3 - Calibration standards and specimens

All microscopes include a scale or read-out of magnification which is helpful for the purposes of routine calibration. However, it is not always possible for such a calibration to be as accurate as is required for quantitative results. The rapid growth of automated measuring systems and the advances in EM technology, particularly with high resolution microscopy, within the last two decades has brought a new importance to the standardisation, verification and assessment of instrumentation. Due to pressures of traceability there is an increasing need for specimens which can be utilised for checking instrument performance whether it be on the scale of an optical microscope or an ultra-high resolution TEM.

Agar Scientific specialises in offering and producing a wide range of specimens specifically for this purpose and always endeavours to maintain the highest possible preparation standards in their production. Where possible, we offer specimens that are certified.

The reasons for calibration and the appropriate specimens for TEM, SEM and light microscopes are outlined in a review by A.W. Agar entitled "Calibration of Microscopes for Magnification and Resolution" in Microscopy and Analysis July 1988. A reprint of this article is available on request.

Magnification standards for light microscopy

Stage micrometers

These are used on the stage of the microscope and provide a simple and reliable means of accurately calibrating eyepiece graticules. A finely divided scale is protected by a cover glass to correspond exactly with the specimen it replaces. The scale is prepared on a glass disc mounted in a metal slide (76 x 26 mm) for convenient handling.

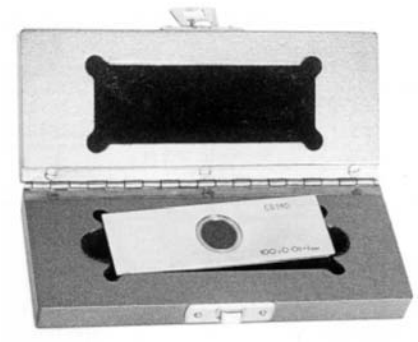
Stage micrometers for use with transmitted light are available with different line lengths and sub-divisions as detailed below:

L4201	Stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 8 µm, accuracy ± 2 µm overall
L4204	Stage micrometer, 2 mm scale, 0.01 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall
L4078	Stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 2 µm, accuracy ± 2 µm overall
L4202	Stage micrometer, 0.1 mm scale, 0.002 mm sub-divisions, line width 1 µm, accuracy ± 1 µm overall
L4203	Stage micrometer, 0.1" scale, 0.001" sub-divisions, line width 2 µm, accuracy ± 0.0001" overall

Micrometers without a cover glass for use with reflected light and suitable for use with metallurgical microscopes are also available.

L4079	Stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 3 µm, accuracy ± 1 µm overall
L4081	Stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall

Certified stage micrometers



Where the highest accuracy of measurement is required or where measurements need to be verified by traceability to known national and international standards, a certified stage micrometer should be specified. Certified stage micrometers are individually calibrated and are supplied with certificates of accuracy. The certificates comply with ISO requirements.

Stage micrometers with UKAS certificate of calibration

Registered laboratories of the United Kingdom Accreditation Service (UKAS) carry out measurements and calibrations that are traceable to national measurement standards held in the UK's National Metrology Institute (NMI), the National Physical Laboratory (NPL). Each UKAS-certified micrometer is permanently marked with an individual reference number, and is supplied in a baize-lined wooden box.

L4201S UKAS-certified stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 8 µm, accuracy ± 2 µm overall

L4204S UKAS-certified stage micrometer, 2 mm scale, 0.01 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall

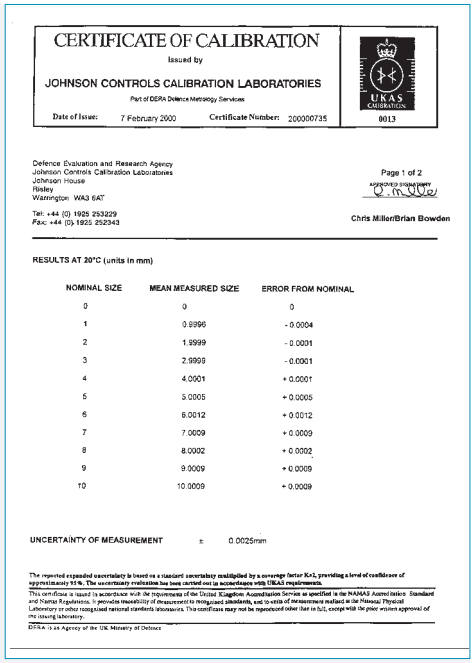
L4078S UKAS-certified stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 2 µm, accuracy ± 2 µm overall

L4202S UKAS-certified stage micrometer, 0.1 mm scale, 0.002 mm sub-divisions, line width 1 µm, accuracy ± 1 µm overall

L4203S UKAS-certified stage micrometer, 0.1" scale, 0.001" sub-divisions, line width 2 µm, accuracy ± 0.0001" overall

L4079S UKAS-certified stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 3 µm, accuracy ± 1 µm overall, for reflected light

L4081S UKAS-certified stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall, for reflected light



CERTIFICATE OF CALIBRATION

Issued by

JOHNSON CONTROLS CALIBRATION LABORATORIES

Part of DERA Defence Metrology Services

Date of Issue: 7 February 2000 Certificate Number: 200000735

UKAS CALIBRATION 0013

Defence Evaluation and Research Agency
Johnson Controls Calibration Laboratories
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Chris Miller/Brian Bowden

RESULTS AT 20°C (units in mm)

NOMINAL SIZE	MEAN MEASURED SIZE	ERROR FROM NOMINAL
0	0	0
1	0.9996	- 0.0004
2	1.9999	- 0.0001
3	2.9999	- 0.0001
4	4.0001	+ 0.0001
5	5.0005	+ 0.0005
6	6.0012	+ 0.0012
7	7.0009	+ 0.0009
8	8.0002	+ 0.0002
9	9.0009	+ 0.0009
10	10.0009	+ 0.0009

UNCERTAINTY OF MEASUREMENT ± 0.0025mm

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

This certificate is issued in accordance with the requirements of the United Kingdom Accreditation Service as specified in the NAMAS Accreditation Standard and Namas Regulations. It provides traceability of measurement to recognised standards, and to units of measurement realised in the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

DERA is an Agency of the UK Ministry of Defence

Stage micrometers with NPL certificate

The NPL, the UK's National Metrology Institute, is a world-leading centre of excellence in developing and applying the most accurate measurement standards. NMIs throughout the world mutually recognise international measurement standards and calibration certificates, including EUROMET, APMP (Asia Pacific) and SIM (Canada & USA). Each NPL-certified micrometer is permanently marked with an individual reference number, and is supplied in a baize-lined wooden box.

L4201NPL NPL-certified stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 8 µm, accuracy ± 2 µm overall

L4204NPL NPL-certified stage micrometer, 2 mm scale, 0.01 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall

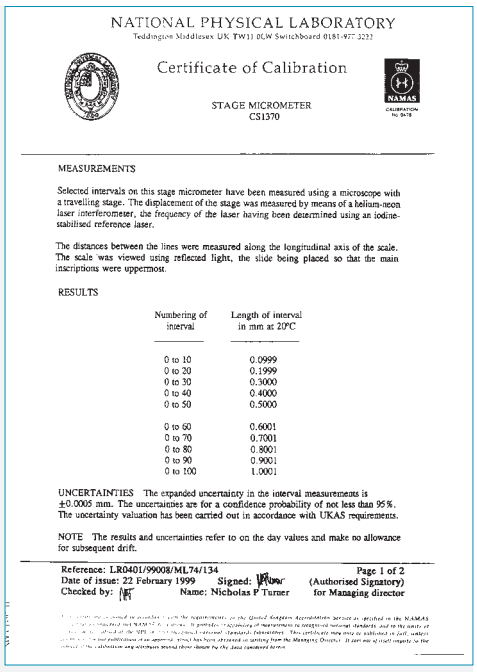
L4078NPL NPL-certified stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 2 µm, accuracy ± 2 µm overall

L4202NPL NPL-certified stage micrometer, 0.1 mm scale, 0.002 mm sub-divisions, line width 1 µm, accuracy ± 1 µm overall

L4203NPL NPL-certified stage micrometer, 0.1" scale, 0.001" sub-divisions, line width 2 µm, accuracy ± 0.0001" overall

L4079NPL NPL-certified stage micrometer, 1 mm scale, 0.01 mm sub-divisions, line width 3 µm, accuracy ± 1 µm overall, for reflected light

L4081NPL NPL-certified stage micrometer, 10 mm scale, 0.1 mm sub-divisions, line width 2.5 µm, accuracy ± 1.5 µm overall, for reflected light



NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Switchboard 0181-977 3222

Certificate of Calibration

STAGE MICROMETER
CS1370

NAMAS CALIBRATION No. 0A78

MEASUREMENTS

Selected intervals on this stage micrometer have been measured using a microscope with a travelling stage. The displacement of the stage was measured by means of a helium-neon laser interferometer, the frequency of the laser having been determined using an iodine-stabilised reference laser.

The distances between the lines were measured along the longitudinal axis of the scale. The scale was viewed using reflected light, the slide being placed so that the main inscriptions were uppermost.

RESULTS

Numbering of interval	Length of interval in mm at 20°C
0 to 10	0.0999
0 to 20	0.1999
0 to 30	0.3000
0 to 40	0.4000
0 to 50	0.5000
0 to 60	0.6001
0 to 70	0.7001
0 to 80	0.8001
0 to 90	0.9001
0 to 100	1.0001

UNCERTAINTIES The expanded uncertainty in the interval measurements is ±0.0005 mm. The uncertainties are for a confidence probability of not less than 95%. The uncertainty valuation has been carried out in accordance with UKAS requirements.

NOTE The results and uncertainties refer to on the day values and make no allowance for subsequent drift.

Reference: LR0401/99008/ML74/134
Date of issue: 22 February 1999
Checked by:

Signed:
Name: Nicholas P Turner

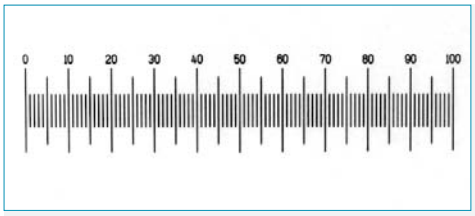
Page 1 of 2
(Authorised Signatory)
for Managing director

Long stage micrometer

Calibration of compound microscopes at low magnifications, stereo microscopes and measurement of fields of view require a longer scale than those traditionally available. This stage micrometer has a high accuracy scale of 20 mm length, which is sub-divided into 10 µm divisions. The scale is produced as a vacuum deposited chrome image on glass, with a cover glass cemented on top. This is mounted in a stainless steel slide mount and is supplied in a polished wooden case.

L4207 Stage micrometer, 20 mm scale, 0.01 mm sub-divisions
L4207S UKAS-certified stage micrometer, 20 mm scale, 0.01 mm sub-divisions
L4207NPL NPL-certified stage micrometer, 20 mm scale, 0.01 mm sub-divisions

Diamond-ruled stage micrometer



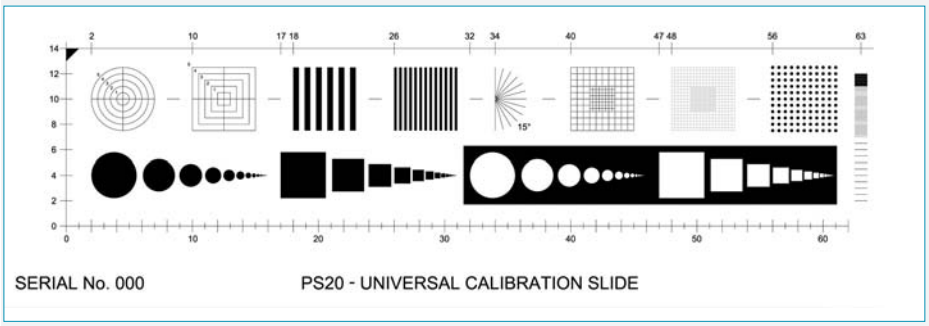
Diamond-ruled scales have very fine lines 3.5 mm long and not wider than 1 µm for high magnification use. The clear line type for transmitted light has lines ruled through a semi-opaque film of Inconel® with a cover glass cemented over the ruling. The ruling appears as bright lines on a dark background.

L4080 Diamond-ruled stage micrometer for transmitted light (clear line)

Universal calibration slide

The universal calibration slide was designed for measurement calibration of microscopes and machine vision systems. It includes 13 different image areas for calibrating numerous parameters, and includes concentric circles and squares, line gratings, grid and dot arrays, geometric root-2 progression of dots and square blocks, and coarse and variable fine linear scales. The slide has fixed datum point marks to easily locate each pattern or array. Each slide has a unique permanent serial number and can be supplied with full or partial UKAS certification.

L4208 Universal calibration slide
L4208S UKAS-certified universal calibration slide



Confocal microscope calibration kit

This is a ready-to-use kit containing slides with multi-fluorescent latex beads in sizes of 0.2, 0.8 and 1.0 µm. The beads on all slides are simultaneously excitable with illumination wavelengths of 458, 488, 514, 543, 568, 633 and 647 nm, and emit fluorescent light simultaneously at 525, 590 and 660 nm.

S1927 Confocal calibration kit

NPL image analysis standard

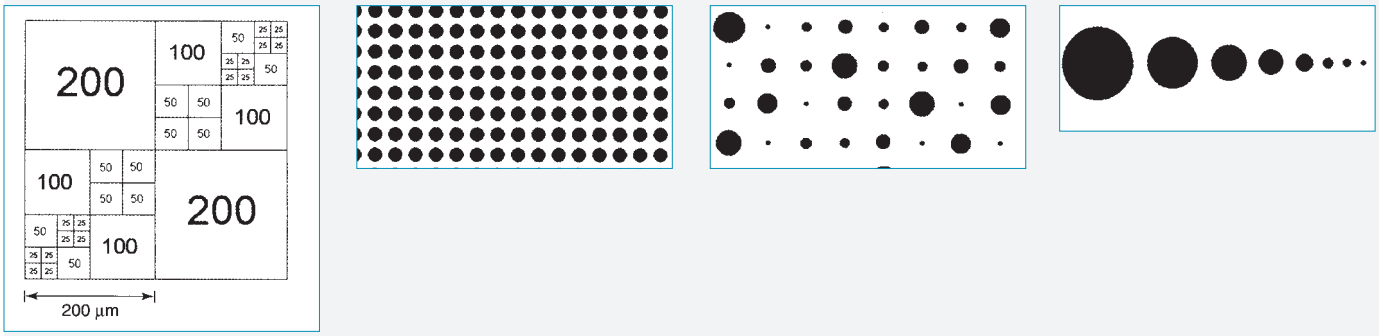
This high precision standard is designed for calibrating image analysis systems and identifying deviations and distortions in optical imaging equipment. The 75 x 25 mm slide has a series of grid patterns of known edge length which can be used for precision measurement.

A mono size array of 15 µm spots is used to check image distortion. A root-2 progression of spots from 3 to 48 µm allows threshold levels and resolution to be checked. Using the log-normal distribution array of 100 spots, the mean and standard deviation of the spot sizes can be determined and compared with the certified values. It is supplied with recommendations for use and an individual NPL certificate of calibration.

There are four test areas (see image):

1. 400 x 400 µm square grid sub-divided into 200, 100, 50 and 25 µm squares which can be used to detect gross image distortions and as an accurate two dimensional stage micrometer.
2. 20 x 17 array of nominally 15 µm diameter dots can be used to identify lens distortions.
3. Root-2 array of spots from 3 to 48 µm in diameter for determining the threshold level of cameras and microscope systems.
4. Log-normal distribution array of 100 spots ranging from 4.5 to 27 µm in diameter enables the mean and standard deviation of the spot size to be determined and compared with certified values.

S1918 Image analysis standard, certified



Micro-Ruler™ MR-1

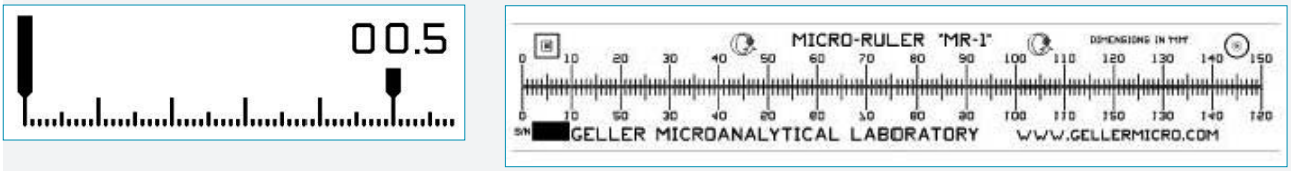
A traceable ruler for magnification verification is an essential part of many quality control programmes. The Micro-Ruler MR-1 is a metric dimensional calibration product to fulfil this purpose. One significant use of the MR-1 is to measure magnified images to determine absolute magnification.

The MR-1 ruler is manufactured using accurate semiconductor fabrication equipment. The pattern is anti-reflective chromium over soda lime glass. The overall size is 180 x 25 x 3 mm and it is labelled in millimetres, with the scale extending over 150 mm with 0.01 mm increments. The linear expansion coefficient is 9 x 10^{-6} ppm/°C and, over its full 150 mm length, the ruler could change dimensions by 1.35 µm/°C. It has been designed to be viewed from either side, as the markings are both right-reading and mirror images, allowing the ruler markings to be placed in direct contact with the sample and avoiding parallax errors. The ruler uncertainty is ± 0.5 µm over 0 to 10 mm length and ± 2.5 µm over the entire 150 mm length.

The ruler also has circles and squares of 0.02, 0.05, 0.10, 0.50, 1.00, 2.00 and 5.00 mm diameter and side length.

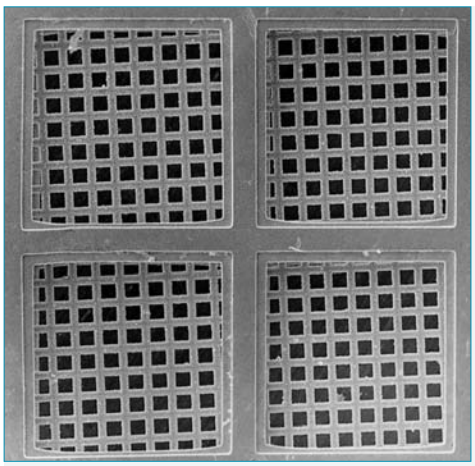
We offer the MR-1 only as a certified traceable reference standard and recommend recertification at five yearly intervals.

L4520 Micro-Ruler MR-1, certified



Magnification standards suitable for both light microscopy and scanning electron microscopy

Fine mesh



This is available in copper, nickel or gold, in 1000, 1500 and 2000 mesh (1000, 1500 or 2000 repeat distance per inch), ie. 25, 18.75 and 12.5 µm. This material is not claimed to be of high accuracy over any one cell spacing. An average over at least 20 spacings should be taken to give reasonable accuracy. The mesh is available in 25 mm squares.

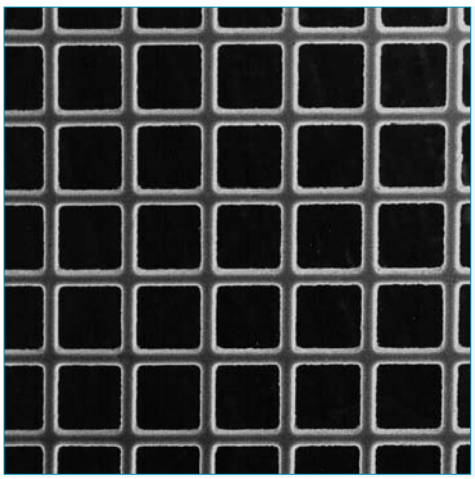
G248C	1000 mesh copper, 25 x 25 mm
G248N	1000 mesh nickel, 25 x 25 mm
G248A	1000 mesh gold, 25 x 25 mm
G243C	1500 mesh copper, 25 x 25 mm
G243N	1500 mesh nickel, 25 x 25 mm
G243A	1500 mesh gold, 25 x 25 mm
G249N	2000 mesh nickel, 25 x 25 mm

The mesh can also be provided as a sandwich in a folding 3.05 mm coarse mesh grid for SEM users.

S151	1000 mesh copper in sandwich grid, 3.05 mm
S152	2000 mesh copper in sandwich grid, 3.05 mm

Please add suffix N (nickel) or A (gold) to catalogue reference if required.

1000 mesh grid



This grid is useful for calibrating magnifications up to x800. An average over at least five lines will give an accuracy of 1.5 %.

S1965	1000 mesh grid

Galvanised mesh

Galvanised mesh is available in copper, gold or nickel with an approximate thickness of 4 µm.

