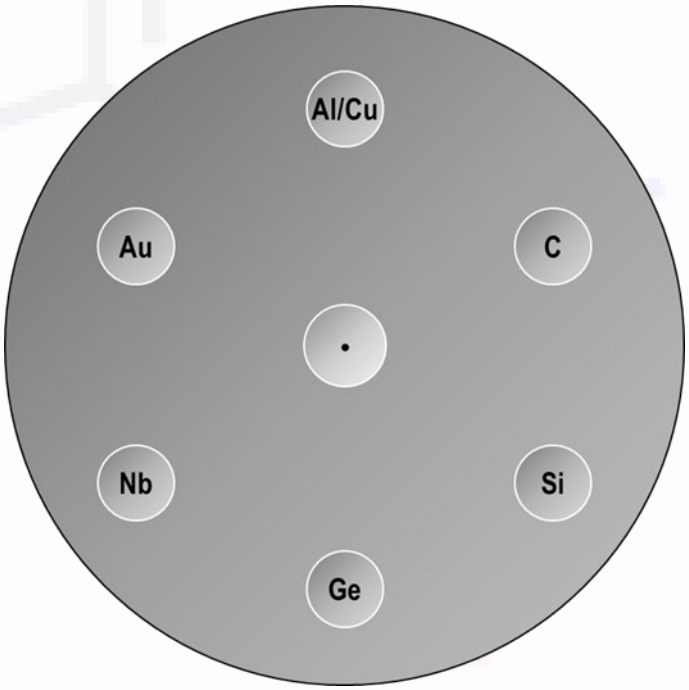


Available to order as:

***ANC-GSR**, 5mm Ø x 5mm Brass Mount*

Multi-Element GSR Standard

The high purity Al/Cu samples embedded into this standard can also be used for energy/beam calibration.



Available to order as:

***BSD-GSR7**, embedded into a standard 12.7mm Ø Pin stub*

Custom/Bespoke Standards

Customised Standards

Although our range of universal standards is extremely comprehensive, MAC are aware that they do not always provide the specialisation that some users require. This is why MAC is happy to work directly with you to help to produce standards as unique as the environment in which they are to be used and reflect the requirements which have been identified.

We are able to design, produce & manufacture standards for most microanalysis instrumentation including customised mounts specially designed for your needs.
We are able to offer mounts manufactured in Brass, Aluminium or Stainless Steel.

When enquiring about custom built standards, we would ask that the following information is provided, to help you with the most appropriate solution:

- Make and model of instrument in which standards are to be used
- Specify quantity and standard materials required
- Outer diameter of the mount or individual required
- Inner diameter where appropriate
- Thickness of mount (5mm normally supplied)
- Material of the mount to be used (normally Brass)
- Whether a Faraday Cup is required
- Any limitation of the X and Y movements of the stage
- Any additional requirements

Customised Standards – Single Materials

Individual standards are usually supplied as:
##-Std – Embedded into a 5mm Ø x 5mm brass mount. *
##-Pin – Embedded into a standard Aluminium 12.5mm Ø pin stub.
##-M4 – Embedded into a 15mm Ø Aluminium Hitachi M4 threaded mount. *
* *Attached to a standard pin stub using a carbon tab for transportation. Can be used either as attached or removed from the stub.* Other sizes/types are available.

Customised Standards - Multiple Materials

The number of standards we would be able to embed into a single mount would be restricted by the mount dimensions. These range from 3mm – 32mm Ø and are usually 5mm thick, although mounts can be manufactured to your specific requirements.
Please contact us or your MAC distributor to discuss your individual requirements.

Unmounted Standards

We are also able to offer unmounted samples/grains of materials which are available as wires 0.25 to 2mm and grains approximately $2mm^3$ in size.

Please contact us or your MAC distributor to discuss your individual requirements.

Mount Examples

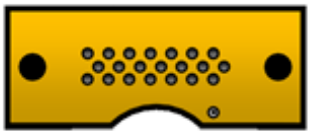
In addition to our standard type mounts that are compatible with most types of SEM stage configurations i.e. JEOL, ZEISS and HITACHI, we also carry a range of carousels and specially manufactured mounts.

Carousels

The carousel is able to nestle around the outside of the users original mount. These mounts are custom made and therefore the original mount dimensions are required. The number of standards which can be embedded in this type of mount is dependent on the dimensions required.

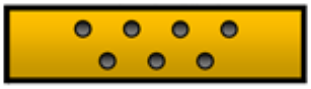
Specially Manufactured Mounts

If our range of mounts do not accommodate your requirements, we would be happy to work with you to provide mounts that meet your specifications.
Some examples are shown below:



Available as: JL-01

Available as: JL-03



Available as: JL-02

Customised Standards

Other MAC Standards

X-ray Fluorescence Spectroscopic Standards

Our XRF standards are available for 60 elements and can be purchased individually or as a set. For an up-to-date list , please refer to our Materials List Brochure or our Website -

http://www.micro-analysis.com/standards/xrf/xrf-standards.asp

These Standards are supplied as 1¼" diameter pressed pellets and are prepared from carefully selected elements and compounds to ensure interference free spectra. Each pellet is supported by a thin-walled aluminium cup which affords protection from damage during handling.

