Measuring Diamond Turned Aspheric and Diffractives Surfaces

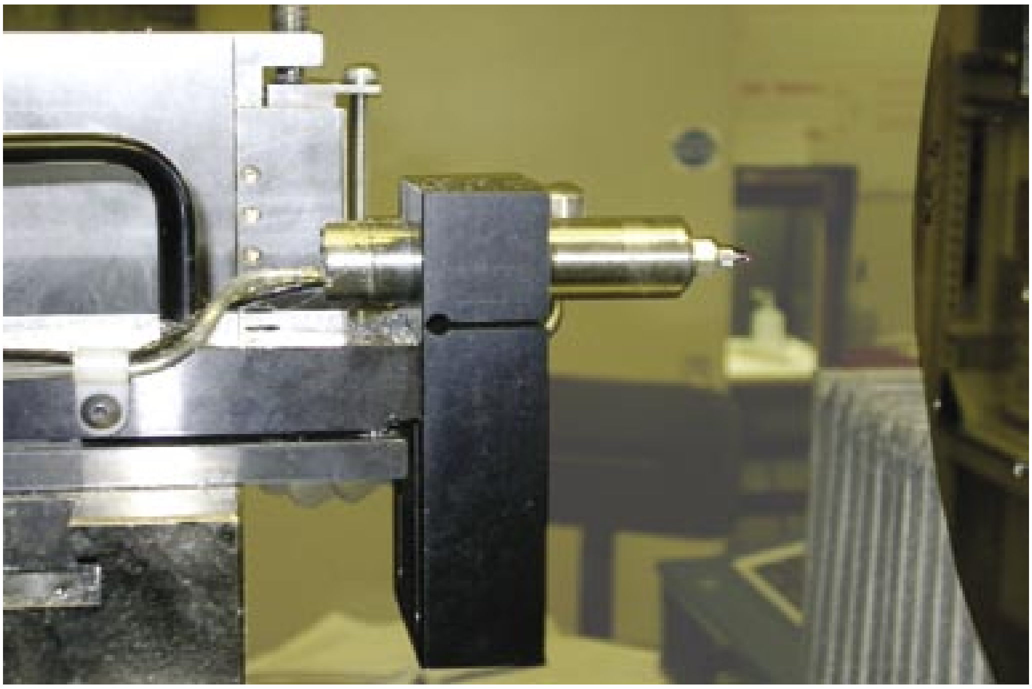
PRECISION-OPTICAL ENGINEERING

DM006

Application Note

Introduction
The measurement of diamond turned aspheric and diffractive surfaces requires a high degree of accuracy. Diamond turned surfaces are typically measured for surface roughness (Ra) in nanometers; form error (or PV) in microns (1 fringe equating to 0.3165 microns) and step height for diffractive surfaces in microns.

Diamond machined aspheric and diffractive surfaces have been designed into optical systems more and more over the last 10-20 years as this enabling technology has grown in stature. Their inclusion has enabled designers to reduce chromatic aberration, correct for colour, correct for focus, reduce weight and also reduce cost. Surface measurement methods include contact and non-contact techniques. Not surprisingly, there is a trade-off between measurement accuracy and cost.



Contact Measurement Systems

a) Surface Profiling
This is the most commonly used contact method. It uses a stylus to gently glide over the aspheric surface profile which then provides an accurate measurement of the surface form. These measurements are plotted in as a graph and allows the operator to determine if the lens drawing tolerance has been successfully achieved or whether more diamond turning passes are required to further improve the surface profile. The surface profile measurements can be fed back into the cnc lathe to then correct the lens and bring it within the stated tolerance. Measurements are typically given in nanometers.

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b) Linear Voltage Displacement Transducer – LVDT
This contact method uses an "on machine probe" (Figure 1) which measures the surface form of an aspheric lens surface whilst mounted on the diamond turning lathe. This can also be used in conjunction with an "on machine" interferometer which measures the surface's figure and form error.
As with surface profiling, any measured error can be fed back to the lathe to allow more passes of the diamond tool to achieve the required end tolerance. The LVDT approach is a very accurate and quick way of assessing the surface profile of an asphere and negates the need for time-consuming "off machine" measurements of the lens surface. This type of measuring capability is a good, cost effective method of checking the aspheric surface profile.

Non-contact Measurement Systems

a) Interferometric use of Computer Generated Holograms
Computer generated holograms can provide a very accurate measurement of an aspheric surface when used in conjunction with an interferometric system. The diamond-turned aspheric surface is then compared against a known standard or datum (the computer generated hologram). These measurements can be used to quantify the wave-front error of the lens and also complete performance of a system.

This is an ideal method in a production environment and can be used to check thousands of components and prove conformance to drawing by way of interferograms. Whilst this method is generally the most accurate way of measuring an asphere or diffractive surface it can also prove to be one of the most expensive, since a new hologram is required for each different surface profile. In addition, supporting fixtures and a variety of transmission spheres are required for this approach.

b) Interferometric use of Null Lens
In a similar approach to the hologram method, aspheric/diffractive surface profiles can be measured in conjunction with an interferometric system utilising a null lens or mirror which reflects or transmits the surface profile through the interferometer. As with the hologram methodology, this can be a very accurate method of measurement. However, it can also be an expensive method with different fixtures and null lenses/mirrors required for each different surface profile.

c) Measuring Diffractive steps
Diffractive steps can be measured using a table top, vertically mounted interferometer. This method enables the step height and radius of the internal step to measured. This system can be used to produce images and interferograms of the sharpness of the diffractive step and their respective measurements.

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