Cat. no.	Material	Mesh	Size (mm)	Hole width (µm)	Bar width (µm)	Max transmission (%)
S188-2000N	nickel	2000	150 x 150	7.6	5	36
S188-1500C	copper	1500	150 x 150	11.2	5.6	44
S188-1500A	gold	1500	150 x 150	11.2	5.6	44
S188-1500N	nickel	1500	150 x 150	11.2	5.6	44
S188-1000C	copper	1000	150 x 150	18	7.4	50
S188-1000A	gold	1000	150 x 150	18	7.4	50
S188-1000N	nickel	1000	150 x 150	18	7.4	50
S188-750C	copper	750	150 x 150	25	8.6	55
S188-750A	gold	750	150 x 150	25	8.6	55
S188-750N	nickel	750	150 x 150	25	8.6	55
S188-670C	copper	670	275 x 275	26	11.7	48
S188-500A	gold	500	150 x 150	40	11.5	60
S188-500N	nickel	500	150 x 150	40	11.5	60
S188-400C	copper	400	190 x 190	49.3	14.2	60
S188-400A	gold	400	190 x 190	49.3	14.2	60
S188-400N	nickel	400	190 x 190	49.3	14.2	60
S188-333C	copper	333	150 x 150	63.7	12.5	70
S188-333A	gold	333	150 x 150	63.7	12.5	70
S188-333N	nickel	333	150 x 150	63.7	12.5	70
S188-300A	gold	300	275 x 275	66	18.5	61
S188-200C	copper	200	150 x 150	112	14.7	78
S188-200A	gold	200	150 x 150	112	14.7	78
S188-200N	nickel	200	150 x 150	112	14.7	78
S188-100C	copper	100	150 x 150	234	19.8	85
S188-100A	gold	100	150 x 150	234	19.8	85
S188-100N	nickel	100	150 x 150	234	19.8	85
S188-80C	copper	80	150 x 150	292.6	24.9	85
S188-80A	gold	80	150 x 150	292.6	24.9	85
S188-80N	nickel	80	150 x 150	292.6	24.9	85
S188-70C	copper	70	275 x 275	344.2	18.5	90
S188-70A	gold	70	275 x 275	344.2	18.5	90
S188-70N	nickel	70	275 x 275	344.2	18.5	90
S188-20C	copper	20	165 x 165	1238	32.3	95
S188-20A	gold	20	165 x 165	1238	32.3	95
S188-20N	nickel	20	165 x 165	1238	32.3	95
S188-5C	copper	5	140 x 140	5029	51	98
S188-5A	gold	5	140 x 140	5029	51	98
S188-5N	nickel	5	140 x 140	5029	51	98

Certified particle size standards

These particle size standards are certified for mean diameter and are traceable to National Institute of Standards and Technology (NIST) standards.

They are available as uniform spheres in a range of discrete sizes from 20 nm to 2000 µm. The spherical diameters are calibrated with linear dimensions transferred from NIST standard reference materials.

The products can be used for the calibration of electron microscopes, AFMs, light scattering instruments and other particle measuring equipment. Size standards are available in polystyrene, silica or glass.

Monosized microsphere size standards 1 - 1000 µm

These highly uniform polystyrene spheres are calibrated by NIST standardised methods which include photon correlation spectroscopy, transmission electron microscopy and light microscopy. The range of diameters from 1 to 1000 µm is ideal for the calibration of electron microscopes, optical microscopes and particle sizing instrumentation. A certificate of calibration and traceability is provided with each standard. Detailed physical and chemical properties are also provided.

They are some of the most uniform spheres available in this size range. Products from 1 to 160 µm are packaged as 15 ml aqueous suspensions in dropper topped bottles. Diameters of 200 µm and larger are packaged as 1 g dry spheres. The spheres have a density of 1.05 g/cm^3 and a refractive index of 1.59 @ 589 nm wavelength.

Cat. no.	Nominal diameter (µm)	Certified mean diameter (µm)	Size distribution std. deviation and CV	Solids content (%)
S1801-1	1.0	0.993 ± 0.021	0.010 µm (1.0 %)	1.0
S1801-2	2.0	2.013 ± 0.025	0.022 µm (1.1 %)	0.5
S1801-2.5	2.5	2.504 ± 0.025	0.025 µm (1.0 %)	0.5
S1801-3	3.0	3.063 ± 0.027	0.03 µm (1.0 %)	0.5
S1801-5	5.0	4.988 ± 0.035	0.05 µm (1.2 %)	0.3
S1801-6	6.0	6.038 ± 0.045	0.07 µm (1.2 %)	0.3
S1801-7	7.0	6.992 ± 0.050	0.07 µm (1.0 %)	0.3
S1801-10	10	9.975 ± 0.061	0.09 µm (0.9 %)	0.2
S1801-15	15	15.02 ± 0.08	0.15 µm (1.0 %)	0.3
S1801-20	20	20.00 ± 0.10	0.20 µm (1.0 %)	0.3
S1801-25	25	25.09 ± 0.12	0.38 µm (1.5 %)	0.5
S1801-30	30	30.10 ± 0.22	0.45 µm (1.5 %)	0.6
S1801-40	40	40.25 ± 0.32	0.6 µm (1.5 %)	0.7
S1801-50	50	50.4 ± 1.0	1.6 µm (3.2 %)	1.4
S1801-60	60	59.8 ± 1.0	2.0 µm (3.3 %)	1.2
S1801-70	70	68.0 ± 1.4	3.2 µm (4.7 %)	1.7
S1801-80	80	79.6 ± 1.0	0.8 µm (1.0 %)	1.8
S1801-100	100	98.5 ± 1.8	2.8 µm (2.8 %)	2.2
S1801-160	160	158.0 ± 3.2	5.5 µm (3.5 %)	5.0

Cat. no.	Nominal diameter (µm)	Certified mean diameter (µm)	Size distribution std. deviation and CV	Count per g
S1801-200	200	200 ± 4.0	5.8 µm (2.9 %)	2.3 x 10^5
S1801-300	300	301 ± 6.0	11.0 µm (3.7 %)	6.6 x 10^4
S1801-500	500	497 ± 10	24.0 µm (4.8 %)	1.5 x 10^4
S1801-750	750	773 ± 15	33.3 µm (4.3 %)	3.5 x 10^3
S1801-1000	1000	1005 ± 20	39.2 µm (3.9 %)	1.6 x 10^3

Uniform polymer microspheres 5 - 40 µm

This series of microspheres has a slightly wider distribution than the monodisperse microsphere size standards. They are suitable for validating a range of instruments, including laser diffraction, electrolyte displacement and other particle sizing methods. The spheres have a density of 1.05 g/cm^3 and a refractive index of 1.59 @ 589 nm wavelength. They are available in a range of sizes from 5 to 40 µm, and supplied in bottles of 15 ml.

Cat. no.	Nominal diameter (µm)	Certified mean diameter (µm)	Size distribution std. deviation and CV	Solids content (%)
S1802-5	5	5.2 ± 0.5	0.6 µm (11.5 %)	0.9
S1802-10	10	10.0 ± 0.3	0.7 µm (7 %)	1.1
S1802-15	15	14.6 ± 0.4	1.1 µm (7.5 %)	0.8
S1802-20	20	20.9 ± 0.6	1.4 µm (6.7 %)	1.3
S1802-30	30	31.1 ± 0.6	1.9 µm (6.1 %)	1.4
S1802-40	40	39.6 ± 0.8	3.6 µm (9.1 %)	1.5

Silica particle size standards 0.5 - 1.6 µm

This series of particle size standards is designed for applications requiring monodisperse inorganic spheres. Like glass, silica has a much higher density than polystyrene and the opaque spheres provide more contrast than polymer particles in optical and electron beams. Calibrated and certified by NIST traceable procedures. These are suitable for a wide variety of particle measuring applications. The spheres have a density of 1.8 - 2.2 g/cm^3 and a refractive index of 1.415 - 1.460 @ 589 nm wavelength. They are supplied in bottles of 15 ml as 2 % solids.

Cat. no.	Nominal diameter (µm)	Certified mean diameter (µm)	Size distribution std. deviation and CV
S1803-05	0.5	0.49 ± 0.02	0.02 µm (4.1 %)
S1803-07	0.7	0.73 ± 0.02	0.03 µm (4.1 %)
S1803-10	1.0	0.99 ± 0.02	0.02 µm (2.0 %)
S1803-16	1.6	1.57 ± 0.02	0.04 µm (2.5 %)

Please ask for a detailed list.

Fluorescent polymer microspheres (aqueous)

Fluorescent microspheres are hard-dyed (internally dyed) polymer beads that incorporate a dye throughout the polymer matrix. This method produces bright fluorescent colours, minimises photo-bleaching and prevents dye leaching in aqueous media. They are available in red, green and blue and are ideal for applications such as contamination control, flow tracing and filter challenges. A range of microsphere sizes is available, from 0.03 - 10 µm in different bottle sizes.

Please ask for detailed list.

Glass size standards

Glass microspheres can be used in any application that requires a NIST traceable size standard with a narrow size distribution, and where sample conditions may not be suitable for polystyrene spheres. The glass microspheres provide better tolerance to chemicals and solvents, in addition to higher mechanical and thermal stability. Also, these glass microspheres are ideal for spacer applications where uniform bond thickness is a necessity.

Glass size standards are ideal for the calibration of microscopes, light scattering instruments and other particle measuring equipment. They can also be used in laser light scattering studies and colloidal research. The glass size standards are highly uniform borosilicate (2 - 20 µm) or soda lime (30 - 2000 µm) glass spheres calibrated with NIST traceable methodology.

The spheres 2 - 20 nm have a density of 2.5 - 2.55 g/cm^3 and a refractive index of 1.56 @ 589 nm wavelength. Those of 30 - 2000 µm have a particle density of 2.4 - 2.5 g/cm^3 and a refractive index of 1.51 @ 589 nm wavelength. Spheres are used instead of irregularly shaped particles to minimise the response of analytical systems to shape effects. Products are packaged as dry spheres.

Cat. no.	Nominal diameter (µm)	Certified mean diameter (µm)	Size distribution std. deviation and CV	Approx number per g
S1816-002	2	2.0 ± 0.5	0.7 µm (35 %)	9.5 x 10^{10}
S1816-005	5	5.6 ± 0.5	0.7 µm (13 %)	4.4 x 10^{9}
S1816-008	8	8.0 ± 0.8	1.0 µm (13 %)	1.5 x 10^{9}
S1816-010	10	9.6 ± 1.0	1.5 µm (16 %)	8.5 x 10^{8}
S1816-015	15	14.1 ± 1.0	1.4 µm (10 %)	2.7 x 10^{8}
S1816-020	20	17.3 ± 1.4	2.0 µm (12 %)	1.5 x 10^{8}
S1816-030	30	30.1 ± 2.1	2.3 µm (7.6 %)	2.9 x 10^{7}
S1816-040	40	40.6 ± 2.8	2.2 µm (5.4 %)	1.1 x 10^{7}
S1816-050	50	49.9 ± 3.0	2.2 µm (4.4 %)	6.3 x 10^{6}
S1816-060	60	60.0 ± 3.6	2.3 µm (3.8 %)	3.6 x 10^{6}
S1816-070	70	72.6 ± 4.4	2.7 µm (3.7 %)	2.1 x 10^{6}
S1816-080	80	79.1 ± 4.0	2.8 µm (3.5 %)	1.6 x 10^{6}
S1816-090	90	90.3 ± 4.5	3.9 µm (4.3 %)	1.1 x 10^{6}
S1816-100	100	97.6 ± 4.9	3.6 µm (3.7 %)	8.3 x 10^{5}
S1816-110	110	111 ± 5.5	4.2 µm (3.8 %)	5.8 x 10^{5}
S1816-120	120	120 ± 6.0	5.2 µm (4.3 %)	4.5 x 10^{5}
S1816-140	140	139 ± 7.0	2.9 µm (2.1 %)	2.9 x 10^{5}
S1816-170	170	167 ± 8.4	6.3 µm (3.8 %)	1.6 x 10^{5}
S1816-200	200	196 ± 5.9	5.7 µm (2.9 %)	1.0 x 10^{5}
S1816-230	230	231 ± 6.9	9.0 µm (3.9 %)	6.2 x 10^{4}
S1816-280	280	279 ± 8.4	9.3 µm (3.3 %)	3.5 x 10^{4}
S1816-330	330	324 ± 10	16.0 µm (4.9 %)	2.2 x 10^{4}
S1816-400	400	391 ± 12	10.1 µm (2.6 %)	1.3 x 10^{4}
S1816-480	480	480 ± 14	17.8 µm (3.7 %)	7.1 x 10^{3}
S1816-550	550	553 ± 17	29.0 µm (5.2 %)	4600
S1816-650	650	655 ± 20	29.0 µm (4.4 %)	2800
S1816-750	750	749 ± 22	19.4 µm (2.6 %)	1825
S1816-950	950	940 ± 28	39.7 µm (4.2 %)	950
S1816-1000	1000	1106 ± 33	28.6 µm (2.6 %)	560
S1816-2000	2000	2007 ± 40	50.9 µm (2.5 %)	95

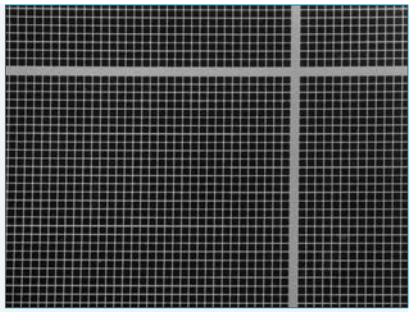
Stainless steel nanoballs

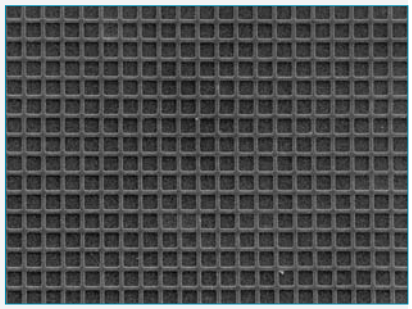
Made from steel, AISI 420c. These balls have a maximum deviation of ± 9.75 µm in diameter and ± 0.25 µm deviation from sphere shape.

S1860-80 Steel nanoballs, nominal size 80 µm. Pack of 10
S1860-100 Steel nanoballs, nominal size 100 µm. Pack of 10
S1860-120 Steel nanoballs, nominal size 120 µm. Pack of 10
S1860-150 Steel nanoballs, nominal size 150 µm. Pack of 10
S1860-200 Steel nanoballs, nominal size 200 µm. Pack of 10

Silicon test specimen

This test specimen is made of single crystal silicon of overall dimensions 5 x 5 mm and is 0.5 mm thick. It is marked with clearly visible squares of periodicity 10 µm. The dividing lines are about 1.9 µm in width and are formed by electron beam lithography. A broader marking line is written every 500 µm, which is a very useful additional feature for light microscopy. This is an excellent specimen for comparing magnification and assessing any distortion in the image field. It is particularly useful in the context of automated counting systems to check for distortions. Where critical measurements must be made, the sample can be mounted directly onto the calibration specimen so that an internal calibration is obtained on the micrograph.





A certificate of calibration can be supplied for the silicon test specimen if required.

S1930 Planotec silicon test specimen, unmounted
S1931 Planotec silicon test specimens, unmounted. Pack of 10
S1932 Planotec silicon test specimen on 12.5 mm pin stub
S1932A Planotec silicon test specimen on 10 mm JEOL stub
S1932B Planotec silicon test specimen on 15 mm Topcon/ISI/ABT stub
S1932C Planotec silicon test specimen on 15 mm Hitachi stub
S1932D Planotec silicon test specimen on customer's stub
S1932E Planotec silicon test specimen on 12.5 mm JEOL stub

The silicon specimen can be supplied on any stub. Please ask.

S1934 Planotec silicon test specimen for incident light microscopy mounted on black slide

Agar calibration service

Individual silicon test specimens can be calibrated to a guaranteed accuracy of better than 1% and are supplied with a laboratory certificate as documented proof. The equipment is checked against a reference specimen calibrated by the NPL by laser beam interferometry. See also recalibration service (page 51).


Agar SCIENTIFIC

SILICON TEST SPECIMEN S1932

CALIBRATED SPECIMEN NO: A679 DATE: 2ND JUNE, 2000

PURCHASER: PURCHASE ORDER NO: 22-0000705063

Glaxo Wellcome Operations
Cobden Street
Montrose
DD10 8EA

Certificate of Calibration

This specimen has been calibrated by diffraction measurements taken from an area approximately 1mm diameter at the centre of the grating area.

The specimen was illuminated by a laser beam of wavelength 632.8nm, and the angular separation of the diffraction beams measured on a certified calibrated rotary table.

The line scribed on the face of the mount was first set horizontal so that rulings perpendicular to this diffracted the incident beam in a horizontal plane (orientation A).

The angular separation of the third to the sixth diffracted beams either side of the centre beam was measured.

The specimen was then rotated to bring the scribed line to the vertical position in order to measure the rulings at right angles (orientation B).

The complete series of readings were performed in duplicate.

The mean angular separation of each diffraction order was calculated. The relationship between the diffraction angle and the grating spacing is given by

$n\lambda = 2d \sin\theta$

where n = diffraction order
λ = illumination wavelength 632.8nm
d = grating spacing in nm
2θ = angle between corresponding diffraction orders on either side of the central beam

Sinθ	d (µm)
0.09469	10.00
0.12657	10.00
0.15813	10.01
0.18984	10.00

L. Howell,
Senior Technical Officer

S1930-CT Certified Planotec silicon test specimen, unmounted
S1932-CT Certified Planotec silicon test specimen on 12.5 mm pin stub
S1932A-CT Certified Planotec silicon test specimen on 10 mm JEOL stub
S1932B-CT Certified Planotec silicon test specimen on 15 mm Topcon/ISI/ABT stub
S1932C-CT Certified Planotec silicon test specimen on 15 mm Hitachi stub
S1932D-CT Certified Planotec silicon test specimen on customer's stub
S1932E-CT Certified Planotec silicon test specimen on 12.5 mm JEOL stub

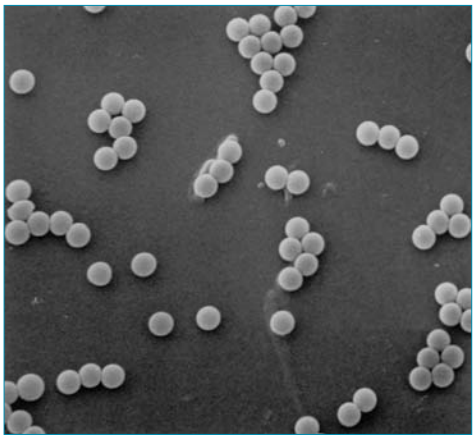
The silicon specimen can be supplied on any stub. Please ask.

S1934-CT Certified Planotec silicon test specimen for incident light microscopy mounted on black slide

Calibration specimens for scanning electron microscopy

Magnification calibration

Polystyrene latex particles



This range of polystyrene particles is excellent for SEM calibration purposes. It is possible to derive an internal standard of size by mixing a suitable concentration of these particles with the particles of unknown size being studied. The wide range of particle sizes available is listed below, with the standard deviation and approximate particle concentration. These values may be subject to variation between different batches.

Cat. no.	Mean particle* size (µm)	Standard deviation (µm)	Particle concentration (approx) n/ml
S130-1	0.120	0.021	1.05×10^{12}
S130-2	0.132	-	7.91×10^{11}
S130-3	0.182	-	3.02×10^{11}
S130-4	0.216	0.0009	1.80×10^{11}
S130-5	0.303	0.0019	6.60×10^{10}
S130-6	0.520	-	1.29×10^{10}
S130-7	0.855	-	3.04×10^{9}

*Particle sizes shown may vary due to batch availability.

Although these standard deviations are very small, the suspension may contain some particles of material with different diameters from the mean. A statistically significant number of latex particles should be included in any micrograph where a size comparison is to be attempted. It is important not to subject these spheres to excessive irradiation. All solutions are approximately 0.1 % weight by volume, packed in vials of 5 ml.

This range of polystyrene latex spheres can be used for either SEM or TEM applications. All solutions are approximately 0.1 % weight by volume. Supplied in a 10 ml vial.

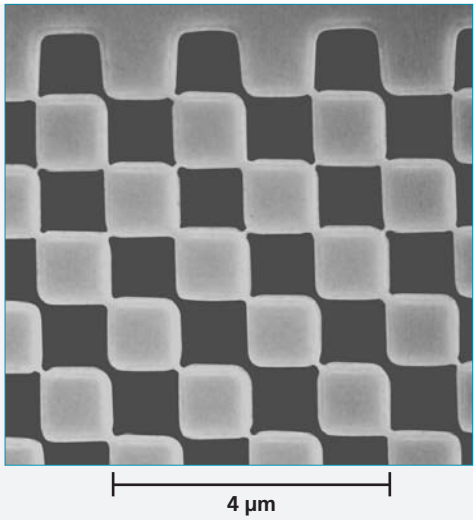
Cat. no.	Nominal size (µm)	Size uniformity (CV)	Particle concentration (approx) n/ml
S130-02	0.03	≤ 18 %	6.74×10^{13}
S130-04	0.08	≤ 15 %	3.55×10^{12}
S130-06	0.09	≤ 5 %	2.50×10^{12}

Chessy test specimen

The Chessy test specimen comprises more than 1.6 million gold squares on silicon which form a four-fold chequerboard pattern in an area of 5 mm square. The pattern is directly written in a resist using e-beam lithography techniques.

The smallest chequerboard on this sample has a size of 10 x 10 µm. These smaller chequerboards then form larger chequerboards of 100 x 100 µm – these again form larger chequerboards of 1 mm². Finally the 1 mm squares are arranged in the same style covering a field of 5 mm². The edges of the empty corners in the 100 x 100 µm chequerboards are additionally marked. The surrounding frame is 10 µm wide and has an outer side length of 5.04 mm.

This test sample is suitable for the calibration of SEM magnification in all ranges between x20 and x50,000. It can also be used for checks of orthogonality and distortion and the positional calibration of motorised stages.