The precious metal foils are approximately 10mm Ø x 0.125mm thick and are mounted into Perspex supports.

Supplied in a specially designed storage/transportation case that contains:

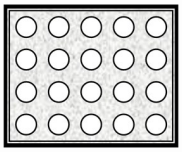
- The standard—protected by an additional specially designed case
- A full electronic booklet on a USB, containing:
  - The plan/layout
  - Certificates of analysis for each material
  - Details on storage and care of your standards
  - Certificate of final inspection
- A replaceable silica gel capsule for protection whilst in transit
- A credit card sized quick reference guide

A copy of the electronic booklet is also accessible from our cloud storage.

X-ray Fluorescence Spectroscopic Standard Sets

These standards are supplied as 1¼" diameter pressed pellets and are prepared from carefully selected elements and compounds to ensure interference free spectra. Each pellet is supported by a thin-walled aluminium cup which affords protection from damage during handling.

Supplied with typical compositions for each pellet mathematically calculated from starting materials used in the manufacture of the pellet.



XRF-UNI

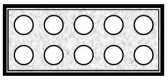
Al ~99%	Ba ~50%	Ca ~40%	Cl ~61%	Cr ~95%
Cu ~99%	Fe ~99%	Pb ~99%	Mg ~90%	Mn ~90%
Ni ~99%	Nb ~63%	P ~20%	Si ~75%	Na ~43%
S ~99%	Sn ~99%	Ti ~99%	W ~90%	Zn ~99%

XRF-A

Al ~99%	Ba ~50%	Ca ~40%	Cl ~61%	Cr ~95%
Co ~99%	Cu ~99%	Fe ~99%	Pb ~99%	Mg ~90%
Mn ~90%	Ni ~99%	P ~20%	K ~39%	Si ~75%
Na ~43%	S ~99%	Ti ~99%	V ~50%	Zn ~99%

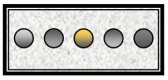
XRF-B

Sb ~67%	As ~68%	Bi ~80%	Br ~81%	Cd ~83%
Cs ~61%	Hf ~4%	I ~17%	Hg ~93%	Mo ~99%
Nb ~63%	Rb ~5%	Se ~10%	Sr ~37%	Ta ~90%
Te ~90%	Sn ~99%	W ~90%	Y ~71%	Zr ~56%



XRF-REE

Ce ~4%	Dy ~4%	Eu ~4%	Gd ~4%	Ho ~4%
La ~4%	Nd ~4%	Pr ~4%	Sm ~4%	Yb ~4%



XRF-PM – 10mm Ø x 0.1mm (thick) foil discs

Au ~99.99%	Pd ~99.99%	Pt ~99.99%	Rh ~99.9%	Ag ~99.99%

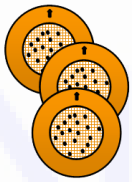
TEM Thin Film Sets

These standards are supplied as fine powders dispersed onto holey carbon films supported by 400 mesh 3.05mm Ø Copper grids. Selected from a range of pure/ synthetic and minerals.

Each sample is supplied with a certificate of analysis that was recorded from our master specimen for each material using our SEM/EDS equipment. These samples had been embedded, polished and Carbon coated.

Film-UNI

Ag_2Te	Baryte	Beryl	Bi_2Se_3	$CaMoO_4$
$CaWO_4$	CdTe	$CeAl_2$	Chalcocite	Chromite
GaAs	G.G.G	HgTe	InP	InSb
Orthoclase	LaB_6	$Li_2Ta_2O_6$	Olivine	Cryolite
K453 Lead Germanate-Glass	$SrTiO_3$	TlBr	ZnS	Zircon



Film-REE

$CeAl_2$	DyF_3	ErF_3	EuF_3	GdF_3
HoF_3	LaF_3	LuF_3	NdF_3	PrF_3
SmF_3	TbF_3	TmF_3	YbF_3	

TEM-EDX Calibration Specimen

Many Transmission Electron Microscopes and Scanning Transmission Electron Microscopes are interfaced to energy dispersive X-ray (EDX) detectors and are used routinely to carry out quantitative and qualitative microanalysis.

MAC now have available uniformly thin (~600°A) Cu films which are carbon coated on both sides mounted on Al grids: they give consistent K:L ratios over the whole specimen.

