TAYLOR HOBSON®

125 years of innovation

Tutorial - Step Height Measurement

Dr Mike Mills,
Chief Metrologist

AMETEK®
ULTRA PRECISION TECHNOLOGIES

Introduction

Measurement of the height of a step within a profile ought to be straightforward, but there are a number of pitfalls to avoid if you want the correct answer. Dr Mike Mills - Chief Metrologist – Reviews the issues and shows how to avoid some of these pitfalls.

Step height measurement is required in many fields including semiconductors, micro-circuitry and printing. Small steps are often measured using a profilometer such as a Talysurf or similar instrument. This tutorial outlines the assessment of steps using a Talysurf, and illustrates a novel approach to step measurement that has been developed by Taylor Hobson.

There are no specific ISO standards covering the measurement of step heights. However, because of the importance of step height standards in calibrating roughness measuring instruments, there is a standard that outlines how these calibration standards should be measured (ISO 5436-1:2000).

Many software analysis packages (for example TalyProfile) that offer step height are based upon the application of the principles of ISO 5436-1. There are two fundamental concepts that are employed:

- The step (which is typically an etched groove) and its neighbouring areas of substrate are of sufficient width to enable them to be assessed without considering stylus flanking.

- Parallel straight lines can adequately model the step and surrounding substrate.

In order to help satisfy the first condition, the software specifically ignores areas adjacent to the step transitions. The analysis normally proceeds by calculating the least-squares straight line through the data, and then identifying the areas above and below this as being step and substrate. The step height is calculated using a least squares fit to the equation:

$$Z = aX + b + h\,\delta$$

where a,b,h are unknowns and δ takes the value of +1 in the higher regions and -1 in the lower regions. The unknowns *a* and *b* represent the slope and intercept of the line. The step height is calculated as twice the value of the third unknown, *h*.

This approach is fine for samples where the flatness of the step and substrate are both good, as in the etched glass calibration standards.

However problems can often be found in industries where the steps, substrate or both are not flat. This is particularly true of printed samples, where surface tension in the inks or paints causes either a rounding or dimpling of the “step”, and the stresses caused by the curing process can cause distortion in the substrate.

In order to deal with these applications, Taylor Hobson has developed a dedicated step height analysis package. The software uses a novel detection method to identify the step regions. This is necessary because the curvature of the substrate might well be sufficient to prevent the use of the simple least-squares line fit. The step and substrate areas are then treated as line segments, allowing the curvature of the substrate to be removed, resulting in a straight-line representation of the substrate. The step heights are calculated from this line in the areas adjacent to each step. Typically the maximum, minimum and mean step heights are displayed, although a number of other parameters can be calculated.

- The principle can be seen by reference to Figures 1 and 2. The first of these figures shows a raw profile of a surface. The step heights are of the order of 9um, but the curvature of the substrate is about 2um. Conventional step analysis would include the curvature in the analysis of the step heights, leading to an uncertainty of about 10% in this case.