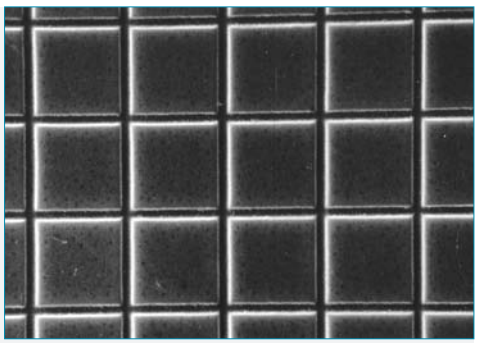


S171 Chessy test specimen

SIRA calibration specimen

This high quality calibration specimen provides a means of testing scanning electron microscopes, scanning transmission electron microscopes (in the SE mode), and electron probe microanalysers particularly for magnification accuracy above x1000, for tilt specifications on the stage, for image distortion and for the measurement of the depth of field. However, they are also suitable for tests of stage stability, stub rotation centering, and checks for symptoms of electrical and mechanical interference, etc.

The metal (resin-backed) grating replica of 2160 lines/mm is mounted on a stub and gold coated. Each replica contains lines in two orthogonal directions with line frequencies guaranteed to be within 1 % of the stated figure on delivery. The specimen is flat with a usable area of over 60 mm², and was originally developed by the SIRA EM Techniques Group.



For detailed information the user is referred to the early research note: I.M. Watt and N.A. Wright, 'A new magnification test specimen for SEMs', *Metron (UK) 3,* No 6, 153 - 156, 1971.

S181 SIRA 2160 lines/mm test specimen on 12.5 mm pin stub
S181A SIRA 2160 lines/mm test specimen on 10 mm JEOL stub
S181B SIRA 2160 lines/mm test specimen on 15 mm Topcon/ISI/ABT stub
S181C SIRA 2160 lines/mm test specimen on 15 mm Hitachi stub
S181D SIRA 2160 lines/mm test specimen on customer's stub
S181E SIRA 2160 lines/mm test specimen on 12.5 mm JEOL stub

The SIRA specimen can be supplied on any stub. Please ask.

The Agar certificate of calibration is available for this specimen. See following page.

Certification of magnification standards for scanning electron microscopy


Agar

SIRA TEST SPECIMEN S170, fine line grating 2160 lines/mm

CALIBRATED SPECIMEN NO: A677 DATE: 2ND JUNE, 2000

PURCHASER: PURCHASE ORDER NO: 20900038

Oxford Instruments Sarl
Batiment Ariane
Domaine Technology De Saclay
4 Rue Rene Razel
91400 Saclay France

Certificate of Calibration

This specimen has been calibrated by diffraction measurements taken from an area approximately 1mm diameter at the centre of the grating area.

The specimen was illuminated by a laser beam of wavelength 632.8nm, and the angular separation of the diffracted beams measured on a certified calibrated rotary table.

The line scribed on the face of the mount was first set horizontal so that the rulings perpendicular to this diffracted the incident beam in a horizontal plane (orientation A).

Owing to the small ruling spacing, the first diffracted beam is at an angle of almost 45° to the incident beam. It is therefore only possible to measure the first diffracted beam on either side of the central beam. In view of the large angle however, the possible errors in angle measurement are very small.

The specimen was then rotated to bring the scribed line to a vertical position so that the rulings at right angles could be measured (orientation B).

The complete series of readings were performed in triplicate.

The relationship between the diffraction angle and the grating spacing is given by

$n\lambda = 2d \sin\theta$

where n = diffraction order
λ = illumination wavelength 632.8nm
d = grating spacing in nm
2θ = angle between corresponding diffraction orders on either side of the central beam

L. Howell,
Senior Technical Officer

In view of the increasing requirement for traceable certified standards we offer a calibration service for some SEM magnification standards, including the silicon (**S1932** series) and SIRA (**S181** series) test specimens. We can calibrate individual specimens to a guaranteed accuracy of 1 %. The specimens are measured under controlled conditions in our laboratory and directly compared with reference standards which have been calibrated by the NPL using laser beam interferometry.

S181-CT	Certified SIRA 2160 lines/mm test specimen on 12.5 mm pin stub
S181A-CT	Certified SIRA 2160 lines/mm test specimen on 10 mm JEOL stub
S181B-CT	Certified SIRA 2160 lines/mm test specimen on 15 mm Topcon/ISI/ABT stub
S181C-CT	Certified SIRA 2160 lines/mm test specimen on 15 mm Hitachi stub
S181D-CT	Certified SIRA 2160 lines/mm test specimen on customer's stub
S181E-CT	Certified SIRA 2160 lines/mm test specimen on 12.5 mm JEOL stub

SEM calibration set

This comprises the SIRA calibration specimen and a silicon test specimen. The SIRA specimen is a metal replica of a cross ruled grating with 2160 lines/mm for high magnification calibration. Accurate to 1 %.

The silicon specimen is made of single crystal silicon, dimensions 5 x 5 mm, with clearly visible squares of 10 µm periodicity.

S1989 SEM calibration set

Please specify stubs required.

The Agar certificate of calibration is available for this set.

S1989-CT SEM calibration set with certificate

Recalibration service


Agar

SIRA TEST SPECIMEN S170, fine line grating 2160 lines/mm

CALIBRATED SPECIMEN NO: A677 DATE: 2ND JUNE, 2000

PURCHASER: PURCHASE ORDER NO: 20900038

Oxford Instruments Sarl
Batiment Ariane
Domaine Technology De Saclay
4 Rue Rene Razel
91400 Saclay France

Certificate of Calibration

This specimen has been calibrated by diffraction measurements taken from an area approximately 1mm diameter at the centre of the grating area.

The specimen was illuminated by a laser beam of wavelength 632.8nm, and the angular separation of the diffracted beams measured on a certified calibrated rotary table.

The line scribed on the face of the mount was first set horizontal so that the rulings perpendicular to this diffracted the incident beam in a horizontal plane (orientation A).

Owing to the small ruling spacing, the first diffracted beam is at an angle of almost 45° to the incident beam. It is therefore only possible to measure the first diffracted beam on either side of the central beam. In view of the large angle however, the possible errors in angle measurement are very small.

The specimen was then rotated to bring the scribed line to a vertical position so that the rulings at right angles could be measured (orientation B).

The complete series of readings were performed in triplicate.

The relationship between the diffraction angle and the grating spacing is given by

$n\lambda = 2d \sin\theta$

where n = diffraction order
λ = illumination wavelength 632.8nm
d = grating spacing in nm
2θ = angle between corresponding diffraction orders on either side of the central beam

L. Howell,
Senior Technical Officer

Where certified magnification calibration standards are used for calibration of microscopes as part of ISO quality assurance procedures, protocols may stipulate that the standards used are recalibrated at fixed time intervals. We offer a recalibration service for all certified specimens where specimens are recertified by the original certifying body. This service is subject to an initial inspection to ensure specimens are in a satisfactory condition. Previously uncertified standards can be certified to conform to NPL standards.

It is also possible to recalibrate the coarse ruled grating specimen (19.7 lines/mm) formerly supplied with the **S170** calibration set and standardise it against a certified stage micrometer.

Resolution and grey level test 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.

For assessments of resolution in scanning electron microscopes, we have developed a range of gold on carbon and tin on carbon test specimens.

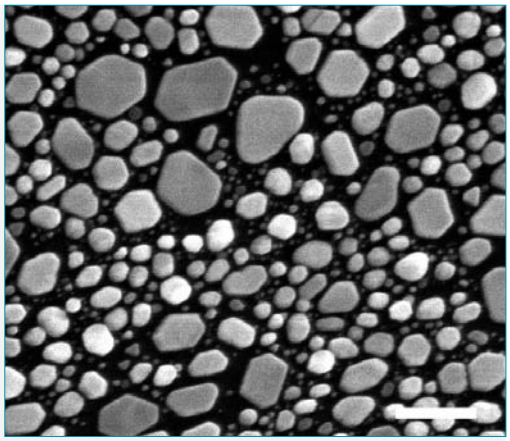
These specimens are suitable for tests of SE and BSE imaging and also for chemical mapping in high resolution systems such as in Auger scanning instruments.

The specimens can be supplied on most types of specimen stub.

Resolution test specimen – gold on carbon

This specimen has a particle size range from approximately 5 - 150 nm. 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.

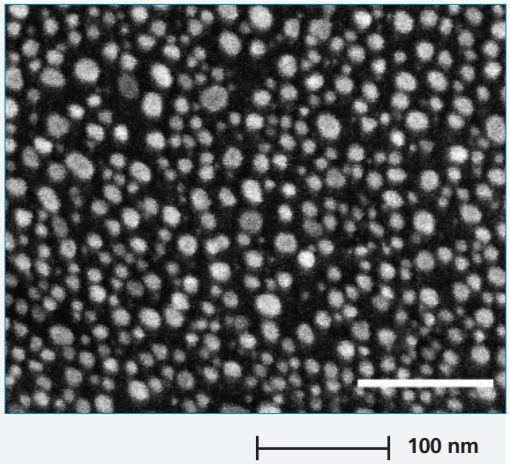
S168	Resolution Au-C test specimen on 12.5 mm pin stub
S168A	Resolution Au-C test specimen on 10 mm JEOL stub
S168B	Resolution Au-C test specimen on 15 mm Topcon/ISI/ABT stub
S168C	Resolution Au-C test specimen on 15 mm Hitachi stub
S168D	Resolution Au-C test specimen on customer's stub
S168E	Resolution Au-C test specimen on 12.5 mm JEOL stub
S168T	Resolution Au-C test specimen on thin carbon disc (0.5 mm)
S168U	Resolution Au-C test specimen unmounted



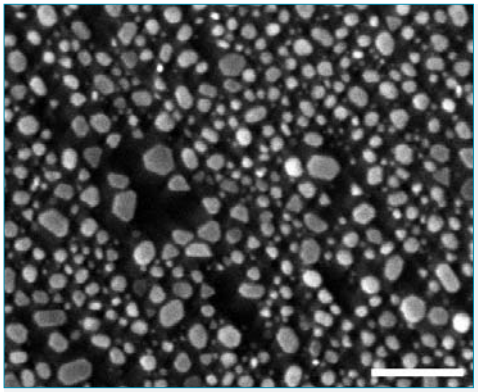
High resolution test specimen – gold on carbon 3 - 50 nm

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 - 50 nm.

S1969	High resolution Au-C test specimen on 12.5 mm pin stub
S1969A	High resolution Au-C test specimen on 10 mm JEOL stub
S1969B	High resolution Au-C test specimen on 15 mm Topcon/ISI/ABT stub
S1969C	High resolution Au-C test specimen on 15 mm Hitachi stub
S1969D	High resolution Au-C test specimen on customer's stub
S1969E	High resolution Au-C test specimen on 12.5 mm JEOL stub
S1969U	High resolution Au-C test specimen unmounted



Ultra high resolution test specimen – gold on carbon <2 - 30 nm

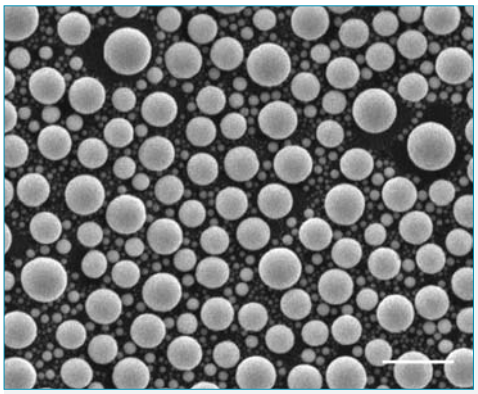


100 nm

For ultra high resolution performance testing, this specimen has a smaller gold island particle size compared to the **S168** specimens described previously. They are suitable for testing at instrument magnifications of x50,000 and above. Particle size range from <2 - 30 nm.

S1987	Ultra high resolution Au-C test specimen on 12.5 mm pin stub
S1987A	Ultra high resolution Au-C test specimen on 10 mm JEOL stub
S1987B	Ultra high resolution Au-C test specimen on 15 mm Topcon/ISI/ABT stub
S1987C	Ultra high resolution Au-C test specimen on 15 mm Hitachi stub
S1987D	Ultra high resolution Au-C test specimen on customer's stub
S1987E	Ultra high resolution Au-C test specimen on 12.5 mm JEOL stub
S1987T	Ultra high resolution Au-C test specimen on thin carbon disc (0.5 mm)
S1987U	Ultra high resolution Au-C test specimen unmounted

Resolution test specimen – tin on carbon

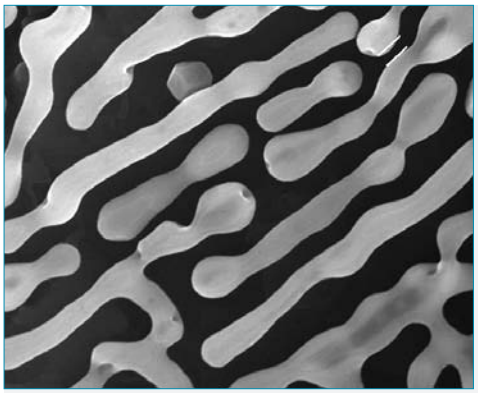


200 nm

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 - 100 nm, 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.

S1967	Resolution Sn-C test specimen on 12.5 mm pin stub
S1967A	Resolution Sn-C test specimen on 10 mm JEOL stub
S1967B	Resolution Sn-C test specimen on 15 mm Topcon/ISI/ABT stub
S1967C	Resolution Sn-C test specimen on 15 mm Hitachi stub
S1967D	Resolution Sn-C test specimen on customer's stub
S1967E	Resolution Sn-C test specimen on 12.5 mm JEOL stub
S1967T	Resolution Sn-C test specimen on thin carbon disc (0.5 mm)
S1967U	Resolution Sn-C test specimen unmounted

Medium resolution aluminium-tungsten dendrites



Courtesy of Vitezslav Ambroz, Demo Lab & Applications TESCAN, Brno, Czech Republic

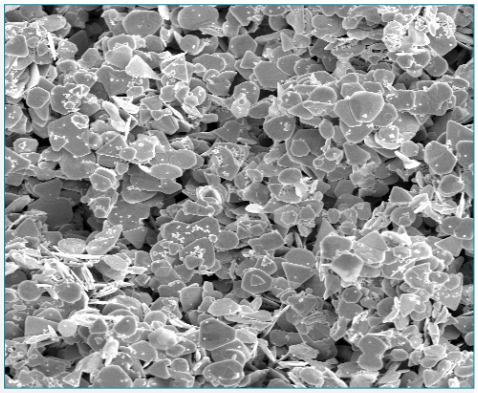
The various spacings created by the dendritic structure of this specimen are suitable for performing point resolution tests and the topographical arrangement of the dendrites for a grey level test. It is non-magnetic, vacuum clean, has no adverse reaction to the electron probe, requires no surface coating and is most useful for working in the probe size range of 25 - 75 nm.
Supplied unmounted, it can easily be attached to a stub using a conductive adhesive such as silver paint.

S145	SEM medium resolution and grey level test specimen (dendrites)

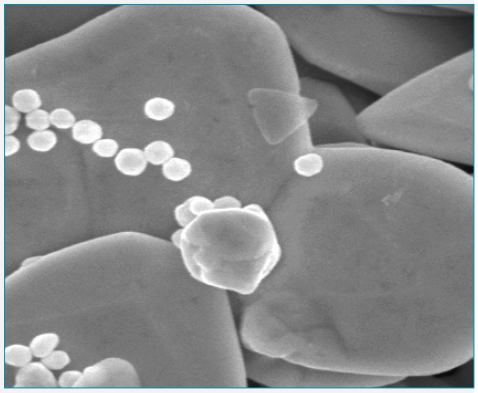
Pelco® gold specimen

This specimen consists of gold platelets with a wide size range and sharp, clearly defined edges, making it useful for determining and correcting astigmatism, and verifying instrument resolution. Clear, sharp, high contrast images are valuable for checking resolution. The sharp-edged gold particles on 1000 mesh grids can be attached to any of the stubs listed below.

S1968	Pelco gold on 12.5 mm pin stub
S1968A	Pelco gold on 10 mm JEOL stub
S1968B	Pelco gold on 15 mm Topcon/ISI/ABT stub
S1968C	Pelco gold on 15 mm Hitachi stub
S1968D	Pelco gold on customer's stub
S1968E	Pelco gold on 12.5 mm JEOL stub
S1968U	Pelco gold unmounted



10 µm

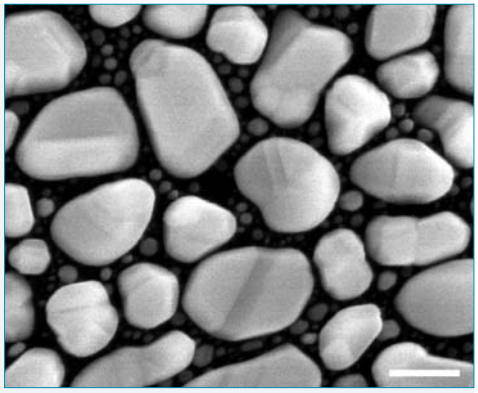


1 µm

Low voltage resolution gold on carbon <30 - 300 nm specimen

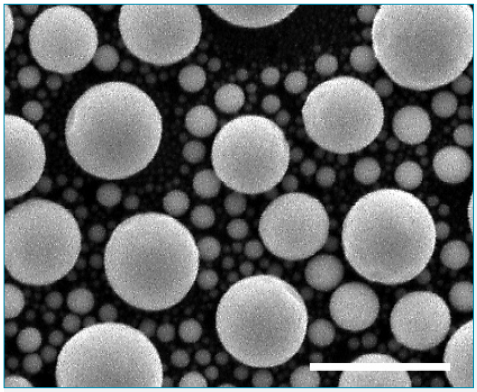
Standard gold or tin on carbon resolution specimens may not be suitable for operating at low accelerating voltages or for use with older instruments. This may be due to inferior resolution at low voltage or poor signal-to-noise ratio when operating at high scanning rates with small spot sizes. The larger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

S168Z	Low kV Au-C test specimen on 12.5 mm pin stub
S168AZ	Low kV Au-C test specimen on 10 mm JEOL stub
S168BZ	Low kV Au-C test specimen on 15 mm Topcon/ISI/ABT stub
S168CZ	Low kV Au-C test specimen on 15 mm Hitachi stub
S168DZ	Low kV Au-C test specimen on customer's stub
S168EZ	Low kV Au-C test specimen on 12.5 mm JEOL stub
S168TZ	Low kV Au-C test specimen on thin carbon disc (0.5 mm)
S168UZ	Low kV Au-C test specimen unmounted



200 nm

Low voltage resolution tin on carbon <20 - 400 nm specimen

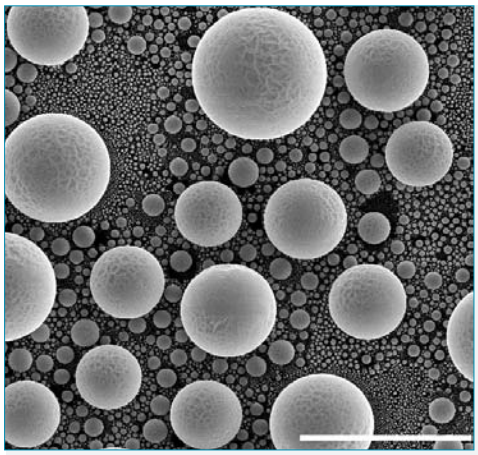


500 nm

Similar to the **S168Z** specimen, this tin on carbon specimen with larger spheres is easier to use in low kV imaging mode and where gold on carbon may not be appropriate. The spherical nature of the balls makes them ideal for astigmatism assessment.

S1988	Low kV Sn-C test specimen on 12.5 mm pin stub
S1988A	Low kV Sn-C test specimen on 10 mm JEOL stub
S1988B	Low kV Sn-C test specimen on 15 mm Topcon/ISI/ABT stub
S1988C	Low kV Sn-C test specimen on 15 mm Hitachi stub
S1988D	Low kV Sn-C test specimen on customer's stub
S1988E	Low kV Sn-C test specimen on 12.5 mm JEOL stub
S1988T	Low kV Sn-C test specimen on thin carbon disc (0.5 mm)
S1988U	Low kV Sn-C test specimen unmounted

Universal resolution tin on carbon <5nm - 30 µm specimen



50 µm

This tin on carbon test specimen has a very wide size range of tin spheres which give high contrast when imaged in the SEM. The largest spheres can be used for basic column alignment at low magnification; intermediate sized spheres are useful for monitoring image shift when changing operating parameters or resolution checking at low kV; and the smallest spheres can be used for resolution checking and astigmatism correction at the very highest magnifications.

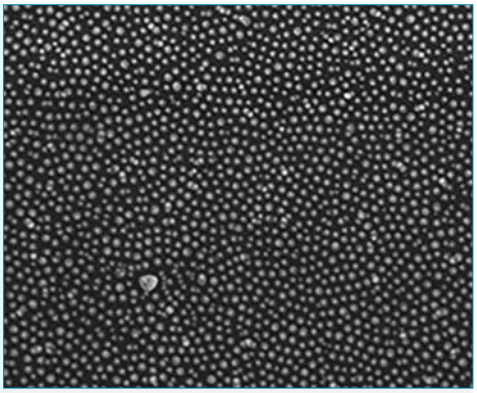
S1937	Universal Sn-C test specimen on 12.5 mm pin stub
S1937A	Universal Sn-C test specimen on 10 mm JEOL stub
S1937B	Universal Sn-C test specimen on 15 mm Topcon/ISI/ABT stub
S1937C	Universal Sn-C test specimen on 15 mm Hitachi stub
S1937D	Universal Sn-C test specimen on customer's stub
S1937E	Universal Sn-C test specimen on 12.5 mm JEOL stub
S1937T	Universal Sn-C test specimen on thin carbon disc (0.5 mm)
S1937U	Universal Sn-C test specimen unmounted

Calibration specimens on ultra thin and alternative substrates

This range of gold on carbon and tin on carbon specimens has been specifically developed for use in conjunction with line width calibration wafers or other test systems where the height of a conventional specimen is a problem. The specimens have the same specifications as the larger standard calibration specimens, but are prepared on a very thin carbon substrate which is approximately 130 µm thick and approximately 7 x 7 mm square.
For applications where carbon is not a suitable substrate we can provide silicon as an alternative. Available as 5 x 5 mm, 500 µm thick or approximately 7 x 7 mm, 200 µm thick.
Supplied unmounted.

