Length Metrology

NPL Reference Stage Graticule

The Optical Metrology Section in the Centre for Length Metrology at the National Physical Laboratory provides dimensional measurement and standards facilities for industries requiring accurate measurements using microscopes. Such measurements include the sizes and positions of microscopic features on components. The need also exists to test the linearity of measuring instruments over a wide range of dimensional measurements.
The achievement of measurement repeatability requires proper instrument alignment and measurement procedures to be followed; the use of an appropriate standard enables accuracy to be achieved and the performance of the equipment to be maintained satisfactorily.

The section now offers a range of calibration standards in chromium films on glass plates. These include a two dimensional position standard, the NPL and NPL-Alvey photomask linewidth standards, a circular optical fibre measurement standard and the reference stage graticule described here. The reference stage graticule has been developed principally to calibrate image analyser systems but also acts as a high precision stage micrometer.

The reference stage graticule is a chrome-on-glass slide made to NPL specifications. It is available either as a 75 mm x 75 mm glass plate or cut to 75 mm x 25 mm. Each graticule is checked and measured at NPL, and is supplied with recommendations on its use and an individual certificate of calibration.
The centre of the graticule has a clear window approximately 19 mm x 19 mm in size. In the centre of the window the letters "NPL" are written in characters 160 µm tall. The standard contains four test areas which are located above, below and at either side of the letters. The individual test areas are described as follows.

The Grid

The grid shown in figure 1 is used to calibrate the image analyser and to detect any gross image distortion. An appropriately 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.

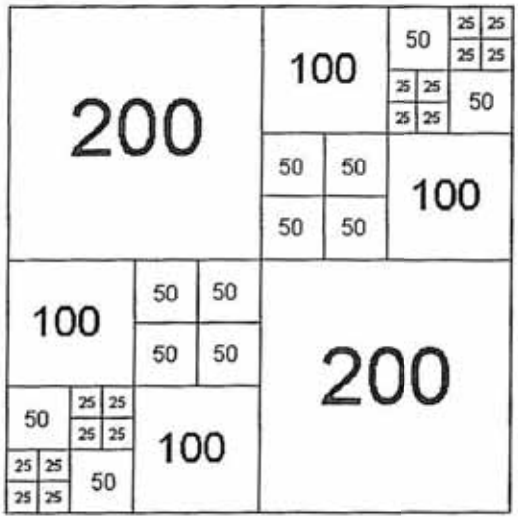

Figure 1 Grid (400 µm square)

The monosize array

The monosize array shown in figure 2 is used to check for localised distortions of the image. These distortions are quite common at the edge of the field of view and a 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 x 17 array of spots fill the screen. The height and width of the spots 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

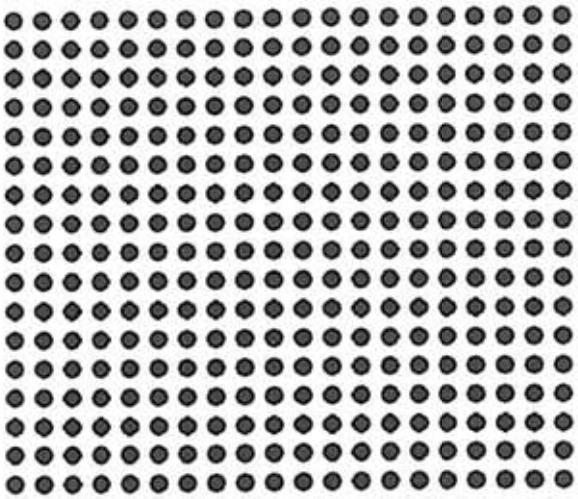

Figure 2 Monosize Array (15 μm spots)

be made rather than direct visual observations because screen distortions may affect judgement.

The Root-2 Array

The root-2 array shown in figure 3 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.

Figure 3 Root-2 Progression (3 μm to 48 μm)

The log-normal array

The final test area is the log-normally distributed array shown in figure 4. 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 corrected or evaluated. The 100 spots should be arranged to fill the screen prior to measurement. 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.

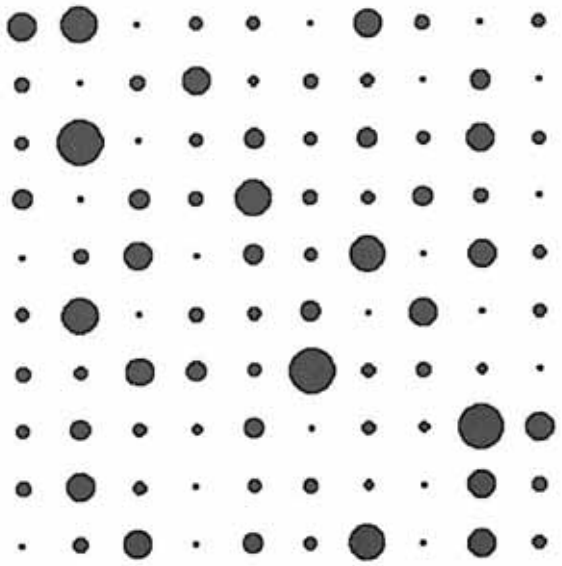

Figure 4 Log-Normal Distribution (4.5 to 27 μm)

Uncertainties

The uncertainty in the grid measurements will not exceed ±0.1 μm. The uncertainty in the dimensions of the diameters of the spots forming the monosize array is ±0.3 μm. The uncertainty in the dimensions of the diameters of the spots forming the log-normal array is ±0.3 μm and the uncertainty of the mean of the distribution is ±0.16 μm. The uncertainty in the dimensions of the diameters of the spots forming the root-2 array is ±0.3 μm for spots number 3, 4, 5, 6, 7 and ±0.5 μm for spots 1, 2, 8 and 9. All uncertainties have been calculated with a 95% confidence limit.

Further Information

Further information on any of the range of microscope calibration standards and details of the cost can be obtained by contacting:

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