Typical data taken from different specimen regions is shown in the table for a specific EDX system. Cu Ka and Cu La intensities and their ratios are given, and it can be seen that the ratio is sensibly constant. The spectra can be obtained without fully focusing the electron probe so the risk of contaminating the sample is small. The carbon coating limits the rate of oxidation of the samples and they can be kept for many months in a vacuum desiccator. The ratio of Cu K:Cu L has also been measured on specimens made at very different times and the values lie within the range shown in the table. The absolute value will of course be different for different EDX systems.

The calculated influence on the Cu K/Cu L ratio, of contamination (taken to be carbon) on the Be window, is modelled, together with the change in detector efficiency for the Cu K and Cu L, which is given for a particular EDX system. The calculated change in the Cu K:Cu L ratio originates totally from absorption of the Cu L in the C. It can be seen from the figure that the ratio increases very significantly if a few hundred nanometres of C are deposited on the window. While the Cu K detection efficiency is constant, the Cu L detection efficiency falls away. This reflects the manner in which the softer (lower energy) signal is absorbed.

By actually measuring the Cu K and Cu L peaks using the MAC test specimen, data similar to that shown in the table can be obtained to monitor the detector performance.

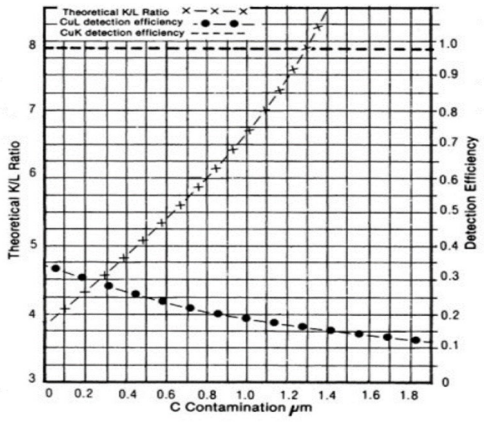
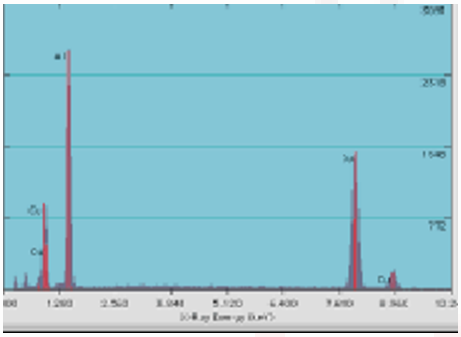


Table showing the X-ray data obtained from the Thin Cu Film

Integrated X-ray counts			Ratio of CuKα/CuLα
Sample 1	CuKα	CuLα	
Area 1	216,831	53,912	4.022
Area 2	239,006	59,678	4.005
Area 3	251,683	63,691	3.952
Area 4	258,388	65,299	3.957
Sample 2			
Area 1	248,226	61,736	4.021

Cu K(α) energy = 8.04 keV

Cu L (α) energy = 0.93 keV



Available to order as:
TEM-CAL *— Cu foil mounted on a 3.05mm Ø Al TEM Grid*

Materials

MAC Materials

We only ever purchase materials from some of the worlds leading material manufacturers and suppliers.

Before any new material is accepted into stock and made available for embedding it goes through a series of vigorous checks:

- **Visual Inspection**
  The material is checked to confirm that the form is as expected and all associated material documentation has been received.
- **Unmounted (loose) SEM Inspection (if needed)**
  The form and approximate composition of the material is checked prior to being processed to the next stage and the results recorded and kept on file.
- **Mounted SEM Inspection**
  A sample of the material is embedded, polished and if required Carbon coated. This embedded piece (our specimen standard) is then checked in our SEM with both the Secondary and Backscattered images recorded and saved on file. The material is then subjected to full analysis using our own EDS equipment with the results stored on file and used as a reference for all future embeddings.

We have a constantly evolving range of materials available from:

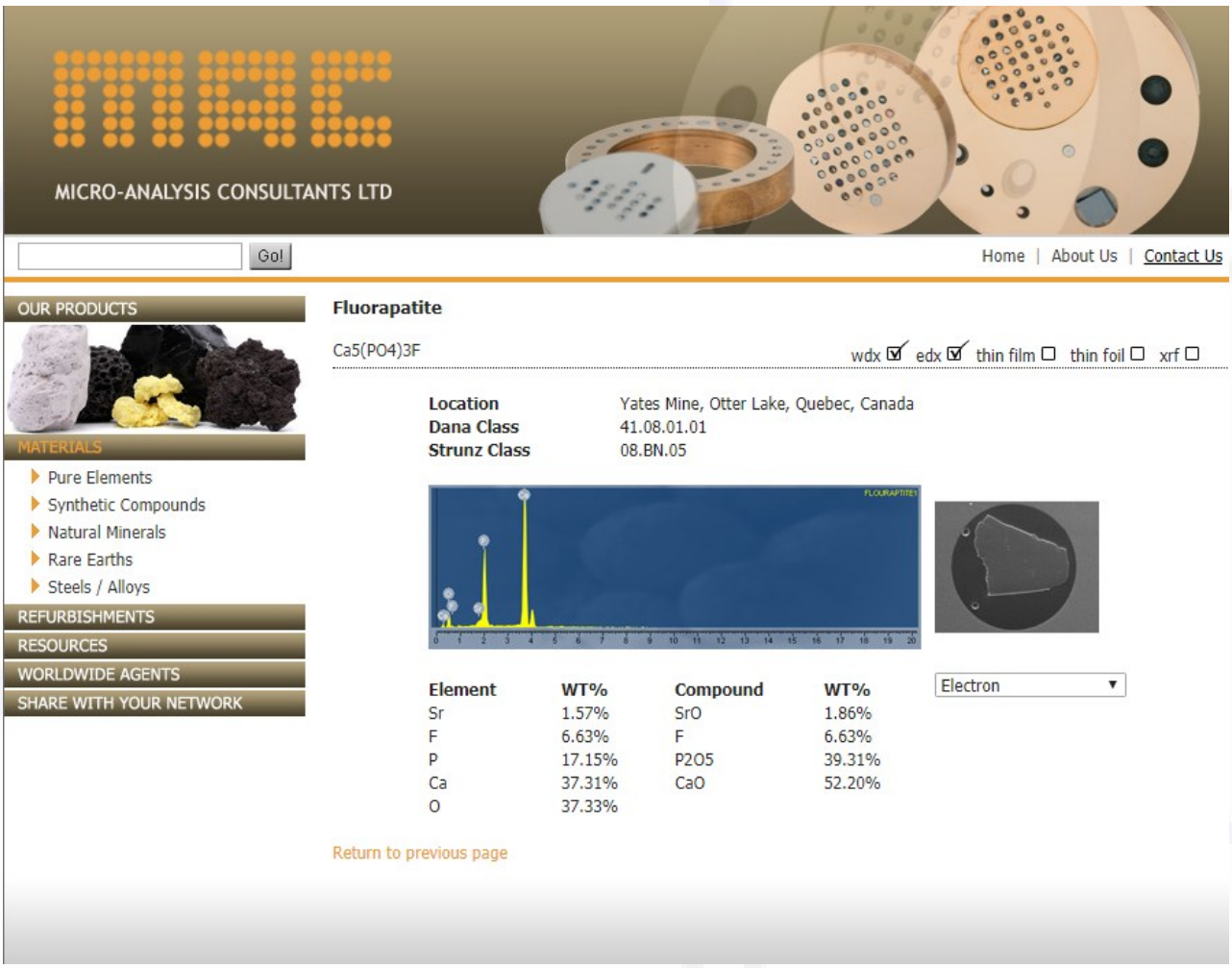
- High Purity Single Elements
- High Purity Synthetic Compounds
- Steels and Alloys, many of which are traceable to a national institution such as NIST
- Natural Minerals and Rocks

For an example of some of the materials available, please refer to our website where you will find further information for each material available.
(see example on the next page)

Please contact us if you find the material you require is not listed as we may still have it.

Should we not be able to fulfil your requirements from our available materials, we will do our best to find a source or enquire about having it custom made.

Example Material from our website



Materials

Refurbishing Your Standards

Refurbishments

We recommend that the standards we manufacture are returned every 2 years for re-polishing. This is to ensure that they consistently deliver the results that are expected. With ISO certification playing a larger role in businesses worldwide, having your standards refurbished on a regular basis can show your commitment to delivering part of the servicing requirements of this certification.

With regular refurbishment of your block of standards, you will be able to consistently achieve the results that your require.

Typical signs that indicate that your block of standards may need refurbishment are:-

- Charging
- Scarring caused by the electron beam
- Handling marks i.e. scratches, fingerprints etc.
- Surface contamination

The refurbishment service which is offered at MAC allows you to have your set of standards restored to a “like new” condition at a fraction of the cost of a replacement. With over 40 years of expertise in the manufacturing of standards that contain a wide variety of materials, we are able to apply this knowledge and experience, not only in the refurbishment of the standards that we have produced but also in refurbishing standards produced by other manufacturers.

The cost of the refurbishment will be dependent upon the type of standard and the work required to return it to an “as new” condition. This can only be possible once the standard has been received at MAC and inspected.

We are happy to offer a preliminary quotation for a basic service which would include:

- Initial standard inspection both optically and in our SEM
- Checking the analysis results via EDX prior to any work commencing
- Cleaning and re-polishing the standard
- Re-application of the Carbon coating (if required)
- Final Inspections and EDX analysis test
- Certificate of Refurbishment

This preliminary quotation would be confirmed or amended once your standard had been received and inspected.

Please do not return any standards to us without first receiving a Returns Authorisation Number.

Refurbishment Programme

Refurbishments—The Process

What happens?