	Particle size	Thin carbon substrate 130 µm	Thin silicon substrate 200 µm	Standard silicon substrate 500 µm
Gold	30 - 300 nm	**S168ZVT**	**S168ZVTSI**	**S168ZSI**
	5 - 150 nm	**S168VT**	**S168VTSI**	**S168SI**
	3 - 50 nm	**S1969VT**	**S1969VTSI**	**S1969SI**
	2 - 30 nm	**S1987VT**	**S1987VTSI**	**S1987SI**
Tin	20 - 400 nm	**S1988VT**	**S1988VTSI**	**S1988SI**
	10 - 100 nm	**S1967VT**	**S1967VTSI**	**S1967SI**
	5 - 30 µm	**S1937VT**	**S1937VTSI**	**S1937SI**

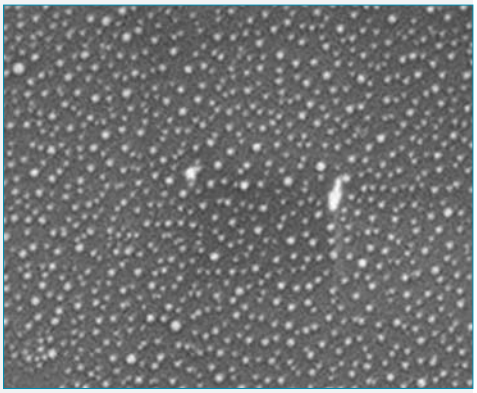
Pelco® Nanogold resolution test standards for SEM and FESEM



These unique gold nanoparticles on silicon provide resolution standards with known and uniform particle size, ideally suited for high resolution tests for SEM, FESEM and FIB/SEM systems. The known particle size combined with uniformity provides a real indication of the performance of the SEM or FESEM. The Nanogold on silicon resolution standards are available in two size ranges:

30 nm (± 4 nm) for high resolution SEM applications
15 nm for ultra high resolution FESEM applications

Provided on 5 x 5 mm silicon wafer chip, unmounted or on the specimen mount of your choice.



S1808	Pelco Nanogold 30 nm test specimen on 12.5 mm pin stub
S1808A	Pelco Nanogold 30 nm test specimen on 10 mm JEOL stub
S1808B	Pelco Nanogold 30 nm test specimen on 15 mm Topcon/ISI/ABT stub
S1808C	Pelco Nanogold 30 nm test specimen on 15 mm Hitachi stub
S1808D	Pelco Nanogold 30 nm test specimen on customer's stub
S1808E	Pelco Nanogold 30 nm test specimen on 12.5 mm JEOL stub
S1808U	Pelco Nanogold 30 nm test specimen, unmounted
S1809	Pelco Nanogold 15 nm test specimen on 12.5 mm pin stub
S1809A	Pelco Nanogold 15 nm test specimen on 10 mm JEOL stub
S1809B	Pelco Nanogold 15 nm test specimen on 15 mm Topcon/ISI/ABT stub
S1809C	Pelco Nanogold 15 nm test specimen on 15 mm Hitachi stub
S1809D	Pelco Nanogold 15 nm test specimen on customer's stub
S1809E	Pelco Nanogold 15 nm test specimen on 12.5 mm JEOL stub
S1809U	Pelco Nanogold 15 nm test specimen, unmounted

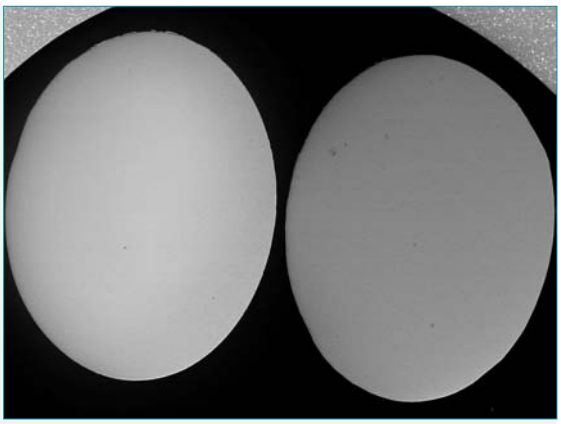
Reference specimens for backscattered electron detection systems

An electron microscope, when equipped with a backscattered electron detector, has the capability to produce images in which the contrast is controlled by differences in atomic number (Z) across the specimen. Four reference specimens are now available that are suitable for testing the atomic number contrast performance of a backscattered electron detection system.

Each of the reference specimens consists of two high purity elements that have an atomic number difference of 1. They are in the form of two wires embedded side by side in a contrasting matrix.

The specimens are available as a single mount either 3 mm or 5 mm diameter brass or aluminium tubes or alternatively can be incorporated into a block of standards.

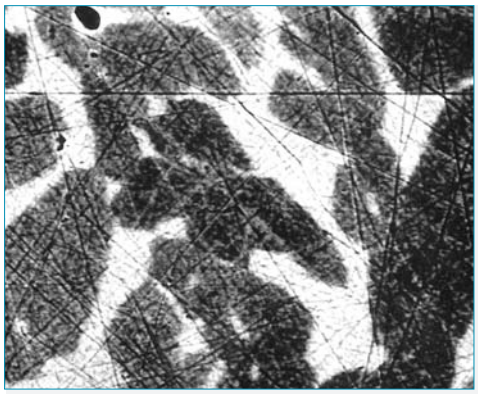
S1950	BSE reference, nickel/copper Z = (28 - 29)
S1951	BSE reference, palladium/silver Z = (46 - 47)
S1952	BSE reference, platinum/gold Z = (78 - 79)
S1954	BSE reference, aluminium/silicon Z = (13 - 14)



Electron micrograph of the nickel/copper backscattered electron reference specimen.

BSE image at low magnification. The contrast difference between the two wires is visible due to the atomic number difference between the nickel/copper.

Duplex reference specimen



10 µm

An alternative and very sensitive test is by means of an alloy with two major copper/zinc phases separated by an atomic number difference of 0.1. The light phase illustrated in the micrograph has a mean atomic number of 29.47 and the dark phase a mean atomic number of 29.37.

S1953 Duplex reference specimen

Critical dimension (CD) calibration test specimens

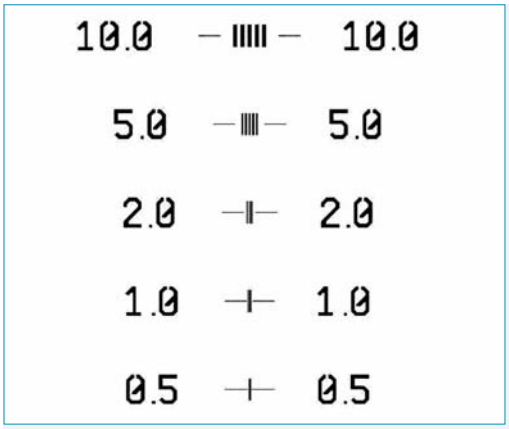
A CD calibration test specimen is of particular interest to microscopists and test engineers using high performance SEMs for critical measurement of semiconductor line width dimensions.

The 4.8 x 4.8 mm silicon standard has a series of chequerboard patterns around its edges with a side length of 480 µm. These can be used for optimising imaging parameters and checking distortion.

The central region of the standard contains a series of five line patterns, each one clearly identified with its pitch size. Each pattern is made up of five bars and spaces of equal width.

Bar pitch for the individual patterns ranges in size from 0.5 - 10 µm for calibrating intermediate size structures and 100 - 500 nm for smaller structures. Each standard is identified by a unique serial number.

The test specimen is available non-certified, or certified by the German Physikalisch-Technische Bundesanstalt. For certified standards, each pitch is measured and a mean value calculated from a series of five measurements. Measurements were made on a dedicated CD measuring system fitted to an FEG SEM at an accelerating voltage of 700 eV.



10-5-2-1-0.5 µm structure

This CD calibration test specimen comprises five line patterns, each one clearly identified by its pitch. Each pattern has five bars and spaces of equal pitch: 10, 5, 2, 1 and 0.5 µm. The central line area may also be used for AFM measurements. The patterns are etched into silicon with a depth of approximately 200 µm. There is no coating on the silicon surface.

S1995A CD calibration specimen, 10-5-2-1-0.5 µm, non-certified

S1997A CD calibration specimen, 10-5-2-1-0.5 µm, certified

Each standard is identified by a unique serial number.

The specimen can be supplied unmounted or mounted on any of the standard range of SEM stubs. Please specify.

500-200-100 nm structure

This advanced CD calibration test specimen is suitable for calibrating smaller structures. It comprises three line patterns, each identified by its pitch. Each pattern has five bars and spaces of equal pitch: 500, 200 and 100 nm. The central line area may be used for AFM measurements. The patterns are etched into silicon with a depth of approximately 45 - 50 nm. There is no coating on the silicon surface.

S1998 CD calibration specimen, 500-200-100 nm, non-certified

S1998A CD calibration specimen, 500-200-100 nm, certified

Each standard is identified by a unique serial number.

The specimen can be supplied unmounted or mounted on any of the standard range of SEM stubs. Please specify.

MetroChip calibration standard

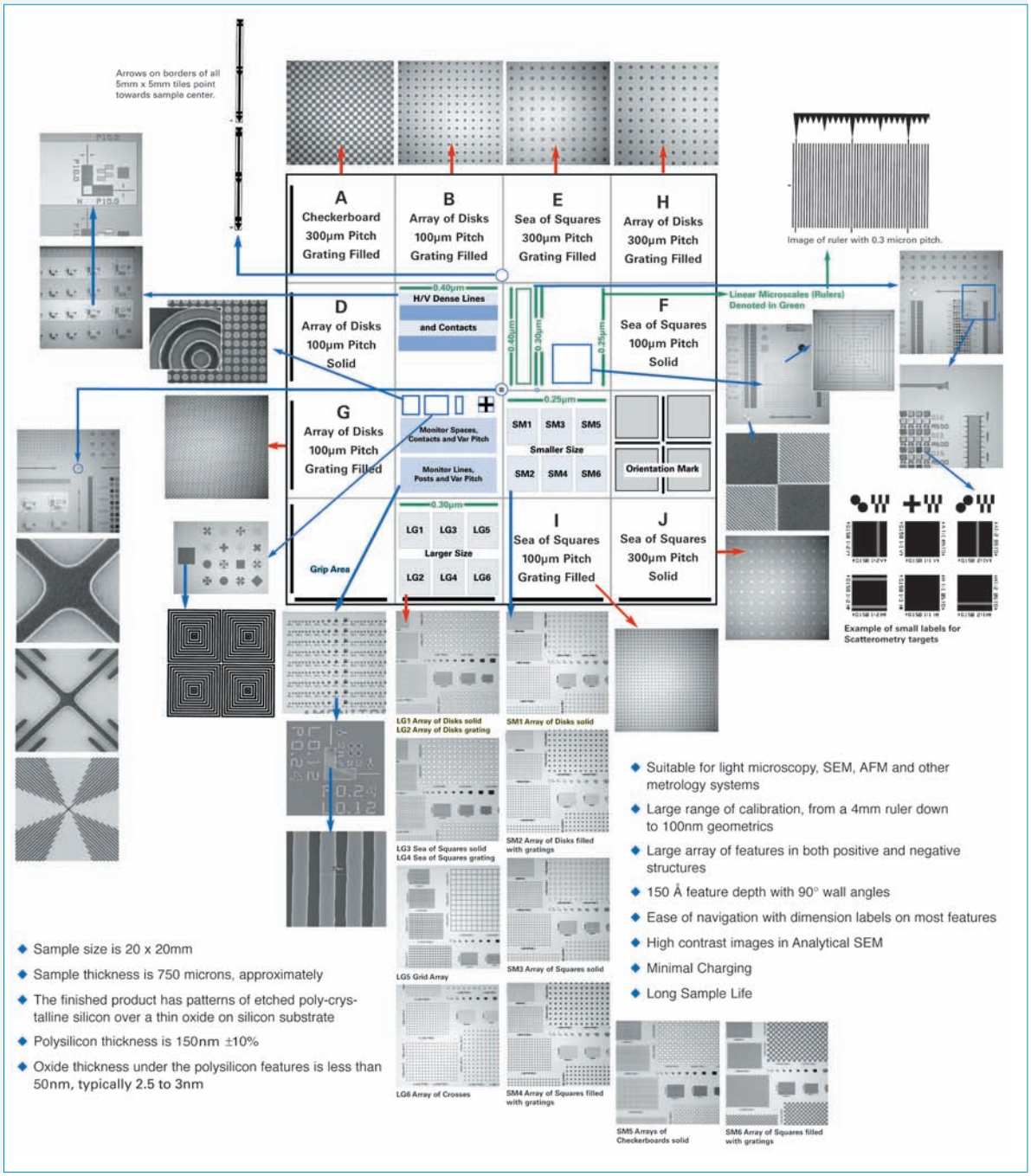
The MetroChip microscope calibration standard provides an extensive range of features for SEM, FIB, AFM, light microscopy and metrology systems calibration. It is supplied on a 20 x 20 mm chip with a thickness of 750 µm, with periodic features for enhanced calibration in the range 4 mm down to 100 nm.

The SEM calibration feature includes alignment marks, linear microscale, distortion measurements, paraxial calibration (image shift), resolution measurements, focus star, stigmator calibration, gratings, concentric circles and squares. The combination of these features on one standard makes the MetroChip ideal as an all-in-one standard both for initial set-up and regular calibration checks. Due to its composition the chip exhibits minimal charging and, if cared for properly, a long sample life.

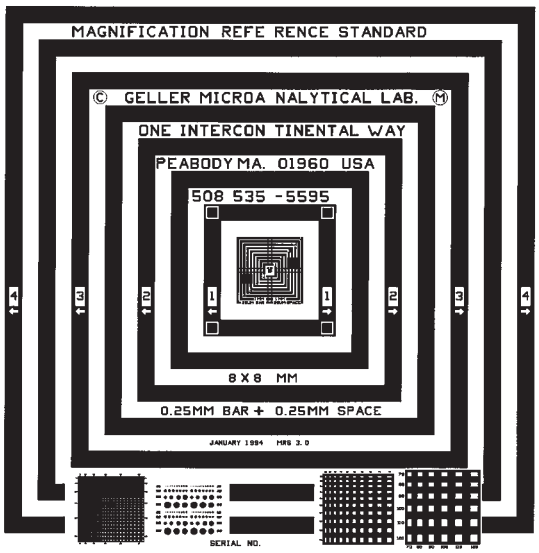
The MetroChip can also be used for light microscopy and AFM and includes a number of features to check linearity, distortion and scan length.

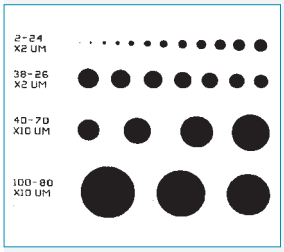
The MetroChip standard is easy to navigate and comes with dimension labels on most features. It is fully traceable to NIST certification.

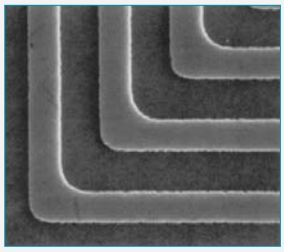
S1949 MetroChip calibration standard, certified

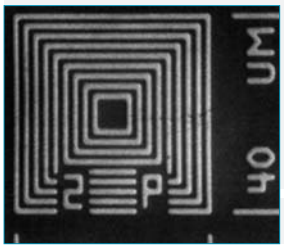


Geller reference standards MRS-3









The MRS-3 is a universal magnification calibration standard suitable for a wide range of instrumentation including scanning, optical reflection and transmission, scanning probe and confocal microscopy. The patterns are anti-reflective chromium on quartz, which have been fabricated using electron beam lithography techniques. This proprietary coating virtually eliminates electron beam charging at any accelerating voltage when used in an SEM.

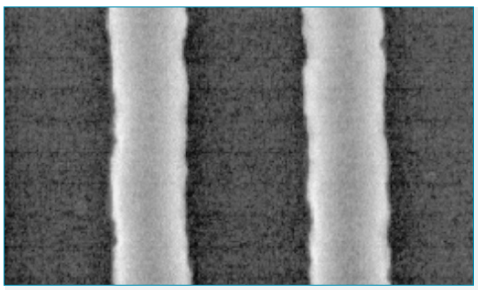
The geometric design of the MRS-3 contains groups of nested squares spanning several orders of magnitude with pitches of 500, 50 and 2 µm. The largest pattern is 8 mm square, giving a magnification measurement range from x10 to x50,000. The patterns include nested squares and rectangles for X, Y calibration that range in size from 1 to 120 µm, as well as circles ranging from 2 to 100 µm in diameter, ideal for checking particle size counting systems. This standard can also be used for measurements in the Z plane where the pattern height is 0.1 µm ± 0.003 µm, and is most useful for profilometry.

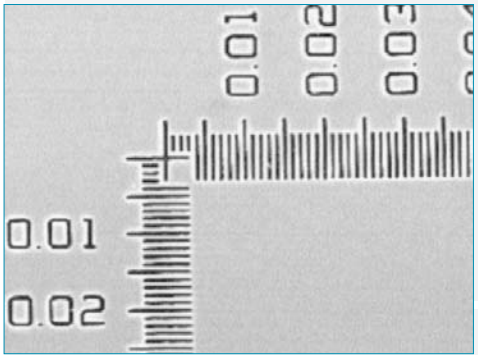
The standard is available in three versions: non-certified; certified in X and Y – NPL and NIST traceable; and certified in X, Y and Z – the Z measurement traceable to NIST only. Although the specimens can be supplied unmounted, the use of a special protective holder is recommended. The universal holder enables the standard to be used for SEM and optical applications using reflected and transmitted illumination. Alternatively it can be supplied in a precision metal slide 25 x 43 mm for optical use only. A separate version, 3.0 mm diameter, 0.5 mm thick, is available for use in transmission electron microscopes using the SED and BED modes.

S1990	MRS-3 reference standard, non-certified
S1991	MRS-3XY certified standard, NPL and NIST traceable
S1992	MRS-3XYZ certified standard, NPL and NIST traceable in X, Y with Z calibration NIST traceable
S1993	MRS-3 reference standard, non-certified 3 mm dia

Please add suffix -S for universal holder and -O for optical holder for unmounted specimens.

Geller reference standards MRS-4





This is similar in design and construction to the MRS-3. For high magnification calibration, two additional nested squares with pitches of 1 and 0.5 µm extend the useful calibration range to x200,000. Two 6 mm long scales in the X and Y directions which are subdivided at 1 µm intervals allow calibration over a wide range of magnifications using the same scale.

S1810	MRS-4 reference standard, non-certified
S1811	MRS-4XY certified standard, NPL and NIST traceable
S1812	MRS-4XYZ certified standard, NPL and NIST traceable in X, Y with Z calibration NIST traceable
S1813	MRS-4 reference standard, non-certified 3 mm dia

Please add suffix -S for universal holder and -O for optical holder for unmounted specimens.

Geller reference standards MRS-5

The MRS-5 calibration standard is approximately 2 x 2 x 0.5 mm, and is suitable for instrument calibration from x1500 to x1,000,000. The pattern is built on a silicon wafer with a 400 nm silicon oxide layer and a 65 nm tungsten layer on top. Consequently imaging contrast in both SE and BSE mode is very high.

The MRS-5 has three types of pattern:

- groups of nested squares spanning several orders of magnitude with pitches of 80, 100, 200 and 500 nm, 1 and 2 µm. To allow for more testing, the 80, 100 and 200 nm patterns are repeated four times
- fine, three-bar patterns with pitches ranging from 80 nm to 3 µm in 15 steps, ideal for measuring the resolution of state-of-the-art optical microscopes, including UV, confocal, laser scanning, etc.
- 500 nm square test pattern with a 1 µm pitch over a 20 µm X and Y field helps to analyse images for all types of dimensional distortion, vibrations and magnetic fields

Typical applications include:

Electron microscopy: SEM (secondary & backscattered electrons) and TEM (for use with a bulk holder) the MRS-5 is conveniently sized at 2 x 2 x 0.5 mm.

Scanning microscopies and profilometry: STM, AFM, stylus and optical, etc. The pattern height is 0.1 µm.

Optical microscopy: reflected, bright/dark field, differential contrast and confocal.

Chemical mapping: EDS, WDS, micro/macro XRF, XPS, Auger and others. The pattern is fabricated using 100 nm tungsten film, over a thin SiO_2 film, over a silicon substrate.

