Application note A139: Steep-sided miniature aspheres

PGI Dimension – aspheres

High precision measurement of steep-sided miniature aspheres

Lucy Cooper, Applications Engineer

"A manufacturer of steep-sided molded lenses had serious yield problems with lenses and molds, which were difficult to manufacture due to the steep slopes and tight tolerances involved. PGI Dimension helped to improve their process control and manufacture, increasing yields by over 10%."

Erik Stover, Business Development Manager, Taylor Hobson

Introduction

Steep-sided miniature aspheres are found in many applications such as blu-ray and standard DVD optics, cell phone camera lenses, digital camera lenses, high power LEDs and fibre coupling optics. Obtaining highly accurate and repeatable measurements of the molds that produce these steep-sided miniature aspheres is critical for both design improvement and manufacturing process control.

In this application note we identify some of the measurement challenges faced by profile measuring instruments and explain how Taylor Hobson's PGI Dimension addresses these by providing high quality multi-profile data and 3D astigmatism analysis.

Figure 1: Measuring a steep-sided miniature asphere

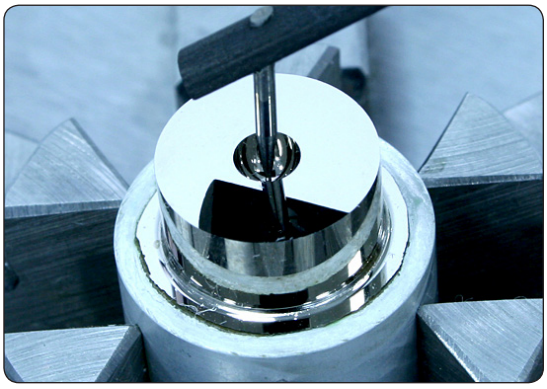

Figure 2: Common applications of steep-sided miniature aspheres

Challenges

Steep-sided aspheric molds for small optics are among the most demanding of today's ultra-high precision form measurement applications and present a number of challenges in obtaining highly accurate and repeatable data.

1. Steep sides – There are two fundamental issues here, the first is to avoid any stylus flanking at all as this totally invalidates the data set (see Figure 3a). Secondly, even if flanking is overcome by a special stylus, many measurement systems will show a progressive deterioration in data quality as the slope gets steeper.

2. Alignment – The measuring instrument needs an alignment capability that ensures that each measurement is taken right over the aspheric axis. Simply measuring over an ill-defined turning point on an asphere will yield poor results. The sample's aspheric axis must be truly aligned with the instrument's rotational axis. This is particularly important if profiles are taken at different angular positions. A measurement taken even a few microns off axis, or where the sample is tilted even slightly, can result in significant measurement errors. It is therefore critical that the instrument alignment process is repeatable and well defined and that the instrument has high inherent accuracy and stability. The smaller the sample and the steeper the sides the more critical this becomes.

3. Measurement repeatability – As discussed, reliable sample alignment is necessary before repeatable measurements can be made. As we are dealing with such small samples and low tolerances this presents a significant challenge and requires the measurement system to be highly capable and highly stable. Instrument set-up, environment and alignment are very important factors.

PGI Dimension – the solution

1. High quality data from steep sides – By tilting the traverse datum, the PGI Dimension prevents stylus flanking and eliminates the need for steep-sided measurements. This prevents data distortion.

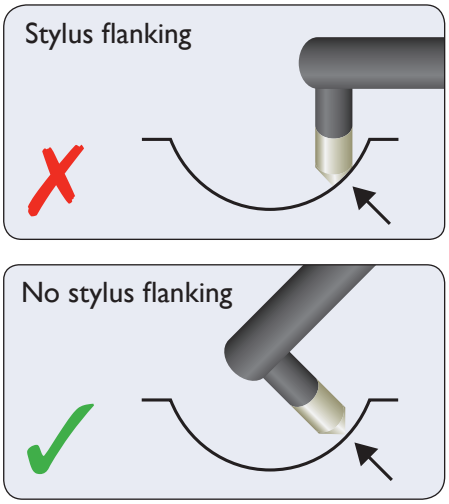

Figure 3: Angled gauge head resolves flanking issue

2. High precision aspheric axis alignment – Before the start of the measurement, the sample is aligned using Taylor Hobson's patented advanced centre and level technique. The alignment is achieved by taking 4 measurements in turn, indexing the spindle by 90 degrees each time. The alignment of opposing measurements are compared to determine the de-centre and tilt compensations required so as to align the sample aspheric axis with the instrument rotational axis.