Once your standard has been received at MAC it will undergo a series of initial inspections to assess whether refurbishment is suitable.

The standard will be checked both optically; under a microscope and electronically in our SEM-EDS. Whilst the standard is in our SEM the analysis will also be checked for any irregularities/contamination.

Upon completion of the inspection

If no additional work has been identified or no further recommendations have been made that would fall outside a standard refurbishment, the preliminary quotation will be confirmed and once authorisation has been received the standard will enter our refurbishment process.

If it is discovered that there is a need for additional work or recommendations, we will contact you detailing our findings. The refurbishment will at this point be put on hold until authorisation has been received to continue.

Examples of recommendations include:

- Faraday Cup replacement
- Material replacement
- Calibration standard replacement

Once your standard has entered our refurbishment process, it will continue via our normal procedures ending with a final polish of ¼ µm and the Carbon coating re-applied (if required). Your standard will then be tested and checked against the original certification issued with the standard (if available).

Should you require new certificates of analysis based upon our EDX final testing, we would require pre-notification as this will be charged for.

A standard refurbishment usually takes 14 days, however this time can be affected by any additional work that maybe required.

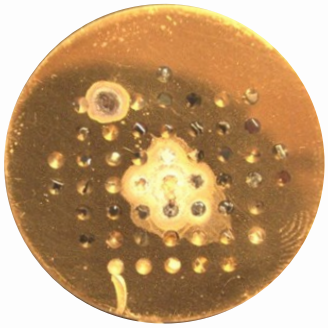
Whilst your standard is with us for refurbishment, it may be worth considering the addition of extra standards as the refurbishment process offers an ideal opportunity for this to occur (please advise during initial conversations if this is something that you may be interested in).

If you are unsure if your standards need to be refurbished please contact us or your distributor and we will be happy to advise you.

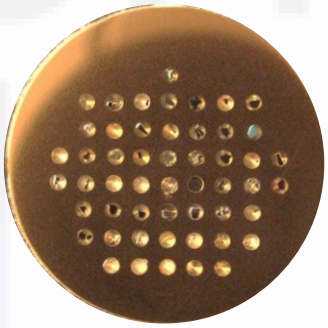
Please do not return any standards to us without first receiving a Returns Authorisation Number.

Refurbishment Programme Examples

Degraded Materials



Before

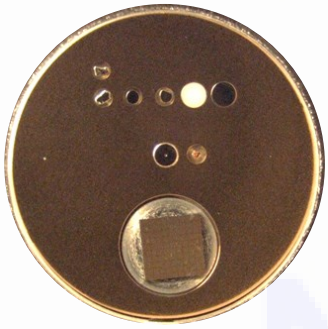


After

The moisture sensitive materials in this standard had degraded due to incorrect storage/handling. The degradation spread across the surface of the mount contaminating the surrounding materials. The effected materials were replaced; complete standard re -polished and Carbon coat re-applied.

Beam Damage

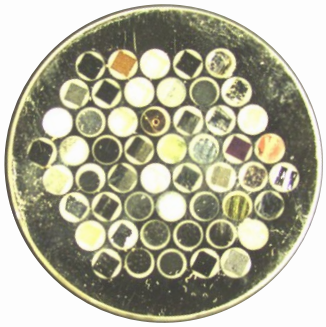
Before



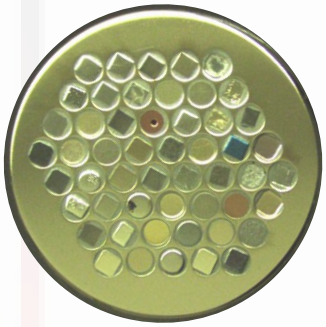
After

The PTFE material mounted into this standard had suffered with extensive damage from the electron beam. The sample was replaced along with the faraday cup; complete standard re-polished; Carbon coat re-applied and a new silicon magnification grid fitted.

Non-MAC Standards



Before



After

This old Charles Taylor standard had suffered from general use over many years. The surface of the mount was dirty and many of the standards were scratched and contaminated. The complete standard was re-polished and the Carbon coat re-applied.

Additional Information

MAC Standards

Standards manufactured by us are designed and built to last, providing you with many years of service. We take great pride in every standard we produce and as such we guarantee them to be free from manufacturing defects for a period of two years*.

The materials used in the manufacture of our standards are only ever sourced from reputable companies and have been tested and checked for suitability prior to being accepted into stock. Where applicable, each material will be accompanied by either a certificate of analysis or certificate of conformity.

Mounted Materials
If applicable, the materials have been embedded into a matrix that is suitable for:

- Affixing the material into position
- Hardening with minimal blow holes (bubbles)
- Withstanding the vacuum and not damaging readily under the action of the electron beam

Should the materials be mounted in an alternative matrix, this will be indicated on the plan that accompanies the standard.