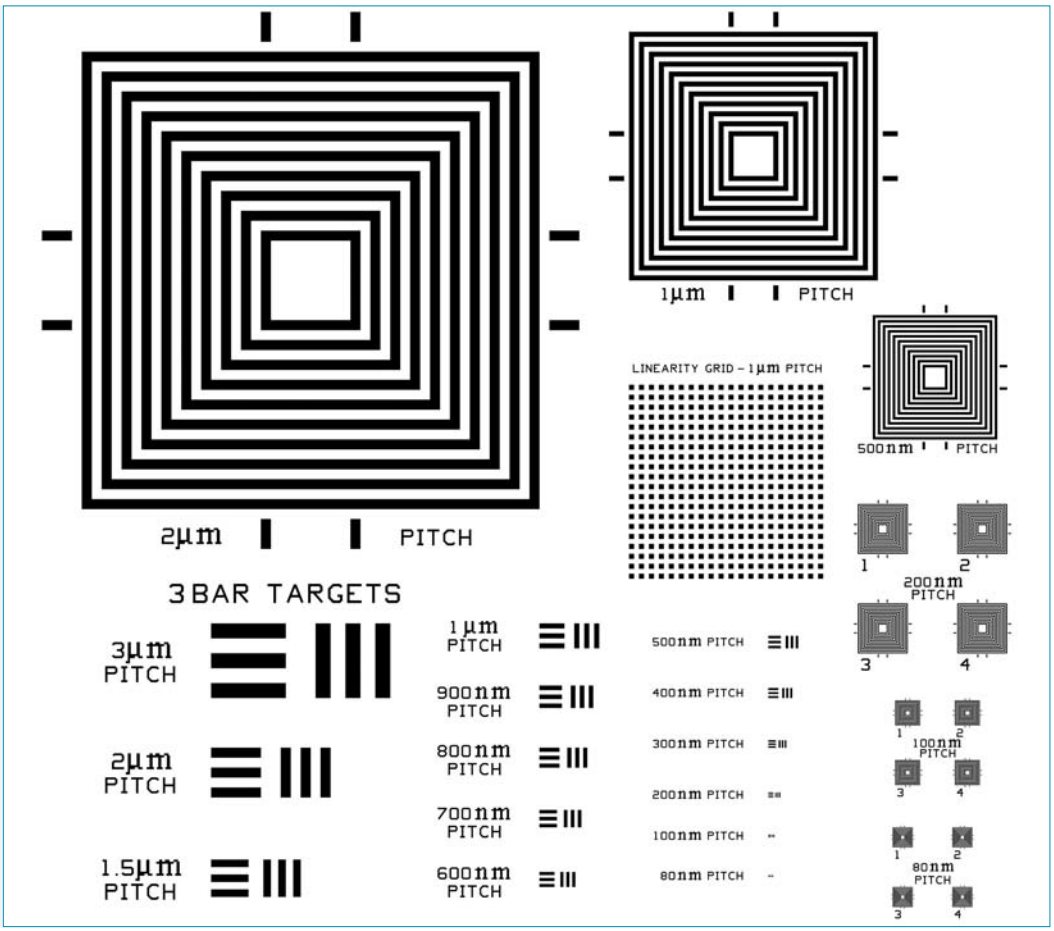
Resolution testing: With a series of two-bar targets (similar to the USAF 1953 patterns) ranging in size from 80 nm to 3 µm.

Linearity testing: With a 1 μm^2 pitch square over 40 x 40 µm. Used for measuring magnification simultaneously in the X and Y directions. This gives a measure of image skew, barrelling, pincushion and other non-linearities which can have various origins, such as from stray magnetic fields.

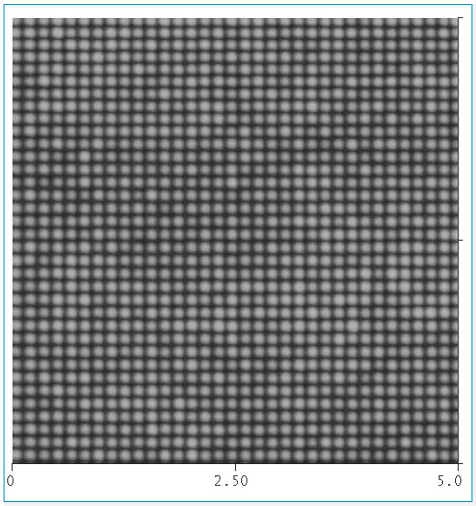
S1814 MRS-5 reference standard, non-certified

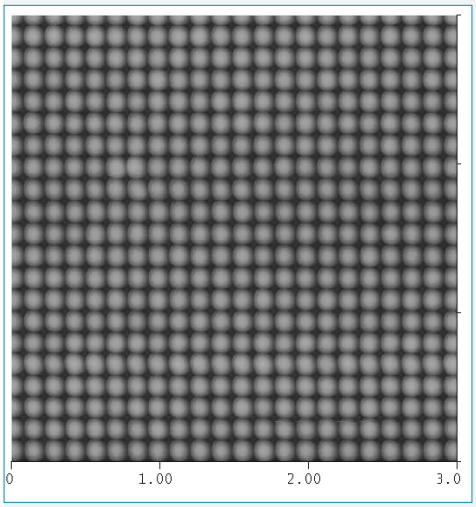
S1815 MRS-5XY certified standard, NPL and NIST traceable

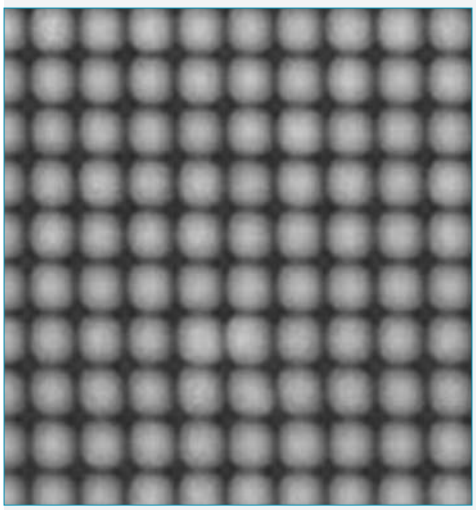
Please add suffix -S for universal holder and -O for optical holder for unmounted specimens.



2-D holographic array standards







These 2-D holographic array standards for simultaneous calibration of X and Y axes have unique characteristics that make them easy to use for AFM, STM, Auger, FIB and SEM.

There are two pitch sizes available:

The 144 nm pitch, two dimensional array is accurate to ± 1 nm and is suitable for SEM and AFM calibrations. The pattern covers the entire chip enabling thousands of measurements to be made without revisiting the same scan area. The surface comprises aluminium 'bumps' on silicon. The bump height is approximately 90 nm and width 75 nm (not calibrated).

For SEM the 144 nm standard works well at all accelerating voltages.

For AFM it can be used in contact, intermittent contact (TappingMode™) and other modes, with image sizes from 250 nm to 10 mm. For AFM the 2-D standard is available unmounted or can be mounted on 12 mm steel discs. The pattern is durable and allows for extended scanning in contact mode, which means that calibration and measurements are faster.

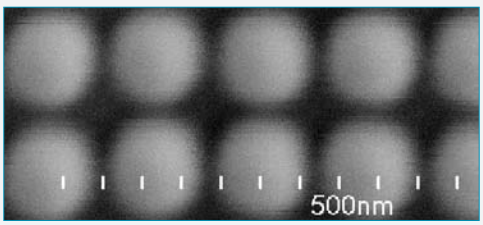
The 144 nm reference specimen comes with a non-traceable manufacturer's certificate. This gives the average period based on batch measurements.

It can also be supplied as a traceable certified standard. Each standard is individually measured in comparison with a similar specimen calibrated at the German PTB (Physikalisch-Technische Bundesanstalt). The uncertainty of a single pitch is typically ± 1.4 nm.

The 300 nm pitch reference standard is particularly useful for SEM, Auger and FIB calibrations. It can be used for a wide range of accelerating voltages (1 kV - 20 kV) and calibrates images from x5000 to x200,000 magnification. It can be also be used for AFM.

The surface structure is aluminium 'bumps' on silicon. The bump height is approximately 50 nm and width 150 nm (not calibrated).

The specimen is supplied with a non-traceable manufacturer's certificate which states the average pitch based on batch measurements.



SEM 144 nm reference standard

S1861	144 nm calibration standard on 12.5 mm pin stub
S1861A	144 nm calibration standard on 10 mm JEOL stub
S1861B	144 nm calibration standard on 15 mm Topcon/ISI/ABT stub
S1861C	144 nm calibration standard on 15 mm Hitachi stub
S1861D	144 nm calibration standard on customer's stub
S1861E	144 nm calibration standard on 12.5 mm JEOL stub
S1861T	144 nm calibration standard on thin carbon disc (0.5 mm)
S1861U	144 nm calibration standard, unmounted

SEM 144 nm reference standard, certified

S1862	144 nm certified calibration standard on 12.5 mm pin stub
S1862A	144 nm certified calibration standard on 10 mm JEOL stub
S1862B	144 nm certified calibration standard on 15 mm Topcon/ISI/ABT stub
S1862C	144 nm certified calibration standard on 15 mm Hitachi stub
S1862D	144 nm certified calibration standard on customer's stub
S1862E	144 nm certified calibration standard on 12.5 mm JEOL stub
S1862T	144 nm certified calibration standard on thin carbon disc (0.5 mm)
S1862U	144 nm certified calibration standard, unmounted

SEM 300 nm reference standard

S1863	300 nm calibration standard on 12.5 mm pin stub
S1863A	300 nm calibration standard on 10 mm JEOL stub
S1863B	300 nm calibration standard on 15 mm Topcon/ISI/ABT stub
S1863C	300 nm calibration standard on 15 mm Hitachi stub
S1863D	300 nm calibration standard on customer's stub
S1863E	300 nm calibration standard on 12.5 mm JEOL stub
S1863T	300 nm calibration standard on thin carbon disc (0.5 mm)
S1863U	300 nm calibration standard, unmounted

AFM 144 nm reference standard

F7050	144 nm AFM calibration standard on 12 mm steel disc

AFM 144 nm reference standard, certified

F7051	144 nm AFM certified calibration standard on 12 mm steel disc

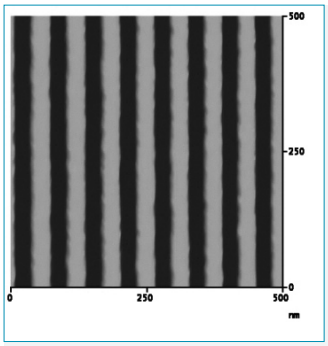
AFM 300 nm reference standard

F7052	300 nm AFM calibration standard on 12 mm steel disc

High magnification, high resolution calibration reference and traceable standards for SEM, AFM, Auger and FIB

These precision, holographic patterns are highly accurate and stable, with moderate ridge heights that are convenient for AFM. This specimen also provides excellent contrast for secondary and backscatter imaging with SEM. It provides accurate calibration for high resolution, nanometre-scale measurements. Available with 70, 145 and 292 nm pitch.

70 nm pitch reference standard for very high resolution calibration of AFM, SEM, Auger and FIB



The 70 nm pitch is accurate to ± 0.25 nm. The calibrated pattern covers a 1.2 x 0.5 mm area.

The surface structure is silicon dioxide ridges on silicon. Ridge height and width are approximately 35 nm (not calibrated).

For SEM it can be used for a wide range of accelerating voltages 1 - 20 kV and calibrates images from x25,000 to x1,000,000.

For AFM it can be used in contact, tapping, and other modes, with image sizes from 100 nm to 3 µm.

It can be supplied with either a non-traceable manufacturer's certificate stating average pitch based on batch measurements, or as a traceable, certified version measured in comparison with a standard calibrated at the German PTB (Physikalisch-Technische Bundesanstalt).

70 nm reference standard

S1865	70 nm resolution standard on 12.5 mm pin stub
S1865A	70 nm resolution standard on 10 mm JEOL stub
S1865B	70 nm resolution standard on 15 mm Topcon/ISI/ABT stub
S1865C	70 nm resolution standard on 15 mm Hitachi stub
S1865D	70 nm resolution standard on customer's stub
S1865E	70 nm resolution standard on 12.5 mm JEOL stub
S1865T	70 nm resolution standard on thin carbon disc (0.5 mm)
S1865U	70 nm resolution standard, unmounted

70 nm reference standard, certified

S1866	70 nm certified resolution standard on 12.5 mm pin stub
S1866A	70 nm certified resolution standard on 10 mm JEOL stub
S1866B	70 nm certified resolution standard on 15 mm Topcon/ISI/ABT stub
S1866C	70 nm certified resolution standard on 15 mm Hitachi stub
S1866D	70 nm certified resolution standard on customer's stub
S1866E	70 nm certified resolution standard on 12.5 mm JEOL stub
S1866T	70 nm certified resolution standard on thin carbon disc (0.5 mm)
S1866U	70 nm certified resolution standard, unmounted

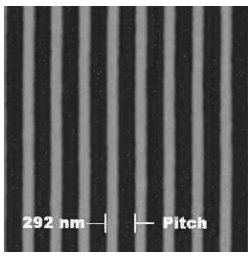
70 nm AFM reference standard

F7053	70 nm AFM reference standard on 12 mm steel disc

70 nm AFM reference standard, certified

F7053T	70 nm certified AFM reference standard on 12 mm steel disc

292 nm pitch reference standard for very high resolution calibration of AFM, SEM, Auger and FIB



The 292 nm pitch is accurate to ± 1%. The surface structure is titanium lines on silicon. The line height is approximately 30 nm with a line width of 130 nm (not calibrated).

For SEM it can be used for a wide range of accelerating voltages <1 - 30 kV and calibrates images from x5,000 to x200,000.

For AFM it can be used in contact, tapping, and other modes, with image sizes from 500 nm to 20 µm.

It can be supplied with either a non-traceable manufacturer's certificate stating average pitch based on batch measurements, or as a traceable, certified version measured in comparison with a standard calibrated at the German PTB (Physikalisch-Technische Bundesanstalt).

292 nm reference standard

S1867	292 nm resolution standard on 12.5 mm pin stub
S1867A	292 nm resolution standard on 10 mm JEOL stub
S1867B	292 nm resolution standard on 15 mm Topcon/ISI/ABT stub
S1867C	292 nm resolution standard on 15 mm Hitachi stub
S1867D	292 nm resolution standard on customer's stub
S1867E	292 nm resolution standard on 12.5 mm JEOL stub
S1867T	292 nm resolution standard on thin carbon disc (0.5 mm)
S1867U	292 nm resolution standard, unmounted

292 nm reference standard, certified

S1868	292 nm certified resolution standard on 12.5 mm pin stub
S1868A	292 nm certified resolution standard on 10 mm JEOL stub
S1868B	292 nm certified resolution standard on 15 mm Topcon/ISI/ABT stub
S1868C	292 nm certified resolution standard on 15 mm Hitachi stub
S1868D	292 nm certified resolution standard on customer's stub
S1868E	292 nm certified resolution standard on 12.5 mm JEOL stub
S1868T	292 nm certified resolution standard on thin carbon disc (0.5 mm)
S1868U	292 nm certified resolution standard, unmounted

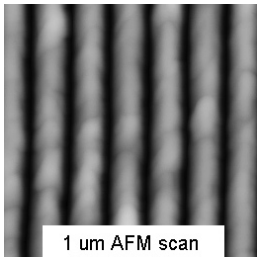
292 nm AFM reference standard

F7055	292 nm AFM reference standard on 12 mm steel disc

292 nm AFM reference standard, certified

F7055T	292 nm certified AFM reference standard on 12 mm steel disc

145 nm pitch reference standard for AFM



The 145 nm pitch is accurate to ± 1 nm. The surface structure is aluminium lines on glass. The line height is approximately 100 nm and width 75 nm.

For AFM it can be used in contact, tapping, or other modes, with image sizes from 250 nm to 10 µm.
It is available with a non-traceable manufacturer's certificate stating average pitch based on batch measurements.

145 nm AFM reference standard

F7054 145 nm AFM reference standard on 12 mm steel disc

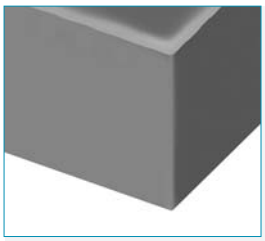
145 nm AFM reference standard, certified

F7054U 145 nm certified AFM reference standard unmounted

FIB and ion beam sputter standards

These are high precision ion sputter standards suitable for the set-up and calibration of ion sputter guns. Thin films of silicon dioxide, silicon nitride, tantalum pentoxide and nickel/chromium are available.

Silicon dioxide (SiO_2)



Silicon wafers (4") with thin films of silicon dioxide are available in thicknesses of 23, 50, 97 and 102.9 nm. The oxide films are grown with a wet oxygen process, which ensures a higher degree of uniformity than other processes.

S1804-1 Silicon dioxide ion sputter standard, 23 nm ± 0.23 nm
S1804-2 Silicon dioxide ion sputter standard, 50 nm ± 2.5 nm
S1804-3 Silicon dioxide ion sputter standard, 97 nm ± 3.8 nm
S1804-4 Silicon dioxide ion sputter standard, 102.9 nm ± 2.5 nm

Silicon nitride (Si_3N_4)

100 nm silicon nitride (CVD) films deposited on a piece of silicon wafer, 1 x 3 cm

S1805 Silicon nitride ion sputter standard

Tantalum pentoxide (Ta_2O_5)

Films of tantalum pentoxide (approximately 100 nm) are anodically grown on 0.5 mm thick tantalum foil. Thickness accuracy is approximately 5 %. Size of standard, 37 x 37 mm.

S1806 Tantalum pentoxide ion sputter standard

Nickel/chromium (Ni/Cr)

This standard consists of 12 alternating layers on a silicon wafer: six layers of chromium approximately 53 nm thick, and six layers of nickel 64 nm thick. The total thickness is 700 nm with a maximum variation across the 75 mm wafer of ± 2 %. The section of polished silicon wafer is 1 x 3 cm. The mass density of the chromium and nickel was determined using electron beam excitation and then by measuring characteristic X-ray intensities.

S1807 Nickel/chromium ion sputter standard

Calibration specimens for transmission electron microscopy

Agar Scientific calibration specimens for TEM are famous worldwide for their quality and reliability. By definition, a test specimen for electron microscopy should only be checked using an electron microscope, and so each Agar specimen not rejected by optical microscopy is checked in an electron microscope.

Specimens are rejected for exceeding 5 % broken grid squares, for excessive dirt, or for inadequate image quality. These criteria govern every Agar calibration specimen. All specimens are prepared on standard 3.05 mm copper grids.

Magnification calibration

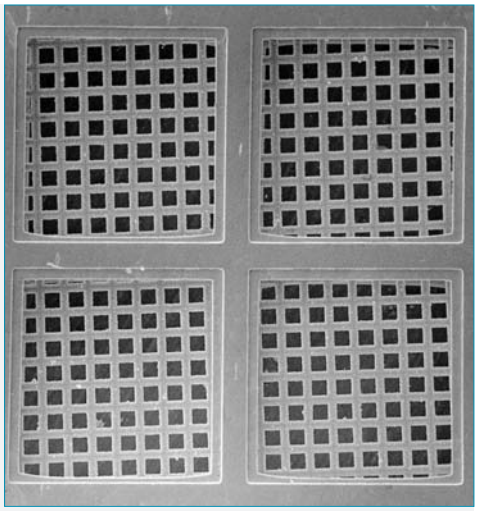
Fine copper, nickel or gold mesh

Suitable for the low magnification range of transmission microscopes.

S151 1000 mesh copper in sandwich grid, 3.05 mm dia
S152 2000 mesh copper in sandwich grid, 3.05 mm dia

Please add suffix N (nickel) or A (gold) to catalogue reference if required.
The mesh is also available in 25 mm square pieces.

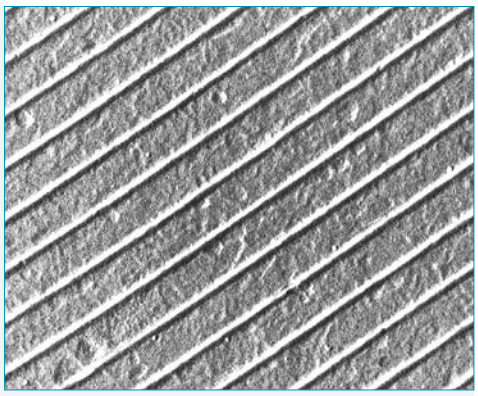
G248C 1000 mesh copper, 25 x 25 mm
G248N 1000 mesh nickel, 25 x 25 mm
G248A 1000 mesh gold, 25 x 25 mm
G243C 1500 mesh copper, 25 x 25 mm
G243N 1500 mesh nickel, 25 x 25 mm
G243A 1500 mesh gold, 25 x 25 mm
G249N 2000 mesh nickel, 25 x 25 mm



Diffraction grating replicas

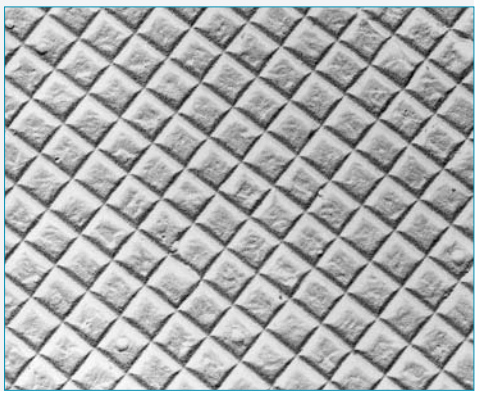
Shadow cast carbon replicas of diffraction line gratings (spacing 462.9 nm) which are used typically for calibrating electron-optical magnifications up to the x80,000 to x100,000 range.