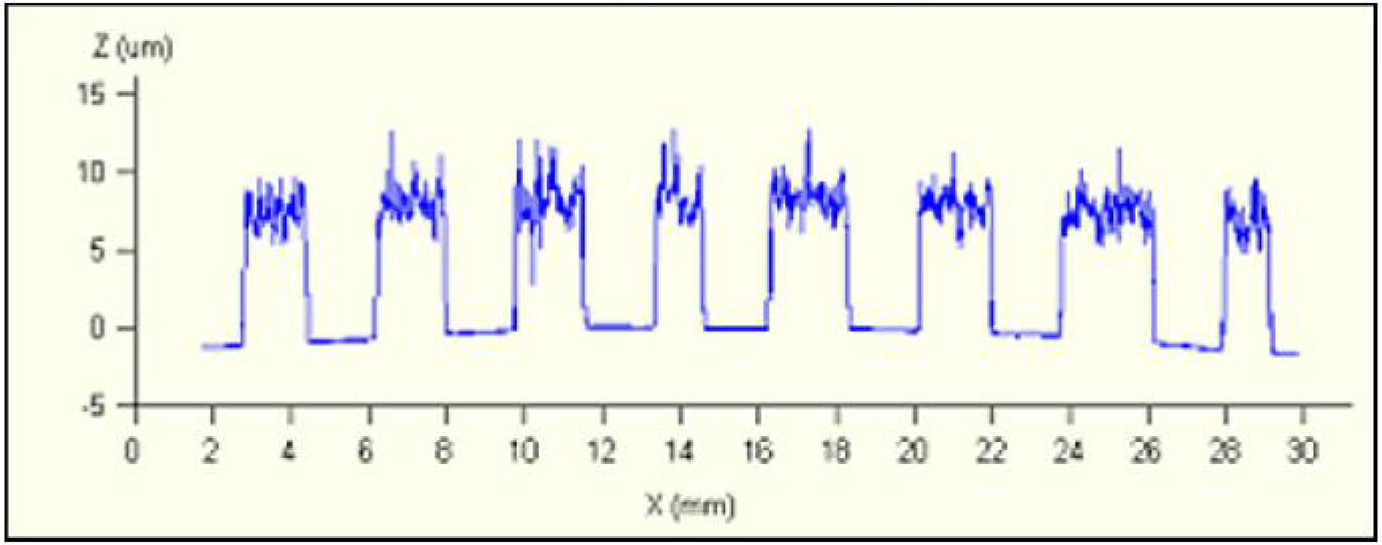

Figure 1 - Profile showing steps on a curved substrate.

Figure 2 shows the modified profile after step analysis by the novel Taylor Hobson method. The curvature of the substrate has been removed, substantially reducing the measurement uncertainty of the step heights.

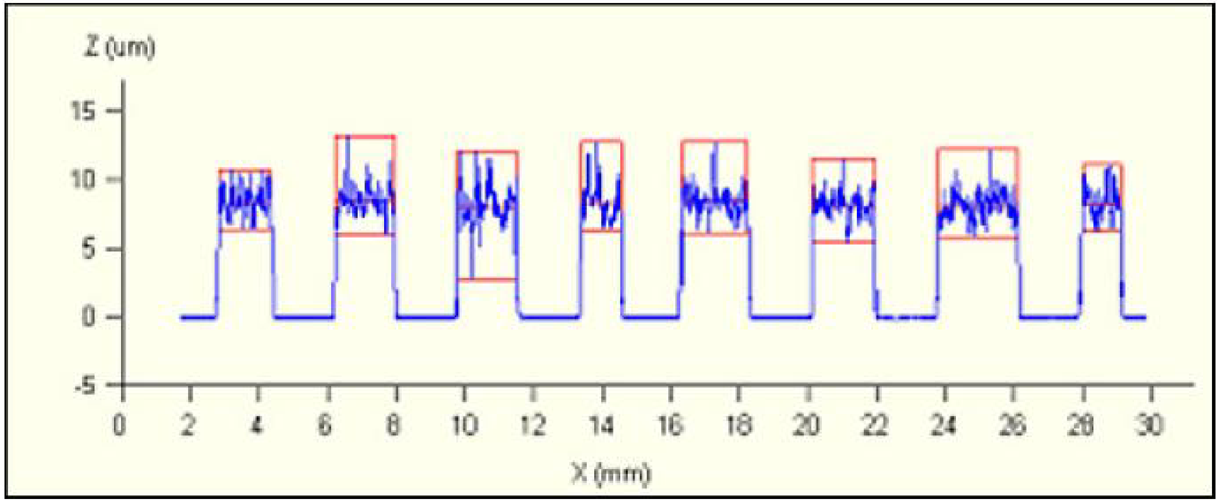

Figure 2 - Profile after analysis by step height software.

- It should be borne in mind that all automated analyses will make some assumptions about the sample, for example that the substrate can be considered to be flat within the step region. Where these assumptions are unreasonable, the automated analysis should not be used. Most software packages allow the user to manually define regions for step analysis where the automatic technique is not appropriate.

Contact us

Material produced by Taylor Hobson Centre of Excellence
For more information contact:
email: taylor-hobson.cofe@ametek.com
or call: +44 116 276 3779

Centre of Excellence Services
For calibration, training and precision metrology beyond the scope of your business expertise, the Taylor Hobson Centre of Excellence has experienced professional metrologists along with state of the art measuring instruments.

Metrology Training Courses
We offer standard and bespoke Training Courses in Surface Finish and Roundness, coupled with contact and non-contact Instrument Operator Training. To improve the understanding and application of Roundness and Surface Finish principles by your operators, inspectors and engineers.

Instrument Training
Without question, the benefits of training are exponentially greater than the cost. When your operators, inspectors and engineers are well versed in the theory and application of metrology they are more confident, more efficient, better informed and more likely to avoid mistakes or misrepresentation of results.

Technical Support
Manned by a team of Experienced Metrologist's, we provide a Case Study or Measurement Report Service alongside a Contract Measurement Service, to help in the correct selection of our metrology systems.