Where necessary the standard will have been coated with approximately 25nm of Carbon, this is to reduce any possible charging effects under the electron beam. If a Carbon coat has been applied, it will be also be indicated on the plan.

The Customer should never attempt to clean the standard or remove the Carbon coating (if applied). The standard should be returned to MAC or your distributor for professional refurbishment.

Health and Safety
Due to the size of the materials used and the way in which they are embedded, our standards offer no serious hazards. Standard laboratory procedures should be used including:

- Keeping the handling of the standard to a minimum
- Wearing suitable gloves or using the appropriate tweezers
- Never attempting to remove an embedded material
- Keeping the standard stored under suitable conditions

Standards no longer required should either be disposed of in a suitable manner or returned to MAC for safe disposal.

Packaging, Storage and Transportation
Our standards are carefully packed to ensure adequate protection during transportation against physical and moisture damage.

WHEN NOT IN USE, THE STANDARD SHOULD BE STORED UNDER VACUUM OR IN A SUITABLE DESICCATOR IN A TEMPURATURE CONTROLLED ENVIRONMENT

**MAC cannot accept responsibility for the misuse or inadequate storage of our standard.*

Intended Use

The standards manufactured/supplied by Micro-Analysis Consultants Limited (MAC) have been designed for use in a Scanning Electron Microscope and may include any of the following:

Accessory Standards

- Faraday Cup - For accurate probe/specimen measurement/monitoring of the SEM beam current.
- Magnification specimens - The Calibration/Verification of the SEM is extremely important if measurements are made on SEM images. Magnification within the SEM changes with working distance and the magnification error can be in the range of up to 10%.
- Resolution specimens - SEM resolution is tested in terms of a combination of criteria, namely resolved gaps and the number of grey levels in the image. This is to ensure that the resolution has not been distorted by using the contrast to maximise visibility of edges. High resolution images ideally should show fine detail together with a lack of noise, evidenced by a good range of grey levels.

Embedded Material Samples

- For the calibration and testing of Energy Dispersive X-ray Spectrometers (EDS), Wavelength Dispersive X-ray Spectrometers (WDS), Backscattered Electron Detectors (BSD) fitted to SEM's and Electron Probe Micro-Analysers (EPMA).

STANDARD PREPARATION *(embedded materials)*

Standards manufactured by MAC are prepared following the guidelines in ISO 22309:2011, ASTM E3-11 and ASTM E1508-12a.
MAC only purchases materials from leading suppliers to ensure consistently high quality. Each standard is stamped with its own unique serial number for identification.

ANALYSIS *(embedded materials)*

EDS analysis was carried out on samples representative of each material batch embedded, following the guidelines detailed in ISO 22309:2011 and ASTM E1508-12A. These representative samples are known as our Master Standards and the materials embedded into this standard have been checked and verified against these Master Standard analytical results.

TRACEABILITY *(embedded materials)*

The Energy Calibration of the equipment used to obtain the analysis results was calibrated using a Cobalt standard traceable to the International System of Units (SI) via NPL (National Physical Laboratory).

EXPIRY *(embedded materials)*

Subject to the correct handling and storage, this standard does not have an expiry date. We do recommend that our standards are returned every two years for cleaning, re-polishing and to have the Carbon coating re-applied if applicable. Some Certified Reference Materials may include an expiry date and if applicable, will be detailed on the materials certificate of analysis.

NOTES

Formulas used for minerals or alloys are the generic formulas and may not represent the actual chemical composition. Please refer to the relevant material certificate for more information.

Care of Standards

The customer should never attempt to clean the standard or remove the Carbon coating if applied. The surface is polished to such a high degree that rubbing with the softest of tissue can damage it. Only recognised cleaning agents such as Evolve CH15 should be used if it is felt necessary and should be carried out by a qualified technician.

ON NO ACCOUNT SHOULD THE STANDARD BE SUBJECTED TO ULTRASONIC CLEANING AS THIS IS TOO RIGOROUS AN ACTION.

Standard laboratory procedures should be used including:

- Keeping the handling of the standard to a minimum
- Wearing suitable gloves or using appropriate tweezers
- Never attempting to remove an embedded material

Storage

Your standard has been carefully packed with silica gel to keep moisture at bay. This is used for transportation purposes only and is not meant as a means for permanent storage.

Some of the material embedded may be moisture/air sensitive and may naturally form a protective oxide layer.

WHEN NOT IN USE, THE STANDARD SHOULD BE STORED UNDER VACUUM OR IN A SUITABLE DESICCATOR IN A TEMPURATURE CONTROLLED ENVIRONMENT

We cannot accept responsibility for the misuse or inadequate storage of the standard by the customer. If in doubt please contact us or your MAC distributor for assistance.