S104 Diffraction grating replica 2160 lines/mm, 3.05 mm grid

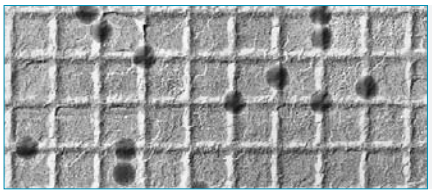


Rulings of 2160 lines/mm, ruled at 90° to one another, give additional accuracy to magnification checks and aid in checking distortion. These replicas should be used with care, avoiding excessive exposure at high probe/beam currents.

S106 Cross grating replica, 3.05 mm grid



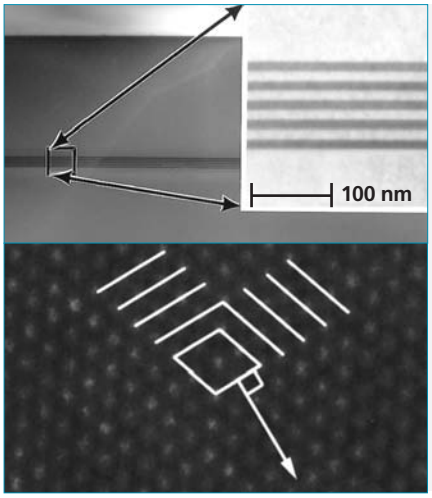
Diffraction grating replica with latex spheres



This standard for calibration provides a double-check of the accuracy of magnification calibration and is particularly useful for higher magnifications. The latex sphere size is 0.261 µm and the grating replica is 2160 lines/mm. Supplied on a 3.05 mm grid.

S106L Cross grating replica with latex spheres

MAG*I*CAL™ calibration standard



Using this standard, the three major instrument calibrations – magnification, camera constant for indexing diffraction patterns and image/diffraction pattern rotation – can all be carried out using a single specimen. The specimen is a single crystal consisting of a series of clearly defined layers of Si and SiGe which have been grown by molecular beam epitaxy. The thicknesses and spacings of these layers have been directly referenced to the (111) lattice spacing of silicon. The layer spacings are designed so that the sample can be used to calibrate almost the entire magnification range in a TEM from x1000 to x1,000,000. The single crystal nature means that it can also be used for camera constant and diffraction pattern rotation calibration. The specimen is in the form of an ion beam thinned wedge and is very stable under the electron beam. A certificate of calibration is also provided.

S1936 MAG*I*CAL calibration standard

Polystyrene latex particles

A drop from a suspension of uniform latex spheres can provide a useful size check when added to any preparation. It can also serve as a focus aid or to delineate structure of low slope, when the preparation has been shadow cast.

The particle sizes available are listed below, with the standard deviation and approximate particle concentration. These values may be subject to variation between different batches.

Material: polystyrene

Cat. no.	Mean particle* size (µm)	Standard deviation (µm)	Particle concentration (approx) n/ml
S130-1	0.120	0.021	1.05×10^{12}
S130-2	0.132	-	7.91×10^{11}
S130-3	0.182	-	3.02×10^{11}
S130-4	0.216	0.0009	1.80×10^{11}
S130-5	0.303	0.0019	6.60×10^{10}
S130-6	0.520	-	1.29×10^{10}
S130-7	0.855	-	3.04×10^{9}

Although these standard deviations are very small, the suspension may contain some particles of material with different diameters from the mean. A statistically significant number of latex particles should be included in any micrograph where a size comparison is to be attempted. It is important not to subject these spheres to excessive irradiation. All solutions are approximately 0.1 % weight by volume, packed in vials of 5 ml.

*Particle sizes shown may vary due to batch availability.

Polystyrene latex particles

This range of polystyrene latex spheres can be used for either SEM or TEM applications. All solutions are approximately 0.1 % weight by volume. Supplied in a 10 ml vial.

Cat. no.	Nominal size (µm)	Size uniformity (CV)	Particle concentration (approx) n/ml
S130-02	0.03	≤ 18 %	6.74×10^{13}
S130-04	0.08	≤ 15 %	3.55×10^{12}
S130-06	0.09	≤ 5 %	2.50×10^{12}

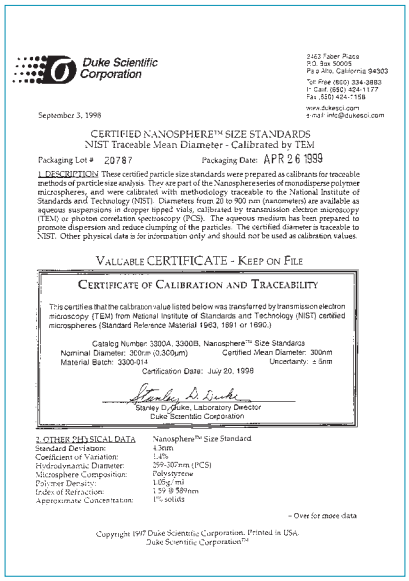
Certified particle size standards

These particle size standards are certified for mean diameter and are traceable to NIST. The highly uniform polystyrene spheres are calibrated by NIST traceable methods, including photon correlation spectroscopy, transmission electron microscopy and light microscopy. The range of diameters from 20 nm to 900 µm is ideal for the calibration of electron microscopes, optical microscopes and particle sizing instrumentation. A certificate of calibration and traceability is provided with each standard. Detailed physical and chemical properties are also shown.

Nanosphere size standards

Highly uniform polystyrene spheres with a density of 1.05 g/cm^3 and refractive index of 1.59 @ 589 nm wavelength. The spheres are supplied as 15 ml aqueous suspensions with 1 % solids in dropper topped bottles. The concentrations are optimised for ease of dispersion and colloidal stability.

Cat. no.	Nominal diameter (nm)	Certified mean diameter (nm)	Size distribution std. deviation & CV (nm)
S1800-20	20	21 ± 1.5	-
S1800-30	30	34 ± 1.4	-
S1800-40	40	41 ± 1.8	-
S1800-50	50	50 ± 2.0	-
S1800-60	60	60 ± 2.5	-
S1800-70	70	73 ± 2.6	-
S1800-80	80	81 ± 2.7	-
S1800-90	90	96 ± 3.1	-
S1800-100	100	102 ± 3	7.6 (7.5 %)
S1800-125	125	126 ± 3	4.4 (3.5 %)
S1800-150	150	155 ± 4	3.1 (2.0 %)
S1800-200	200	204 ± 6	3.1 (1.5 %)
S1800-300	300	304 ± 6	4.3 (1.4 %)
S1800-400	400	404 ± 4	5.9 (1.5 %)
S1800-500	500	503 ± 4	6.3 (1.3 %)
S1800-600	600	600 ± 5	6.6 (1.1 %)
S1800-700	700	701± 6	9.0 (1.3 %)
S1800-800	800	802 ± 6	9.6 (1.2 %)
S1800-900	900	895 ± 8	9.1 (1.0 %)



Duke Scientific Corporation

September 3, 1998

CERTIFIED NANOSPHERE™ SIZE STANDARDS
NIST Traceable Mean Diameter - Calibrated by TEM

Packaging Lot # 20787 Packaging Date: APR 26 1999

1. DESCRIPTION These certified particle size standards were prepared as calibrants for traceable methods of particle size analysis. They are part of the Nanosphere series of monodisperse polymer microspheres, and were calibrated with methodology traceable to the National Institute of Standards and Technology (NIST). Diameters from 20 to 900 nm (nanometers) are available as aqueous suspensions in dropper topped vials, calibrated by transmission electron microscopy (TEM) or photon correlation spectroscopy (PCS). The aqueous medium has been prepared to promote dispersion and reduce clumping of the particles. The certified diameter is traceable to NIST. Other physical data is for information only and should not be used as calibration values.

VALUABLE CERTIFICATE - KEEP ON FILE

CERTIFICATE OF CALIBRATION AND TRACEABILITY

This certifies that the calibration value listed below was transferred by transmission electron microscopy (TEM) from National Institute of Standards and Technology (NIST) certified microspheres (Standard Reference Material 1963, 1691 or 1690.)

Catalog Number: 3300A, 3300B, Nanosphere™ Size Standards
Nominal Diameter: 300nm (0.300µm) Certified Mean Diameter: 300nm
Material Batch: 3300-014 Uncertainty: ± 6nm
Certification Date: July 20, 1998

Stanley D. Duke, Laboratory Director
Duke Scientific Corporation

2. OTHER PHYSICAL DATA Nanosphere™ Size Standard
Standard Deviation: 4.3nm
Coefficient of Variation: 1.4%
Hydrodynamic Diameter: 299-307nm (PCS)
Microsphere Composition: Polystyrene
Polymer Density: 1.05g / ml
Index of Refraction: 1.59 @ 589nm
Approximate Concentration: 1% solids

– Over for more data

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Duke Scientific Corporation™

Unconjugated gold and silver nanoparticles

These nanometre-sized gold and silver particles of uniform size and shape are invaluable for nanotechnology, light scattering and single molecule detection. Gold nanoparticles can be attached to proteins, alkanethiols and DNA by various methods. Supplied in water, with trace amounts of citrate, tannic acid and potassium carbonate, they are citrate-stabilised with a net negative surface charge. The pH ranges are approximately 6 for 5 nm gold and less than 9 for the larger sized particles. Silver nanoparticles have similar functional characteristics. The high quality manufacturing techniques ensure that these particles are perfectly spherical, mono-disperse and have a coefficient of variation of less than 8 %.

Gold particles are available in sizes from 2 - 250 nm.

Silver particles are available in sizes from 20 - 80 nm.

Unconjugated gold colloids

Particle size (nm)	Particles per ml	Quantities 100 ml	500 ml	20 ml
2	15×10^{13}	**R14076**	**R14076-1**	**R14076-2**
5	5×10^{13}	**R14077**	**R14077-1**	**R14077-2**
10	5.7×10^{12}	**R14078**	**R14078-1**	**R14078-2**
15	1.4×10^{12}	**R14079**	**R14079-1**	**R14079-2**
20	7.0×10^{11}	**R14080**	**R14080-1**	**R14080-2**
30	2.0×10^{11}	**R14081**	**R14081-1**	**R14081-2**
40	9.0×10^{10}	**R14082**	**R14082-1**	**R14082-2**
50	4.5×10^{10}	**R14150**	**R14150-1**	**R14150-2**
60	2.6×10^{10}	**R14151**	**R14151-1**	**R14151-2**
80	1.1×10^{10}	**R14152**	**R14152-1**	**R14152-2**
100	5.6×10^{9}	**R14153**	**R14153-1**	**R14153-2**
150	1.7×10^{9}	**R14154**	**R14154-1**	**R14154-2**
200	7.0×10^{8}	**R14155**	**R14155-1**	**R14155-2**
250	3.6×10^{8}	**R14156**	**R14156-1**	**R14156-2**

Silver colloids

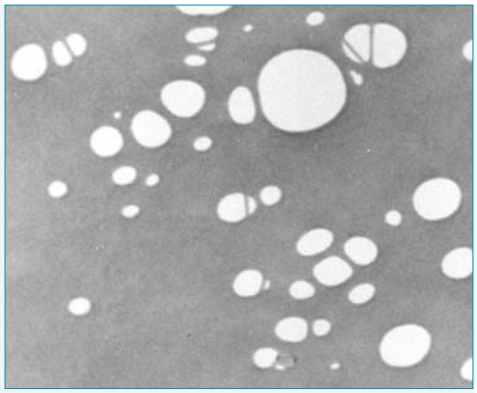
Particle size (nm)	Particles per ml	Quantities 100 ml	500 ml	20 ml
20	7.0×10^{11}	**R14270**	**R14270-1**	**R14270-2**
40	9.0×10^{10}	**R14271**	**R14271-1**	**R14271-2**
60	2.6×10^{10}	**R14272**	**R14272-1**	**R14272-2**
80	1.1×10^{10}	**R14273**	**R14273-1**	**R14273-2**

All gold colloids are supplied at optical density 1.0 measured at 520 nm.
They contain 0.01 % concentration of $HAuCl_4$, except the 2 nm particle size, which has a concentration of 0.002 %.

Resolution and magnification calibration

Perforated carbon film

This specimen is one of the quickest and easiest to use for performance checks since it gives information about nearly all causes of loss of resolution. The Agar Scientific perforated carbon films yield holes small enough to be imaged at an instrumental magnification of x200,000. If these holes are not present in a grid square they will be found in an adjacent square. The holes are round, with smooth unthickened edges. Perforated carbon films are thin films of carbon which have been treated to obtain a large number of small holes. The examination of the Fresnel fringe around a hole when the objective lens is slightly defocused enables the astigmatism to be corrected. The clarity of the fringe also gives information about the mechanical and electrical stabilities and available resolution of the instrument. When higher resolution equipment is used, the slightly underfocused image of the carbon film itself is used for astigmatism correction.



S100 Perforated carbon film, 3.05 mm grid

Lattice plane specimens

Crystal lattice plane spacings provide a good test of microscope stability and a figure of merit for resolved lattice resolution. At the same time, since lattice spacing is accurately known from X-ray measurements, it provides calibration in the upper range of magnification of the instrument.

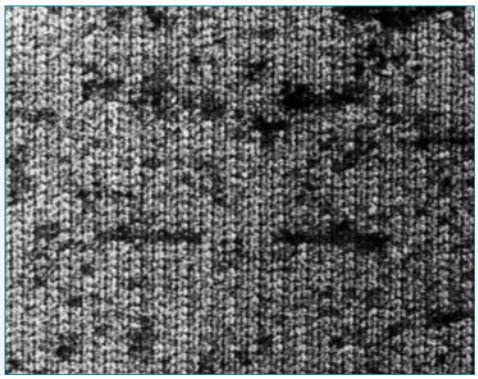
Catalase

Negatively stained catalase crystals show lattice plane spacings of approximately 8.75 and 6.85 nm very clearly (using TEM and STEM). (Figures determined by Wrigley. *J. Ultrastructure Res*. 24, 454. 1968).

They are valuable for high magnification calibration.

S124 Catalase crystals, 3.05 mm grid

For higher magnifications, one of the crystal lattice plane specimens listed as a resolution check can be used. See **S140** or **S135**, pages 71 and 72.

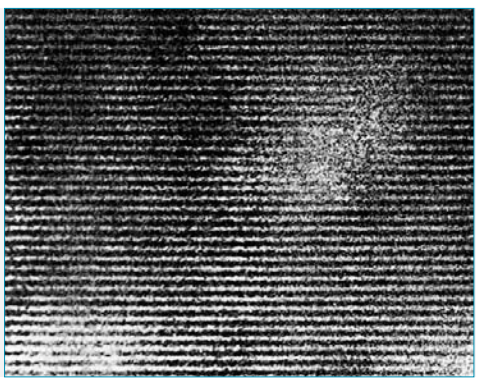


Plane spacing 1.0 nm

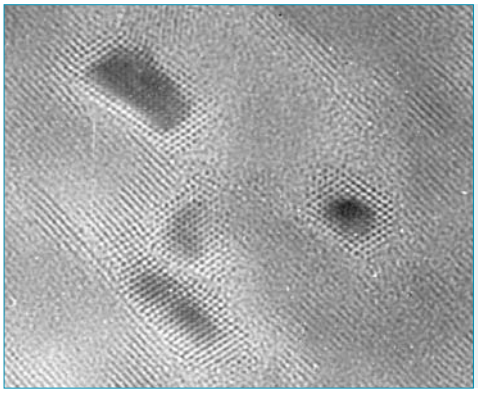
Copper phthalocyanine

Numerous images of this material appear in literature on transmission electron microscopy. The spacing gives a convenient test, but the specimens are beam sensitive and quickly lose their crystalline structure under the electron beam.

S136 Copper phthalocyanine, 3.05 mm grid



Plane spacing 1.75 and 1.3 nm

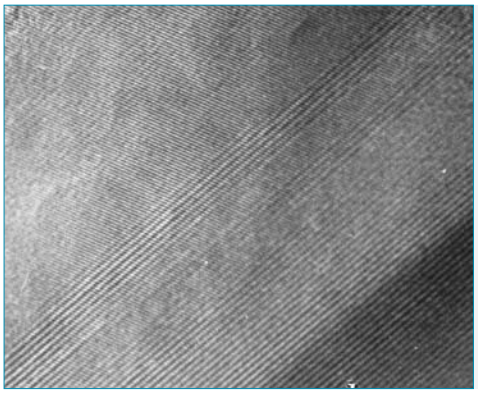


Chloro-copper phthalocyanine

These crystals are more irradiation-resistant than copper phthalocyanine and are therefore better for the visualisation of lattice planes (Murate, Y., Baird, T., and Fryer, J.R. *Nature* 262, 721. 1976). The sample must be tilted at 26.5° to the horizontal to reveal the spacings. Owing to the particular difficulties of the preparation process, these specimens are fragmentary and normal grid coverage is not achieved.

S156 Chloro-copper phthalocyanine, 3.05 mm grid

Plane spacing 0.9 and 0.45 nm

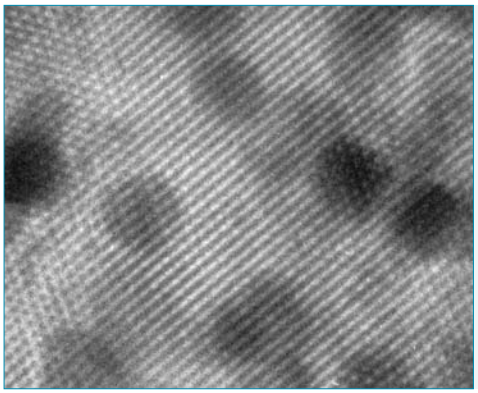


Crocidolite

The 0.9 nm spacing (020) will be found along the axis of the crocidolite fibres. The 0.45 nm spacing (021) appears at an angle of about 60° to this, in suitable crystal orientations.

S122 Crocidolite crystals, 3.05 mm grid

Plane spacing 0.56 nm

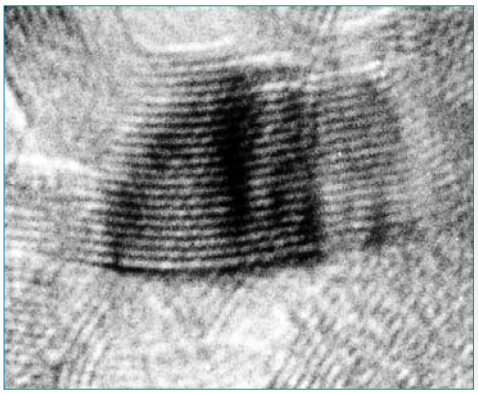


Potassium chloroplatinate

This is a uniform distribution of crystallites thinly dispersed on a 3.05 mm grid and exhibits a lattice plane spacing of 0.56 nm. It is advisable to tilt the specimen at 35° to the horizontal to reveal the plane spacing. This specimen is moderately stable in the electron beam.

S118 Potassium chloroplatinate crystals, 3.05 mm grid

Plane spacing 0.34 nm



Graphitised carbon black

Being stable and highly reproducible, this is a standard resolution test for transmission electron microscopes.

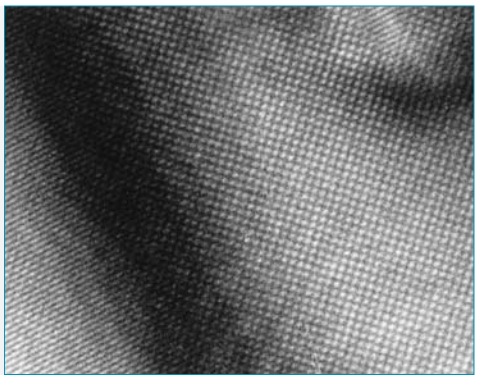
S140 Graphitised carbon black, 3.05 mm grid

Plane spacing 0.204, 0.143 and 0.102 nm

Oriented single crystal gold foil

Resolution, image quality, magnification and instrumental stability in higher resolution TEMs can be checked by setting up the conditions for imaging the 0.204 (200 plane), 0.143 (220 plane) and 0.102 nm planar spacing in these specially prepared crystals. The tests are particularly recommended if height adjustments are made on the specimen stage. The gold foils are mounted on gold grids.

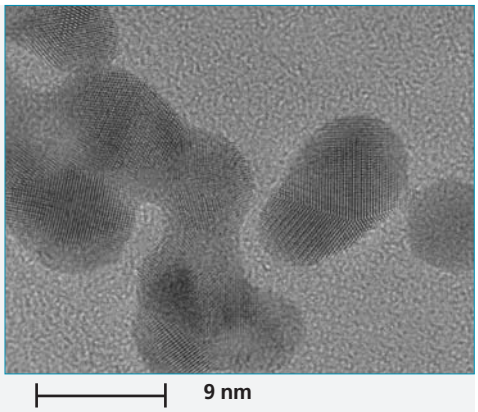
S135 Oriented gold crystal, 3.05 mm grid



High resolution test specimen gold particles on carbon film

An arrangement of finely dispersed thin gold particles has an advantage over single crystal gold foil for tests of high resolution imaging capabilities in TEM. As with gold foil, image quality, magnification and instrumental stability are readily assessed, however, this gold particle specimen is superior for the determination of resolution capabilities since it offers a choice of crystalline orientations on static or low tilt stages. In addition, the thickness of the crystalline material is easily calculated from the projected shape of the gold crystal. The background noise arising from structure in the support film helps with determinations of the operating transfer function.

S132 Gold particles on carbon film, 3.05 mm grid



Micrograph courtesy of Dr D.A. Jefferson, Department of Physical Chemistry, University of Cambridge.