3. Excellent repeatability – Taylor Hobson's PGI Dimension uses precision datums on a highly stable measurement platform and ensures that samples are consistently well aligned to the instrument's rotational axis.

Asphere measurement results

After auto-alignment, a steep sided sample was measured ten times in the 0–180 degree and the 90–270 degree positions. Figure 4 shows the clear aperture and sag of the sample. Figure 5 shows the 3D astigmatism result.

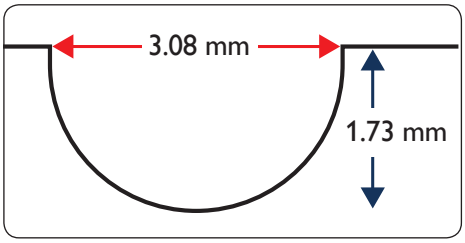

Figure 4: Clear aperture & sag

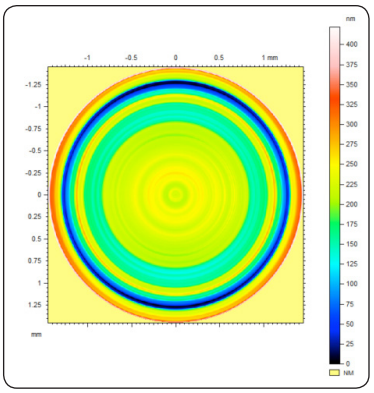

Figure 5: 3D astigmatism

Repeatability

Figure 6 shows the results of the ten measurements on a single graph. Such excellent repeatability makes the PGI Dimension ideally suited for manufacturing process control.

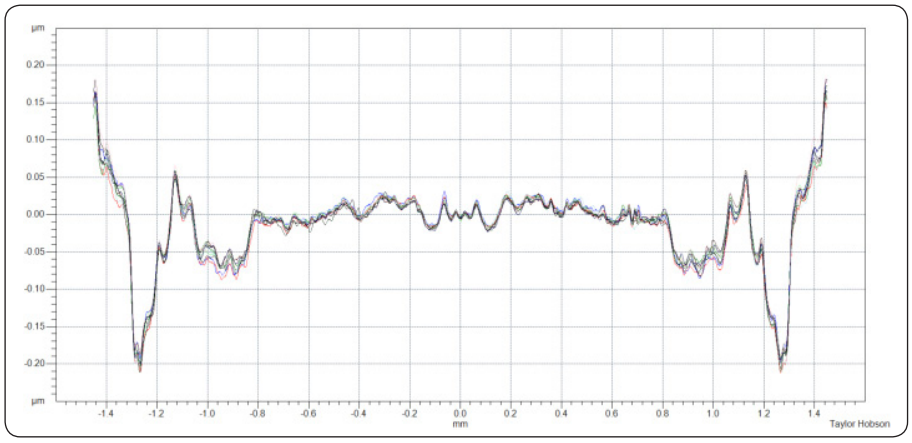

Figure 6: Repeatability measurements

Measurement	1	2	3	4	5	6	7	8	9	10	SD
Form Error (Pt) nm	375	378	383	366	362	372	383	358	366	369	8.55

Table 1: 10 form error (Pt) results (0–180 deg)

Conclusions: The PGI Dimension provides a highly stable measurement platform, ideally suited for the measurement of steep-sided miniature aspheres. It ensures that the aspheric axis is correctly aligned to the instrument rotational axis and eliminates the data distortion normally seen when profilometers measure steep sides. Its excellent repeatability makes it the perfect instrument for production process control.

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