Caring for your Standard

Traceable/Certified Materials for Microanalysis - Microprobe or SEMS' With EDS or WDS

Traceability

In many countries, national standards for weights and measures are maintained by a National Measurement Institute (NMI) which provides the highest level of standards for the calibration / measurement traceability infrastructure in that country. Examples of government agencies include the National Physical Laboratory, UK (NPL) the National Institute of Standards and Technology (NIST) in the USA, the Physikalisch-Technische Bundesanstalt (PTB) in Germany, and the National Metrology Institute of Japan (NMIJ).

"Traceability is the property of the result of a measurement, not of an instrument or calibration report or laboratory. It is not achieved by following any one particular procedure or using special equipment. Merely having an instrument calibrated, even by NIST, is not enough to make the measurement result obtained from that instrument traceable to realizations of the appropriate International System of Units (SI) unit or other specified references. The measurement system by which values and uncertainties are transferred must be clearly understood and under control". (source, NIST website).

The term "measurement traceability" is used to refer to an unbroken chain of comparisons relating an instrument's measurements to a known standard. Calibration to a traceable standard can be used to determine an instrument's bias, precision, and accuracy. It may also be used to show a chain of custody - from current interpretation of evidence to the actual evidence in a legal context, or history of handling of any information.

Certified Reference Materials

Certified Reference Materials (CRM's, SRM's, etc) can be commonly misunderstood. A CRM is usually certified for a specific type of analysis using the method stated in the certificate.
Certified Refence Materials that have been specifically designed for Electron Dispersive X-ray Spectroscopy (EDS, EDX, EDXS or XEDS), Wavelength Dispersive X-ray Spectroscopy (WDXS or WDS) or Electron Probe Micro Analyser (EMP or EMPA) are very sparse and are usually found as alloys or glasses.
High purity single elements are even rarer and it is usually the measurement of the trace elements that are certified and not the Major element itself. The purity of this would normally be calculated by difference. As most of the trace elements detected would be less than the detection limits of EDS, WDS etc, they would not be seen.

The problems associated with the shortage of microanalytical reference materials available for Electron Microprobe, Scanning Electron Microprobe and other in situ instruments that provide quantitative chemical analysis are well known and an interest group exists that are working to remedy this (FIGMAS).

MAC Materials (excluding Minerals)

Many of the materials sourced have been obtained from world leading material suppliers and have had in-depth testing, however the suppliers at present are reluctant to supply information regarding which laboratory tested the material and whether they were ISO accredited or not. They seem to regard this information as business sensitive.
Some materials, even available to order today have been produced some time ago, before ISO was popular.
All have stated that they stand behind all data included in their C.O.A's.

Minerals

Most Mineral specimens are obtained from collectors/dealers and as such are supplied with no analysis results. In the majority of cases the analysis result shown in the COA has been obtained using our inhouse testing.

Please contact us for further information

Standard Terms & Conditions for Sale of Goods

I. **Definitions**

In this document the following words shall have the following meanings:

1. "Buyer" means the organisation or person who buys Goods
2. “Goods" means the articles/services to be supplied to the Buyer by the Seller;
3. Intellectual Property Rights" means all patents, registered and unregistered designs, copyright, trademarks, know-how and all other forms of intellectual property wherever in the world enforceable;
4. "Seller" means Micro-Analysis Consultants Ltd (MAC) 19-21 Edison Road, St Ives, Cambridgeshire, PE27 3LF, United Kingdom

II. **General**

1. These Terms and Conditions shall apply to sales of Goods by the Seller to the Buyer to the exclusion of all other terms and conditions referred to, offered or relied on by the Buyer whether in negotiation or at any stage in the dealings between the parties, including any standard or printed terms tendered by the Buyer, unless the Buyer specifically states in writing, separately from such terms, that it wishes such terms to apply and this has been acknowledged by the Seller in writing.
2. Any variation to these Terms and Conditions (including any special terms and conditions agreed between the parties) shall be inapplicable unless agreed in writing by the Seller.

III. **Price and Payment**

1. Unless otherwise noted, prices do not include freight, handling fees, taxes and/or duties and are subject to correction or change without notice.
2. The Buyer will be responsible for payment of all applicable national, state and local sales taxes and import duties.
3. Credit terms may be offered subject to satisfactory credit vetting of the Buyer by the Seller. The offer of credit will be at the sole discretion of the Seller.
4. Where credit is offered payment of the price and VAT and any other applicable costs shall be due within 30 days of the date of the invoice supplied by the Seller, unless otherwise agreed in writing. In cases where credit is not offered payment will be required before release of goods by the Seller.
5. The Seller shall be entitled to charge interest on overdue invoices from the date when payment becomes due from day to day until the date of payment at a rate of 2 per cent per annum above the base rate of the Bank of England
6. If payment of the price or any part thereof is not made by the due date, the Seller shall be entitled to:
    1. Require payment in advance of delivery in relation to any Goods not previously delivered;
    2. Refuse to make delivery of any undelivered Goods without incurring any liability whatever to the Buyer for non-delivery or any delay in delivery;

IV. **Description**

Any description given or applied to the Goods is given by way of identification only and the use of such description shall not constitute a sale by description. For the avoidance of doubt, the Buyer hereby affirms that it does not in any way rely on any description when entering into the contract.