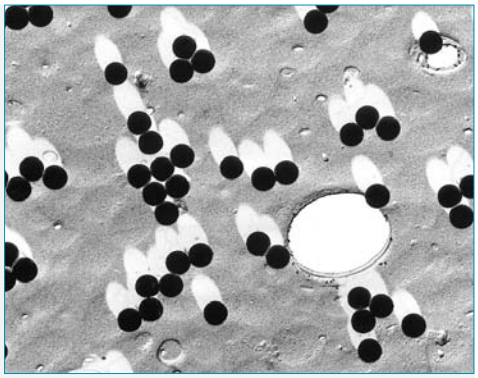
Polystyrene latex particles

Shadowed latex particles of 0.216 µm diameter provide dense markers, and small metal aggregates may be found at the edges of the metal shadowing for particle separation resolution checks.

S128A-4 Polystyrene latex particles shadowed with palladium/platinum alloy on 3.05 mm grid

Shadowed latex particles of other sizes are available as shown below:

S128A-1 Polystyrene latex particles, 0.120 µm, shadowed
S128A-2 Polystyrene latex particles, 0.132 µm, shadowed
S128A-3 Polystyrene latex particles, 0.182 µm, shadowed
S128A-5 Polystyrene latex particles, 0.303 µm, shadowed
S128A-6 Polystyrene latex particles, 0.520 µm, shadowed
S128A-7 Polystyrene latex particles, 0.855 µm, shadowed



Particle size may change subject to availability.

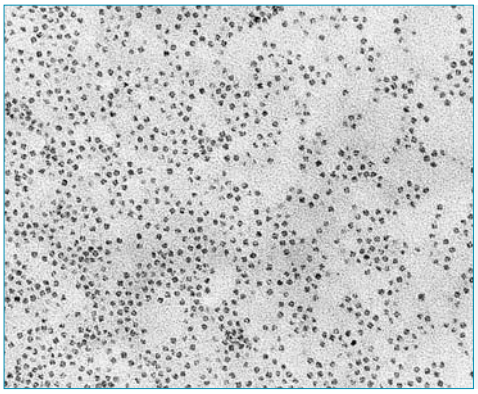
Gold shadowed latex particles

These are latex particles of 0.216 µm diameter shadowed with a fairly heavy coating of gold. The gold forms islands of strongly scattering material and produces a suitable test object for STEM.

S128B Polystyrene latex particles shadowed with gold, 3.05 mm grid

Please note any particle size shown on page 72 can be shadowed.

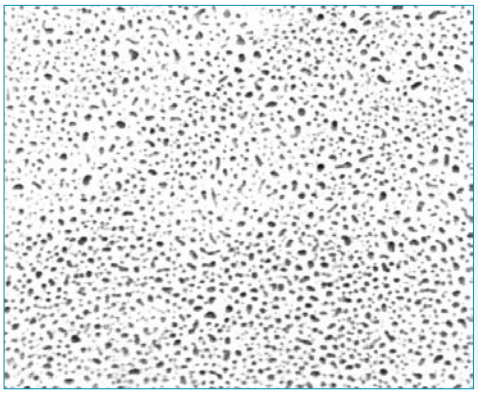
Ferritin



Ferritin molecules display a quad structure with a separation of 1.25 nm, which is useful as a resolution check. This specimen is a dispersion of ferritin molecules on a Formvar®/carbon substrate.

S126 Ferritin, 3.05 mm grid

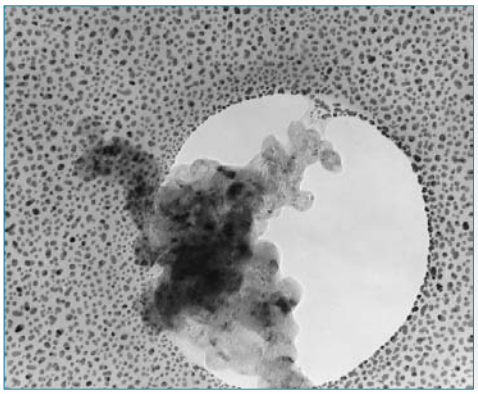
Evaporated platinum/iridium



The evaporated platinum/iridium specimen is supplied on a perforated carbon support film that provides holes for ease of focus and astigmatism correction. The grains of evaporated metal provide dense, high contrast particles for resolution checks by the point separation test.

S114 Platinum/iridium on perforated carbon, 3.05 mm grid

Combined test specimen



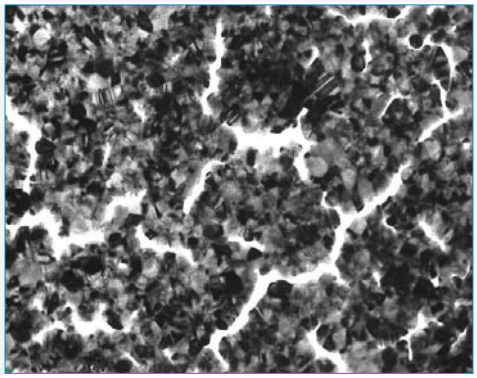
A perforated carbon film is shadowed with gold and graphitised carbon particles are deposited. These particles viewed over the holes may be used for assessment of factors limiting the microscope performance. The evaporated gold forms small polycrystalline islands and within these islands lattice fringes can be resolved. This specimen can also be used for the measurement of contamination rates in the electron microscope by noting the deposition rate of carbon within the holes found in the gold film.

S142 Combined test specimen, 3.05 mm grid

Standard for HVEM

Normal resolution test specimens are difficult to see on the viewing screen because of low contrast. These specimens are grids coated with a thick layer of evaporated gold, which forms crystallites containing lines of strong diffraction contrast. The lines are of different spacings allowing for checking performance at a variety of levels.

S155 HVEM test specimen, evaporated gold, 3.05 mm grid

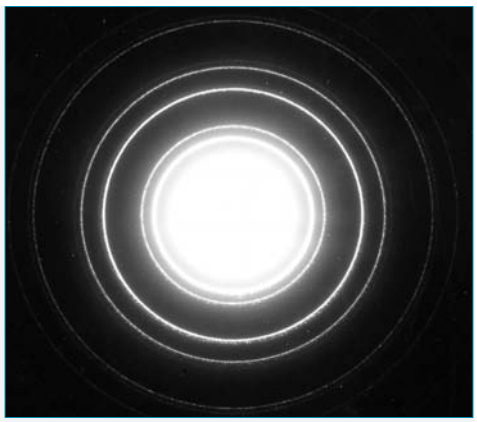


Diffraction standards

Camera length

The nominal value of the effective camera length of an electron microscope operating in the selected area mode is not sufficiently accurate for calculating lattice spacing. The actual value of camera length must be calibrated at the same accelerating voltage and objective lens setting by reference to a known substance with well defined diffraction spacings. The normal specimens for this are evaporated films of aluminium or thallous chloride. The very small crystallite size yields ring patterns suitable for calibration purposes. Each specimen is supplied with a list of the principal lattice spacings.

S108 Evaporated aluminium film, 3.05 mm grid



S110 Evaporated thallous chloride, 3.05 mm grid

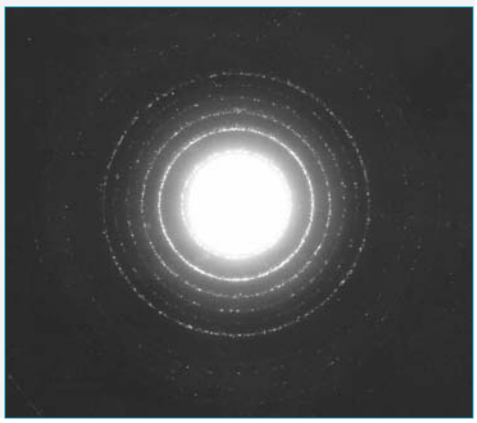
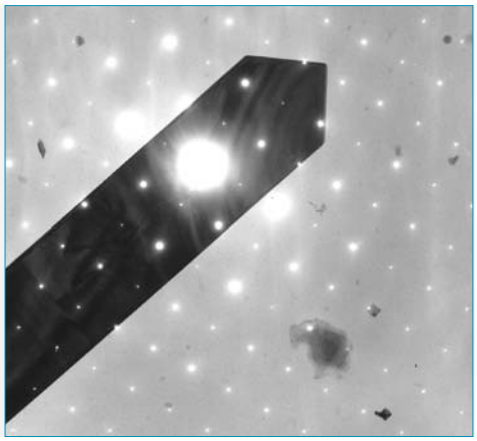


Image rotation

Molybdenum trioxide crystals

A test specimen with molybdenum trioxide crystals on a carbon film is good for the calibration of the image-diffraction rotation angle in TEM and STEM mode. Molybdenum trioxide is pseudo-orthorhombic (lattice parameters a 0.397 nm, b 1.385 nm and c 0.370 nm). From a double-exposure, or the overlaying of an image and diffraction pattern, the rotation angle can be established.

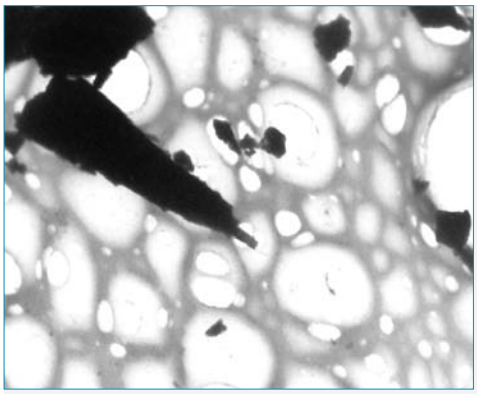
S112 Molybdenum trioxide crystals, 3.05 mm grid



X-ray standards

A large proportion of all transmission and scanning electron microscopes have an X-ray analytical attachment to provide quantitative chemical information about the sample. This supplements the morphological information. In spite of the steadily improved software packages, it is still necessary to have good quality X-ray standards available.

X-ray standards for TEM



Augite particles dispersed onto holey carbon film.

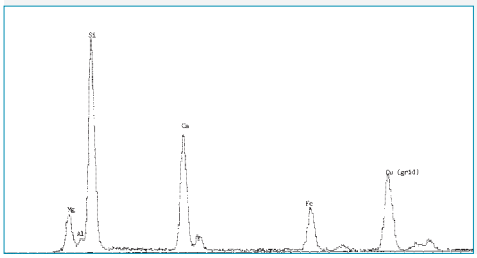
These standards are supplied as fine powders dispersed onto holey carbon films and are selected from a range of certified materials and synthetic compounds. They are supplied on 3.05 mm grids. Normally the holey carbon films are supported by 400 mesh copper grids although alternative grid materials can be specified.

The universal set contains 25 compound standards and the rare earth set 14 compounds.

S1980 Universal TEM X-ray standards. Set of 25

S1981 Rare earth TEM X-ray standards. Set of 14

Alternatively standards can be chosen from the list on pages 78 - 80, a minimum of five per set.



For STEM applications, there is a thin foil standard set consisting of 25 high purity metal foils, each measuring 3 mm diameter and 0.1 mm thick. Alternatively, these foils can be supplied as a set of five.

S1982 Metal foil standards. Set of 25

S1983 Metal foil standards. Set of 5 (specify metals required)

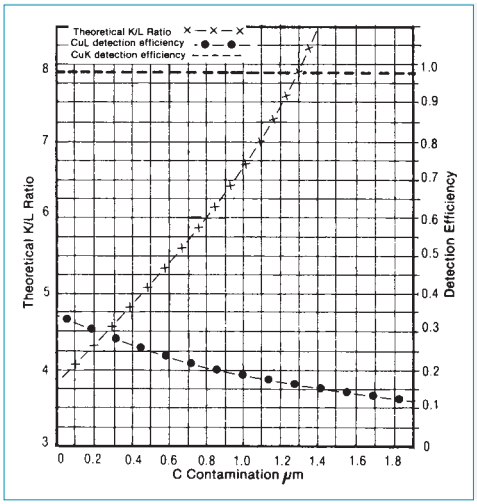
Further details available on request.

Boron carbide standard

Mounted on a carbon support film, this dispersion of small boron carbide particles provides a low atomic number analysis standard for determining the energy resolution of wavelength dispersive X-ray spectrometers.

S144 Boron carbide, 3.05 mm grid

Copper foil on aluminium grid



This dual-purpose specimen determines detector efficiency, generating two well separated Klines to check the calibration of the X-ray detector. The aluminium generates a low energy line at 1.49 keV and the copper K-alpha peak occurs at 8.04 keV. The copper film is a very uniform thickness of about 60 nm, carbon coated on each side.

The ratio of the Cu K/Cu L X-ray intensities is measured. This will provide a measure of detector efficiency. The detector efficiency is normally assumed to be a constant, but in fact a contaminant layer on the beryllium window can significantly affect its efficiency. It is most important to check for such variation if any reliance is to be placed on quantitative results obtained.

S149 Calibrating copper foil for X-ray detectors, 3.05 mm grid

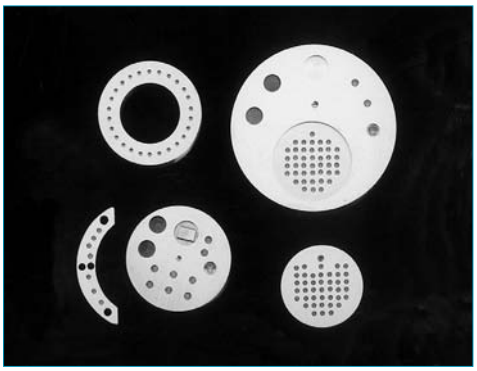
Reference standards for X-ray microanalysis (SEM)

Micro-Analysis Consultants range

This range of standards can be supplied individually or in the form of multi-element sets either fixed or as a selection to the choice of the user. Standards can be supplied that are suitable for energy dispersive or wavelength dispersive X-ray microanalysis systems.

All standards are supplied with fully authenticated certificates of analysis and a location map for standard identification. A Faraday cup for accurate specimen current measurements is available as an optional extra on all mounts.

The standards are polished to a ¼ µm diamond finish and carbon coated. They are available in a variety of brass holders, 25 mm or 32 mm diameter blocks containing up to 50 standards, carousels, 13 mm diameter blocks to fit pin stubs, or individual tubes of 2 mm, 3 mm or 5 mm diameter.



Basic calibration set

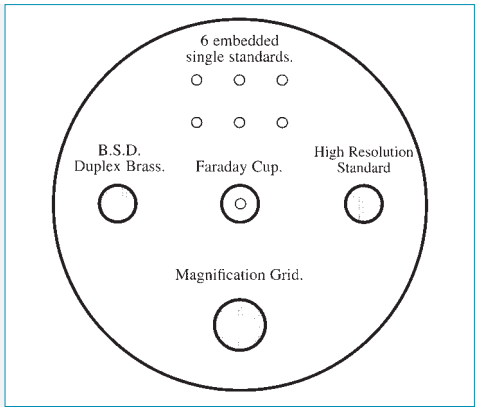
A set of six standards plus a Faraday cup mounted in a 25 mm diameter block, designed to provide a wide range of calibrations and performance checks. The six standards BN, C, Mn, Co, Cu and $Mn_3Al_2Si_3O_{12}$ can be used for determining energy scale calibration, detector resolution, light element sensitivity and resolution, thin window contamination and probe current stability.

S1928 Basic calibration set

Multi-purpose calibration block

This set combines a number of test specimens in a single 32 mm diameter holder. Six analytical standards specified by the user are provided for EDX calibration together with a Faraday cup. A silicon test specimen is used for magnification calibration, a gold on carbon test specimen for resolution checking and a duplex brass specimen for checking backscattered electron detector performance. Supplied with certificates of analysis and a certificate of accuracy for the magnification standard. Other combinations available on request.

S1919 SEM calibration block



Quality control test calibration block

The quality control test calibration block is a round brass block with four test samples, a Faraday cup, a particle feature, two resolution standards and a magnification grid. It allows the calibration of the three major elements in any SEM imaging and analysis system (SEM, BSD, EDX/WDX).

The gold on carbon specimen has a particle size range of 5 - 150 nm. A square grid pattern with large crystals in the centre of each grid and fine crystals at the edges allow medium and high resolution point separation tests. The tin on carbon specimen consists of tin spheres sized from 10 - 100 nm, ideal for medium resolution tests and astigmatism correction. The silicon magnification grid is used for the SEM magnification calibration. The particle feature is used to calibrate the initial grey scale level of the backscattered electron detector and the duplex brass sample for checking the resolution and performance.

The four individual elements (which can be specified by the customer) along with the carbon and cobalt from the particle feature are used for the setting up and calibration of the EDX system.

S1957 Quality control test calibration block

Universal set with Faraday cup

B	Ni	InAs
BN	Cu	Sn
C	Zn	Sb
Jade	GaP	BaF_2
MgO	Ge	LaB_6
Al_2O_3	Se	$CeAl_2$
$KAlSi_3O_8$	SrF_2	Hf
$CaSiO_3$	Y	Ta
Ti	Zr	W
V	Nb	Ir
Cr	Mo	Pt
Mn	Rh	Au
Fe	Pd	HgTe
FeS_2	Ag	PbTe
Co	Cd	Bi

A set of 45 standards with Faraday cup.

S1914 Universal standards set, 25 mm block
S1915 Universal standards set, 32 mm block

Biological set

BN	KCl	FeS_2
C	KBr	Se
NaCl	$CaCO_3$	InP
MgO	$CaSO_4$	BaF_2
Al	Ti	$BaSO_4$
SiO_2	V	Bi

A set of 18 standards and a Faraday cup suitable for biological applications.

S1920 Biological standard set, 25 mm block
S1921 Biological standard set, 32 mm block

Semiconductor set

B	FeS_2	Ag_2S
C	Cu_2S	CdS
Mg_2Sn	ZnS	InP
Al_2SiO_5	GaP	InSb
Si	GaAs	HgTe
CaF_2	Bi_2Te_3	PbTe
$FeSi_2$	Ge	Bi_2Se_3

A set of 21 standards chosen for semiconductor applications.

S1916 Semiconductor set, 25 mm block
S1917 Semiconductor set, 32 mm block

Faraday cup

A Faraday cup for accurate specimen current measurements is available.
Supplied mounted in a 12.5 mm pin stub.

S1929 Faraday cup in 12.5 mm pin stub

X-ray microanalysis standards refurbishment

A refurbishment service for MAC standards includes re-polishing, carbon coating and inspection. Individual standards will be replaced if found to be damaged. Costs are dependent on the number of standards in the block and the condition of the returned block. It is recommended that standards are returned to us every two years.

Please ask for further details.

Multi-element standards

The tables show the complete list of certified pure element and compound standards from which the user may select the most appropriate combination to suit their application. Alloy standards are also available.

Individual or multi element reference standards can be chosen from the selection of pure elements, compounds, REE glass, minerals, and metals, listed in the following tables.

