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NPL Management Ltd – Registered in England and Wales No 2937881

Certificate of Calibration

UKAS CALIBRATION
0478

REFERENCE STAGE GRATICULE
510

FOR	Graticules Optics Limited 17-19 Morley Road Tonbridge Kent TN9 1RN United Kingdom
DESCRIPTION	The NPL reference stage graticule consists of a glass slide approximately 25 mm × 75 mm in size. The slide consists of chrome design produced by direct copying of master drawn using electron-beam lithography. The design consists of a central area, in the middle of which is a crosshair, surrounded by four patterns such as square grid, mono array spots, log-normal distribution spots and root-2 progression spots.
IDENTIFICATION	NPL Reference Stage Graticule 510
DATE(S) OF CALIBRATION	10 July 2024 to 15 July 2024

Calibrations marked 'Not UKAS Accredited' in this certificate have been included for completeness.

Reference: 2024060049/1

Date of issue: 19 July 2024

Checked by:

Signed:

Name: A J Lewis

(Authorised Signatory)

on behalf of NPLML

MEASUREMENTS

The grid was measured four times along all four of the 400 µm sides with a length measuring microscope, using a 100 × objective and a refractive index compensated laser interferometer fitted to the stage. The lengths were measured between the centres of the two parallel lines forming opposite sides of the grid.

The spots were measured three times using a microscope with a 100 × objective and an image analyser. They were compared with spots calibrated against an interferometrically measured optical linewidth standard. The diameters are calculated from the area of the spots and thus represent an average spot diameter.

The measurements were taken in a laboratory with temperature maintained to 20 °C ± 1 °C.

RESULTS

The mean length of the sides of the grid is 399.99 µm.

The monosize array has a mean diameter of 14.66 µm. The largest single average spot diameter is 14.74 µm and the smallest single average spot diameter is 14.58 µm.

The diameters of the spots forming the root-2 array are:

Spot number	Average spot diameter /µm
1	2.50
2	3.74
3	5.53
4	8.02
5	11.57
6	16.53
7	23.55
8	33.48
9	47.57

The log-normal distribution has a mean of 10.58 µm and a standard deviation of 1.51 µm*.

* The determination of the standard deviation is not UKAS Accredited.

Checked by: Ype 1dP

UNCERTAINTIES

The expanded measurement uncertainty in the grid measurement is 0.15 µm.

The expanded measurement uncertainty in the measured diameters of the spots forming the monosize array is 0.20 µm.

The expanded measurement uncertainty in the measured diameters of the spots forming the root-2 array is 0.20 µm.

The expanded measurement uncertainty in the value reported for the mean of the log-normal distribution is 0.20 µm.

The reported expanded measurement uncertainties are based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a coverage probability of approximately 95 %.

The uncertainty evaluations have been carried out in accordance with UKAS requirements.

NOTES

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

2. A guide to the practical use of the reference stage graticule and the formulae used to calculate the log-normal parameters are given in the enclosed sheets.

Checked by: Ype TdP

USE OF THE NPL REFERENCE STAGE GRATICULE

The Reference Stage Graticule comprises four test areas. They are as follows:

1. THE GRID

The grid is used to calibrate the image analyser and to detect any gross image distortion. An appropriate sized square should be imaged on the screen and the analyser calibrated across the square in the normal way. The squareness of the calibration can be checked by using the other two sides of the square (on some analysers calibration in a second direction is not possible and a variable frame can be used). Many image analysers can produce a software-generated grid. If this grid is superimposed on the image of the graticule grid, any large-scale image distortions will become evident.

2. THE MONOSIZE ARRAY

The monosize array is used to check for localised distortions of the image. These distortions are quite common at the edge of the field of view and knowledge of where and by how much the scaling breaks down allows determination of the usable measuring area of the image. The slide is positioned so that the 20 × 17 array of spots fill the screen. The height and width of the spots (usually feret 90 and feret 0 respectively) are then measured and either by printing out these sizes with the spot position or by labelling the image on the screen if this is possible, the deviation in the sizes of the spots at the edges can be seen by comparison with spots in the middle of the screen. Measurements must be made rather than direct visual observations because screen distortions may affect judgement.

3. THE ROOT-2 ARRAY

The root-2 array is used to determine the threshold level required to measure the spots correctly. The image analyser works by the user choosing a grey level at which anything darker is spot and anything lighter is background. As the edge of a spot is not a clean edge, but a blurred one, due to the limited resolution of the camera and the physical limits of optical microscopy, the specified threshold level affects the measured size of the spots. This array of spots provides a useful research tool for investigating the effects of background lighting, detect level, focus etc. on measured spot size.

4. THE LOG-NORMAL ARRAY

The final test area is the log-normally distributed array. This is an idealised distribution of maximum dynamic range for a full screen and is used as a final check on the analyser when all other variables have been evaluated and corrected. The 100 spots should be

arranged to fill the screen and are measured using the software that may be provided with the image analyser, the mean and standard deviation of the log-normal distribution can be determined and compared with the certified values. The mean and standard deviations have been calculated using the following equations.

The equations that define the mean and standard deviation of the log-normal distribution are:

$$MEAN = \exp\left(\sum_{i-1}^{100} \frac{\log d_i}{100} \right)$$

$$STANDARD\ DEVIATION = \exp\left[\left(\sum_{i-1}^{100} \frac{(\log MEAN - \log d_i)^2}{100} \right)^{1/2} \right]$$

where d_i is the diameter of spot number i.

Please contact NPL if you wish the log-normal parameters to be calculated using alternative formulae.

Always ensure the graticule is clean before use.

NPL Contact

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