V. **Sample**

Where a sample of the Goods is shown to and inspected by the Buyer, the parties hereto accept that such a sample is representative in nature and the bulk of the order may differ slightly as a result of the manufacturing process.

VI. **Delivery**

1. Unless otherwise agreed in writing, delivery of the Goods shall take place at the address specified by the Buyer on, or as close as possible to the date required by the Buyer. The Buyer shall make all arrangements necessary to take delivery of the Goods whenever they are tendered for delivery.
2. If the Seller is unable to deliver the Goods because of actions or circumstances under the control of the Buyer, then the Seller shall be entitled to place the Goods in storage until such times as delivery may be effected and the Buyer shall be liable for any expense associated with such storage.
3. Any damages, shortages, over deliveries and duplicated orders should be reported to the Seller within 14 days of signed receipt to enable replacement or refund.

VII. **Risk**

Risk in the Goods shall pass to the Buyer upon receipt of the goods. Where the Buyer chooses to collect the Goods itself, risk will pass when the Goods are entrusted to it or set aside for its collection, whichever happens first.

VIII. **Title**

Title in the Goods shall not pass to the Buyer until the Seller has been paid in full for the Goods.

IX. **Return of Unused Goods**

1. All goods are sold on a firm sale basis, i.e. the Seller will not take back any goods not required or sold by the Buyer, unless otherwise agreed, in which case the following terms apply.
2. Any returns must be authorised by a representative of the Seller before any credit will be given.
3. Where the Seller agrees to accept the return of goods that are not damaged the Buyer will be responsible for the cost of carriage and will ensure that they are carefully packaged to avoid any damage in transit. The Seller will not be obliged to accept any goods that are damaged in any way. The Seller will only accept returns that appear in the Sellers current Stock List.
4. Credit of amounts due or paid in will only be given for goods that are in saleable condition.

X. **Warranties**

All products manufactured by the seller are covered by a 2 year warranty. Products damaged as a result of negligent, improper or inappropriate use or storage will, if possible, be repaired but at the Buyers cost.

XI. **Limitation of Liability**

1. The Seller shall not be liable for any loss or damage suffered by the Buyer in excess of the contract price.
2. Nothing contained in these Terms and Conditions shall be construed so as to limit or exclude the liability of the Seller for death or personal injury as a result of the Seller's negligence or that of its employees or agents.

XII. **Intellectual Property Rights**

All Intellectual Property Rights produced from or arising as a result of the performance of this Agreement shall, so far as not already vested, become the absolute property of the Seller and the Buyer shall do all that is reasonably necessary to ensure that such rights vest in the Seller by the execution of appropriate instruments or the making of agreements with third parties.

XIII. **Force Majeure**

The Seller shall not be liable for any delay or failure to perform any of its obligations if the delay or failure results from events or circumstances outside its reasonable control, including but not limited to acts of God, strikes, lock outs, accidents, war, fire, breakdown of plant or machinery or shortage or unavailability of raw materials from a natural source of supply and the Seller shall be entitled to a reasonable extension of its obligations. If the delay persists for such time as the Seller considers unreasonable, it may, without liability on its part, terminate the contract.

XIV. **Relationship of Parties**

Nothing contained in these Terms and Conditions shall be construed as establishing or implying any partnership or joint venture between the parties and nothing in these Terms and Conditions shall be deemed to construe either of the parties as the agent of the other.

XV. **Assignment and Sub-Contracting**

The contract between the Buyer and Seller for the sale of Goods shall not be assigned or transferred, nor the performance of any obligation sub-contracted, in either case by the Buyer, without the prior written consent of the Seller.

XVI. **Waiver**

The failure by either party to enforce at any time or for any period any one or more of the Terms and Conditions herein shall not be a waiver of them or of the right at any time subsequently to enforce all Terms and Conditions of this Agreement.

XVII. **Severability**

If any term or provision of these Terms and Conditions is held invalid, illegal or unenforceable for any reason by any court of competent jurisdiction such provision shall be severed and the remainder of the provisions hereof shall continue in full force and effect as if these Terms and Conditions had been agreed with the invalid, illegal or unenforceable provision eliminated.

XVIII. **Governing Law and Jurisdiction**

This Agreement shall be governed by and construed in accordance with the laws of England and the parties hereby submit to the exclusive jurisdiction of the English courts

For Further Information

Please Contact Your Local Distributor

or

Micro-Analysis Consultants Ltd

Tel: +44 (0) 1480 462626

Email: standards@micro-analysis.com

Website: www.micro-analysis.com