Pure elements

Ag	Silver	In	Indium	Se	Selenium
Al	Aluminium	Ir	Iridium	Si	Silicon
As	Arsenic	Mg	Magnesium	Sn	Tin
Au	Gold	Mn	Manganese	Ta	Tantalum
B	Boron	Mo	Molybdenum	Tb	Terbium
Be	Beryllium	Nb	Niobium	Te	Tellurium
Bi	Bismuth	Nd	Neodymium	Ti	Titanium
C	Carbon	Ni	Nickel	Tl	Thallium
Cd	Cadmium	Os	Osmium	Tm	Thulium
Co	Cobalt	Pb	Lead	V	Vanadium
Cr	Chromium	Pd	Palladium	W	Tungsten
Cu	Copper	Pt	Platinum	Y	Yttrium
Dy	Dysprosium	Re	Rhenium	Yb	Ytterbium
Fe	Iron	Rh	Rhodium	Zn	Zinc
Gd	Gadolinium	Ru	Ruthenium	Zr	Zirconium
Ge	Germanium	Sb	Antimony		
Hf	Hafnium	Sc	Scandium		

REE glass standards

Ba	Barium REE glass	K	Potassium REE glass	Sr	Strontium REE glass
Ce	Cerium REE glass	La	Lanthanum REE glass	Tb	Terbium REE glass
Ce, Eu, Ho, Tm	REE glass 4 % each	La, Sm, Gd, Yb	REE glass 4 % each	Th	Thorium REE glass
Cs	Cesium REE glass	Lu	Lutetium REE glass	Tm	Thulium REE glass
Dy	Dysprosium REE glass	Nd	Neodymium REE glass	U	Uranium REE glass
Er	Erbium REE glass	Nd, Th, Lu	REE glass 4 % each	Y	Yttrium REE glass
Eu	Europium REE glass	Pr	Praseodymium REE glass	Y, Pr, Dy, Er	REE glass 4 % each
Gd	Gadolinium REE glass	Rb	Rubidium REE glass	Yb	Ytterbium REE glass
Ho	Holmium REE glass	Sm	Samarium REE glass		Glass blank

Multi-element standards

Compound standards

Ag_2Te_3	Silver telluride	Gd_2O_3	Gadolinium(III) oxide	PbO	Lead oxide
AgCl	Silver(I) chloride	GdF_3	Gadolinium(III) fluoride	PbS	Lead sulphide
AgS_2	Silver sulphide	GeO_2	Germanium(IV) oxide	PbSe	Lead selenide
Al_2O_3	Aluminium oxide	HfO_2	Hafnium oxide	PbTe	Lead telluride
AlF_3	Aluminium fluoride	HgS	Mercury sulphide (black)	PrF_3	Praseodymium fluoride
AlN	Aluminium nitride	HgTe	Mercury telluride	PTFE	Polytetrafluoroethylene
AlSb	Aluminium antimonide	HoF_3	Holmium fluoride	RbBr	Rubidium bromide
B_2O_3	Boron trioxide	In_2Se_3	Indium selenide	RbI	Rubidium iodide
B_4C	Boron carbide	In_2Te_3	Indium telleride	Sb_2S_3	Antimony sulphide (stibnite)
BaF_2	Barium fluoride	InAs	Indium arsenide	Si_3N_4	Silicon nitride
$BaTiO_3$	Barium titanite	InP	Indium phosphide	SiC	Silicon carbide
Bi_2O_3	Bismuth oxide	InS	Indium sulphide	SiO_2	Silicon(IV) oxide
Bi_2Se_3	Bismuth selenide	InSb	Indium antimonide	Sm_2O_3	Samarium oxide
Bi_2Te_3	Bismuth telluride	KBr	Potassium bromide	SmF_3	Samarium fluoride
BN	Boron nitride	KCl	Potassium chloride	Sn	Tin wire
$CaMoO_4$	Calcium molybdate	La_2O_3	Lanthanum(III) oxide	SnO_2	Tin(IV) oxide
$CaTiO_3$	Calcium titanium oxide	LaB_6	Lanthanum hexaboride	SrF_2	Strontium fluoride
$CaWO_4$	Calcium tungstate	LaF_3	Lanthanum(III) fluoride	$SrTiO_3$	Strontium titanite
CdS	Cadmium sulphide	$LiNbO_3$	Lithium niobate	Ta_2O_5	Tantalum pentoxide
CdSe	Cadmium selenide	$LiTaO_3$	Lithium tantalate	TaN	Tantalum nitride
CdTe	Cadmium telluride	LiF	Lithium fluoride	$TaSi_2$	Tantalum silicide
$CeAl_2$	Cerium alumate	LuF_3	Lutetium fluoride	TbF_3	Terbium fluoride
CeF_3	Cerium(III) fluoride	$LuSi_2$	Lutetium silicide	$TbSi_2$	Terbium silicide
CeO_2	Cerium(IV) oxide	Mg_2Sn	Magnesium tin alloy	TeO_2	Tellurium(IV) oxide
Co_3O_4	Cobalt(II, III) oxide	MgF_2	Magnesium fluoride	ThO_2	Thorium oxide
$Cr_{23}C_6$	Chromium carbide	MgO	Periclase (magnesium oxide)	TiC	Titanium carbide
Cr_2O_3	Chromium oxide C-1100	$MgOAl_2O_4$	Spinel	TiN	Titanium nitride
Cr_3C_2	Chromium carbide	$Mn_{15}Si_{26}$	Manganese silicide	TiO	Titanium monoxide
CrN	Chromium(III) nitride	$MnCO_3$	Manganese carbonate	TiO_2	Titanium(IV) oxide
CsBr	Cesium bromide	MnF_2	Manganese fluoride	$TiSi_2$	Titanium(IV) sulfide
CsI	Cesium iodide	MnO_2	Manganese(IV) oxide	TlBr	Thallium(I) bromide
CuI	Copper iodide (powder)	MnS	Manganese sulfide	TlI	Thallium(I) iodide
CuO	Copper(II) oxide	$MnTiO_3$	Manganese(II) titanate oxide	TmF_3	Thulium fluoride
CuS	Copper(II) sulphide	Mo_2C	Molybdenum carbide	$TmSi_2$	Thulium silicide
$CuSO_4$	Copper(II) sulphate	MoO_3	Molybdenum(VI) oxide	V_2O_5	Vanadium oxide
DyF_3	Dysprosium fluoride	MoS_2	Molybdenum(IV) sulphide	VC	Vanadium carbide
ErF_3	Erbium fluoride	Na_3AlF	Cryolite	WC	Tungsten carbide
Eu_2O_3	Europium(III) oxide	NaCl	Sodium chloride	WSi_2	Tungsten silicide
EuF_3	Europium(III) fluoride	NaF	Sodium fluoride	Y_2O_3	Yttrium oxide
Fe_2P	Iron phosphide	Nb_2O_3	Niobium oxide	YbF_3	Ytterbium fluoride
FeO	Iron ferrous oxide	Nb_2O_5	Niobium(V) oxide	ZnO	Zinc oxide
FeS	Iron(II) sulphide	Nd_2O_3	Neodymium oxide	ZnS	Zinc sulphide
$FeSi_2$	Iron silicide	NdF_3	Neodymium fluoride	ZnSe	Zinc selenide
Ga_2Se_3	Gallium selenide	Ni_2Si	Nickel silicide	ZnTe	Zinc telluride
GaAs	Gallium arsenide	NiAs	Nickel arsenide	ZrB_2	Zirconium boride
GaN	Gallium nitride	NiO	Nickel oxide	ZrC	Zirconium carbide
GaP	Gallium phosphide	NiP	Nickel phosphide	ZrN	Zirconium nitride
GaS	Gallium sulphide	$NiSO_4$	Nickel sulphate	ZrO_2	Zirconium oxide
GaSb	Gallium antimonide	PbF_2	Lead fluoride		

Multi-element standards

Mineral standards

Ag_3AsS_3	Proustite
AgI	Iodargyrite
Al_2SiO_5	Kyanite
$AlSi_2O_6$	Pollucite
$Al_2Si_2O_5(OH)_4$	Kaolinite powder
$Ba(Al_2Si_2O_8)$	Celsian
$BaSO_4$	Baryte
$BaSO_4$	Baryte (Shropshire)
$BaSO_4$	Baryte 2 (Cumbria)
$BaTiS_3O_9$	Benitoite
$Be_3Al_2Si_6O_{18}$	Beryl
Bi_2S_3	Bismuthinite
C	Diamond
$(Ca)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2.nH_2O$	Ca - Montmorillonite
$Ca_3Al_2(SiO_4)_3$	Grossular
$CaAl_2Si_2O_8$	Anorthite
$CaCO_3$	Calcite
CaF_2	Fluorite
$Ca_3Fe_2(SiO_4)_3$	Andradite
$CaMg(CO_3)_2$	Dolomite
$Ca_2(Mg, Fe, Al)_5 (Al, Si)_8O_{22}(OH)_2$	Hornblend(e)
$(Ca,Mg,Fe)_2(SiAl)_2O_6$	Augite
$Ca(Mg,Fe)Si_2O_8$	Diopside
$CaMgSiO_4$	Monticellitite + intergrown calcite
$Ca_2Mg_5Si_8O_{22}(OH)_2$	Tremolite
$(Ca,Na)(Si,Al)_4O_8$	Labradorite
$Ca_5(PO_4)_3F$	Fluorapatite
$Ca_5(PO_4)_3(F,Cl,OH)$	Apatite 2
$Ca_{10}(PO_4)_6(OH)_2$	Hydroxyapatite
$CaSiO_3$	Wollastonite
$CaSO_4$	Anhydradite
$CaTiSiO_5$	Sphene (titanite)
$CaWO_4$	Scheelite
CoAsS	Cobaltite
$(Co,Ni)As_3$	Skutterudite
$CuFeS_2$	Chalcopyrite
Cu_2O	Cuprite
$Cu_2(OH)_2CO_3$	Malachite
$Cu_3(OH)_2(CO_3)_2$	Azurite
Cu_2S	Chalcocite
$(Fe_5Al)(AlSi_3)O_{10}(OH)_8$	Chlorite (chamosite)
$Fe_3Al_2Si_3O_{12}$	Almandine garnet (magnesium rich)
$Fe_3Al_2Si_3O_{12}$	Almandine garnet (iron rich)
$FeCO_3$	Siderite
$FeCrO_4$	Chromite
Fe_2O_3	Iron oxide (haematite)
Fe_3O_4	Magnetite
FeS_2	Pyrite
FeS_2	Marcasite
$FeTiO_3$	Ilmenite
$Gd_3Ga_5O_{12}$	Gadolinium gallium garnet
$K[AlSi_3O_8]$	Sanidine
$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$	Illite powder
$K(Mg,Fe,Mn)_3Si_3AlO_{10}$	Phlogopite
$K(Mg,Fe)_3(Si_3Al)O_{10}(OH,F)_2$	Biotite
$KAl_2(AlSi_3O_{10})$	Muscovite
$KAlSi_3O_6$	Microcline
$KAlSi_3O_8$	Orthoclase
$LiAlSiO_6$	Spodumene
$Mg_3Al_2(SiO_4)_{33}$	Pyrope garnet (red)
$MgCaSi_2O_6$	Chrome diopside
$MgCO_3$	Magnesite
$(Mg,Fe)_2SiO_4$	Olivine
$Mg_6(OH)_8(Si_4O_{10})$	Serpentine
Mg_2SiO_4	Forsterite
$Mn_3Al_2Si_3O_{12}$	Garnet spessartine
MnCaMgO	Rodocrosite
$(Mn,Ca)_3Si_3O_9$	Bustamite
$(Mn,Fe^{2+})(Nb,Ta)_2O_6$	Columbite
$Mn(II)_3Al_2(SiO_4)_3$	Spessartine
$MnSiO_3$	Rhodonite
MoS_2	Molybdenite
$Na_4AlBe(Si_4O_{12})Cl$	Tugtupite
$(Na)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2.nH_2O$	Na - Montmorillonite powder
$NaAl(Si_2O_6)$	Jadeite
$NaAlSi_3O_8$	Albite
$Na_4Al_3(SiO_4)_3Cl$	Sodalite
$NaAlSi_2O_6 \cdot H_2O$	Analcime
$Na_2Ca_2Al_6Si_9O_{30} \cdot 8(H_2O)$	Mesolite
$NaCa_2(Mg_4Ti)Si_6Al_2O_{23}(OH)_2$	Kaersutite
NiS	Millerite (nickel sulphide)
$PbCrO_4$	Crocoite powder
$Pb_5(PO_4)_3Cl$	Pyromorphite
PbS	Galena
$Pb_5(VO_4)_3Cl$	Vanadinite
Sb_2O_3	Valentinite (antimony oxide)
Sb_2S_3	Stibnite
SiO_2	Obsidian
SiTiAlFeMgCaNaKO	Kaersutite KK1 - 15
SnO_2	Cassiterite (tin oxide)
$SrCO_3$	Strontianite
$SrSO_4$	Celestine
$Y_3Al_5O_{12}$	Yttrium aluminium garnet (YAG)
YPO_4	Xenotime
$ZnAl_2O_4$	Gahnite (zinc aluminium oxide)
$ZnAl_2O_4$	Gahnite, dry gulch
ZnS	Sphalerite
Zn_2SiO_4	Willemite
$ZrSiO_4$	Zircon
$ZrSiO_4$	Cubic zirconia

Multi-element standards

In addition to the compound standards listed, we have a range of alloy standards with specific compositions. These include steels, stainless steels, non-ferrous alloys and glasses. They can be supplied as single standards or incorporated into multi-standard blocks. Certificates of analysis are traceable to European, American or British standards.

Metal standards
British chemical standards

BCS/CRM No. 355	Tin ore, Sn 31.42 %
BCS/CRM No. 355	Sn 31.42 %
BCS/SS CRM No. 470	Ferritic stainless steel
BCS/SS CRM No. 464/1	Austenitic stainless steel
BCS/SS CRM No. 474	Stainless steel
BCS/SS No. 461	Austenitic stainless steel
BCS/SS No. 464	Austenitic stainless steel
BCS/SS No. 465	Austenitic stainless steel
BCS/SS No. 466	Austenitic stainless steel
BCS/SS No. 495/1	13 % Manganese steel
BCS 204/4	High carbon Fe-Cr
BCS 332/SS No. 62	Austenitic stainless steel
BCS 333/SS No. 63	Austenitic stainless steel
BCS 342/SS No. 72	Ferritic stainless steel
BCS No. 179/2	High tensile brass
BCS No. 238/2	0.2 % Carbon steel
BS 153	AISI Grade 430F stainless steel
BS 154	Stainless steel 430FR (high silicon)
MBH - 111X12670	Cr 19.31 %, W 10.1 %
MBH - 11X0331.2 (batch H)	Corr-R cast iron (chill cast)
MBH - 11XS1CR1 (batch J)	Corrosion resistant cast iron
MBH - 13M BS 186A	High alloy stainless steel
MBH - 13M BS 89E	AISI stainless steel
MBH - 13M BS 91E	AISI stainless steel
MBH - 13X18001	Austenitic stainless steel
MBH - 14M BS 190	High manganese stainless steel
MBH - 14XHS1	High speed steel
MBH - 210X11775 (batch F)	Ni/Co/Cr/Al/Ti cast
MBH - 27 X 14386	Ni/Cr/Co/Mo cast
MBH - 31XWSB1 (batch B)	Silicon brass cast
MBH - 37M BS 314B	Copper alloy
MBH - 37M BS 360A	Copper alloy
MBH - 37M BS 630	Copper alloy
MBH - 43XZ2	Zinc/aluminium/copper cast
MBH - 54XG251H4	
MBH - 55xG02D6	Aluminium/silicon/copper
MBH - 55XG26H5	Aluminium/silicon/copper
MBH - 55XG900J5	Aluminium/silicon/copper
MBH - 55XG900J5	Aluminium/silicon/copper
MBH - 58XG40H9	Aluminium/zinc
MBH - 59XG77 J1 (batch D)	Al/Zn/Mg/Cu/cast
MBH - 65XMGA3	Magnesium/aluminium/zinc
MBH - 65XMGA5	Magnesium/aluminium/zinc
MBH - 81X Pb/Sb	Sb 12.6 %, Pb 87.4 %
MBH - C101P6790	Titanium alloy
MBH - C13X170020	Austenitic stainless steel
MBH - C22X755	Nimonic type alloy
MBH - C31XB40 (batch A)	Brass chippings
MBH - C31XB60 (batch H)	Brass chippings
MBH - C31XB80 (batch H)	Brass chippings
MBH - C55XG02D60	Aluminium/silicon/copper
MBH - C55XG04H60	Aluminium/silicon/copper
MBH - C55XG04H80	Aluminium/silicon/copper
MBH - C55XG26H50	Aluminium/silicon/copper
MBH - MGA1	Magnesium/aluminium/zinc

Multi-element standards

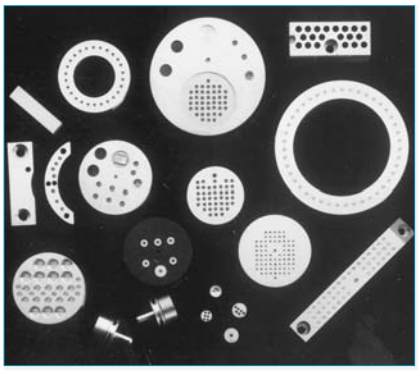
Standard reference materials

SRM 101g	Cr 18 %, Ni 10 %
SRM 1134	High silicon steel
SRM 1159, 1160	Ni 80 %, Mo 4 %, Fe 14 %
SRM 121d	Cr 17 %, Ni 11 %, Ti 0.3 %
SRM 1276a	Cupro-nickel
SRM 12H	Basic open hearth steel, 0.4 % carbon
SRM 132b	Tool steel
SRM 13g	0.6 % Carbon steel
SRM 160b	Cr 18 %, Ni 12 %, Mo 2 %
SRM 179	High silicon steel
SRM 1872	Set of three glasses (K-453, K-491, K-968)
SRM 343a	Cr 16 %, Ni 2 %
SRM 348a	High temp alloy A286
SRM 361	Steel
SRM 362	AISI 94B17 Steel (modified)
SRM 478	Cu 73 %, Zn 27 %
SRM 480	W 20 %, Molybdenum alloy
SRM 481	Au/Ag set of six
SRM 482	Au/Cu set of six
SRM 661	AISI 4340 Steel
SRM 663	Chromium - vanadium steel (modified)
SRM 665	Electrolytic steel
SRM 710	Soda-lime-silica glass
SRM 73c	Stainless steel, Cr 13 %
SRM 872	Phosphor bronze
SRM C1287	High alloy steel
SRM C2400	High alloy steel

Others

10A Bronze ref. 0683	Cu 85 %, Sn 5 %, Pb 5 %, Zn 5 %
204JC	Fluorspar (powder)
281-1	Cr 18.7 %, Ni 9.3 %
481-1	Cast iron
AISI 304L	Stainless steel
AISI 316	Stainless steel
Al, Cu, Mg	Dural
Al, Mg, Si	Al 99 %, Mg 0.5 %, Si 0.5 %
Al, Si	Al/Si rod
BL-5	Uranium ore
$CoSi_2$	Co 66 %, Si 16 %, B 12 %, Fe 4 %, Mo 2 %
Mg, Al, Mn, Zn	Magnesium alloy foil
Ni, Al	Ni 59 %, Al 41 %
N50.01	Nickel-based alloy, Cu 24 %, Sn 16 %, Fe 5 %, Mg 3 %
Std. Sample	Chromium - tungsten steel
T212	Si 3.84 %
W Ti	W 95 %, Ti 5 %

Standards for use in ultra high vacuum instruments



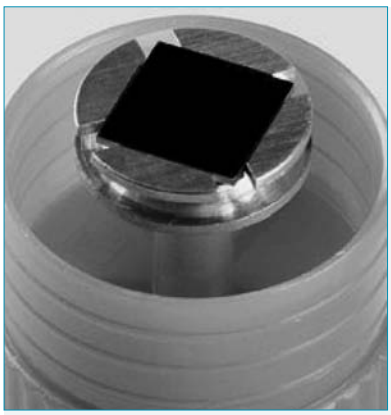
This series of standards is available for laboratories employing ultra high vacuum analysis instruments (Auger, EXCA, electron probe, SEM, etc.). A choice can be made from a range of approximately 180 high purity single element and compound reference materials. Multi-element blocks containing up to 50 such materials can be made to suit the configuration of most instruments, the size and shape being determined by the physical limitations imposed by the specimen holder and chamber.

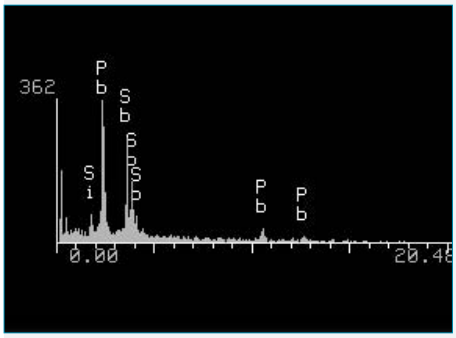
Each block is made from a low outgassing stainless steel (AISI 304), set with the chosen elements and compounds, which in turn are mounted in Wood's metal, and polished to a 0.25 µm finish. All blocks are supplied with certificates of analysis and a location map. A Faraday cup can be incorporated if required.

The electronics material set, containing 33 relevant reference materials, will be of particular interest to those working in the investigation of the surface chemistry of electronics materials. Further details of these standards are available upon request.

S1984 UHV standards, electronic materials set
S1985 UHV standards, to customer's choice

Particle analysis standard





The SPS-5P-2 is a standard especially designed for adjustment, calibration and validation of analytical SEM/EDX systems used for automated analysis of particles. They are especially suitable for quick system validation checks and quality assurance procedures.

Using a special process, Pb/Sb/Ba particles are precipitated onto the surface of an 8 x 8 mm silicon chip which has previously been applied with a 10 µm polyimide layer. The particles are randomly distributed but at known locations. There are four distinct particle sizes of approximately 0.5, 0.8, 1.2 and 2.4 µm in diameter. In addition, three 10 µm particles are provided in order to facilitate simple data cross-checking of performed automated particle analysis. Finally the sample is carbon coated in order to avoid or minimise charging effects and sample damage.

It is recommended that the BSE signal is used for imaging the particles as this gives a high contrast differential between the Pb/Sb/Ba particles and the silicon substrate. There is a 100 x 100 µm Pb/Sb/Ba control pad on the chip that can be used to adjust the BSE signal to the required level. A primary electron beam current not exceeding 2 nA is recommended in order to avoid possible damage to the specimen.

Each specimen is individually checked and the correct number of Pb/Sb/Ba particles is certified.

S1823 SPS-5P-2 synthetic particle calibration specimen

Standards for X-ray fluorescence spectroscopy

A large range of high purity single element standards for the setting-up, calibration and routine instrument monitoring of X-ray fluorescence spectrometers is available.

The standards are supplied as 1¼" diameter pressed pellets or, where appropriate, metal foils, and are prepared from carefully selected high purity 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 0.125 mm thick and are stretched across plastic supports.

Standards are available for 60 elements and these can be purchased individually or as a set.

Universal set

Na	Mg	Al	Si	P
S	Cl	Ca	Ti	Cr
Mn	Fe	Ni	Cu	Zn
Nb	Sn	Ba	W	Pb

S1830 Universal set of 20 elements

Rare earth set

La	Ce	Pr	Nd	Sm
Eu	Gd	Dy	Ho	Yb

S1831 Rare earth set of 10 elements

Precious metal set

Rh	Pd	Ag	Pt	Au

S1832 Precious metal set of 5 elements

Two sets of standards with a useful combination of elements

Set A

Na	Mg	Al	Si	P
S	Cl	K	Ca	Ti
V	Cr	Mn	Fe	Co
Ni	Cu	Zn	Ba	Pb

S1833 Standards set A, 20 elements

Set B

As	Se	Br	Rb	Sr
Y	Zr	Nb	Mo	Cd
Sn	Sb	I	Cs	Hf
W	Hg	Bi	Ta	Te

S1834 Standards set B, 20 elements

A single standard is also available. Please specify standard required.

S1835 Single standard