The AccuFiz provides a simple, repeatable method for measuring the homogeneity of bulk materials and finished optics.

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Measuring Homogeneity with the AccuFiz®

Introduction

Spatial inhomogeneity of an optic's refractive index can be caused by the melting process, by variations in density or by permanent stresses due to temperature gradients during cooling. The degree of homogeneity is obtained by measuring the transmitted wavefront error (the deviation of a test beam as it passes through the optic), then isolating and removing the contributions of the surfaces.

Laser interferometry is a long-standing method for measuring the homogeneity of optical materials. 4D Technology's AccuFiz® laser interferometer provides a simple, repeatable tool for measuring the homogeneity of both bulk material samples and finished optics. The test requires a sample that has been polished to reasonable optical quality, with sufficient wedge that fringes only develop between the transmission flat and any one surface at a time.

In total, four measurements are required in order to determine homogeneity (Figure 1):

- the empty cavity
- the sample in transmission
- the front face in reflection
- the back face in reflection.
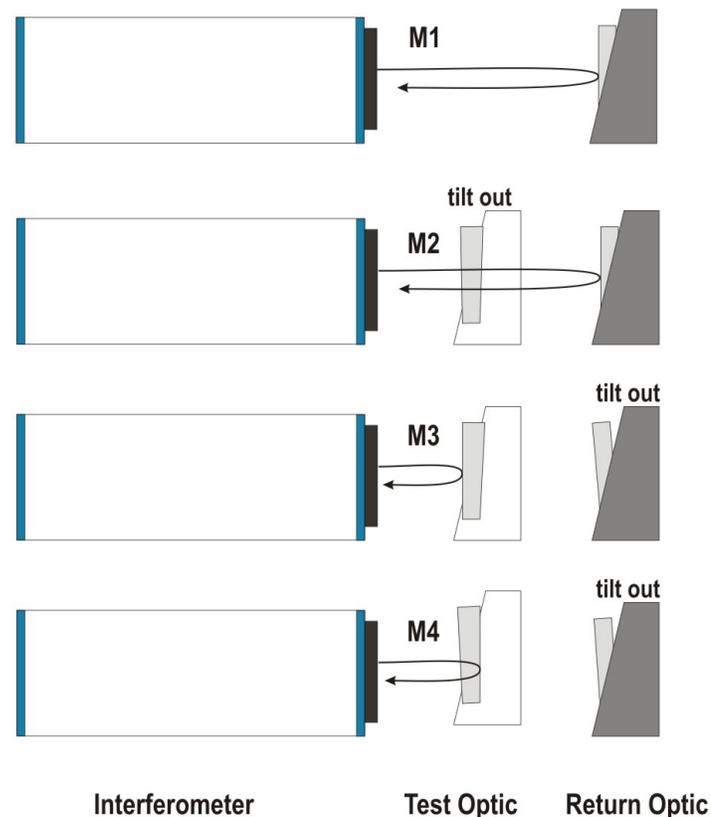
Figure 1. Four measurements are required for the homogeneity calculation. "Tilt Out" indicates that the optic is tilted far enough that fringes do not develop between it and the transmission flat.

Measurement Procedure

Careful alignment of the optical components is critical to accurate measurements. The following procedure minimizes the amount of movement of the optics, providing the best measurements for homogeneity:

1. Set up the overall measurement:

   a. Mount and position the transmission flat (t-flat).

   b. Launch 4Sight software.

   c. Choose **Edit > Optical Parameters**.

   d. Set the **Wedge Factor** to 0.5, then click **OK** to close the dialog box.

   e. Click the **Measurement Screen** button.

   f. Click the **Input Alignment Camera** button to view the **Alignment Screen**. An alignment spot from the t-flat should be visible.

   g. Adjust the tip and tilt of the t-flat until the alignment spot passes through the center of the alignment target.

   h. Place the test part in a mount with tip and tilt adjustment. Position the mount in the beam path, as close to the interferometer as possible.

   i. You should now at least one additional alignment spot from the test sample on the Alignment Screen (if the sample is only mildly wedged then there may be one from the front and one from the back surface). Adjust the tip and tilt of the test part such that the alignment beam from the front surface passes through the center of the alignment target (i.e., align the front surface of the test sample with the t-flat).

   j. Using the handheld controller and viewing the 4Sight **Live Video** screen, adjust the **Zoom** to 1:1 (i.e., no zoom).

   k. Place a card against the front surface of the sample, then use the **Focus** adjustment on the handheld controller to bring the card's edge into sharp focus.

Tip: If you are unsure which alignment spot is generated by the front and back surfaces, rub a cotton swab soaked with alcohol across the back surface. The alcohol will affect the intensity of the alignment spot from the back surface. **Is this correct? Or, do you only see this effect when you have fringes?**

   l. Adjust the **Source** size button on the handheld controller to minimize any rings around dust particles or at the edges of the test surface.

Note: Once the Focus, Zoom and Source are set they should not be adjusted for the remainder of this procedure.

   m. Place the return flat in a mount with tip and tilt adjustment. Position the flat as close to the sample mount as possible.

   n. Remove the sample mount from the beam path.

   o. You should now see an alignment spot on the Alignment Screen from the return flat. Adjust the return flat tip and tilt such that the alignment beam passes through the center of the alignment target.

2. Make the M1 (empty cavity) measurement:

   a. Viewing 4Sight's Live Video screen, null the fringes between the return flat and t-flat.

   b. Click the **Camera Settings** button, then adjust the **Gain** and **Exposure** values to just below saturation.

   c. Make the M1(empty cavity) measurement. You can take a **Single** measurement, but an **Average** of 16 or more measurements is suggested for improved accuracy.

   d. Save the measurement to disk. The default location and file name used by the script is C:\4D\Data\ EmptyCavity.h5.

Note: You can save the files with any location; however, using the default names and locations will save you a step when running the script.

3. Set up the M2 (transmission measurement):

   a. Position the sample mount between the interferometer and the return flat again.

   b. You should now at least one additional alignment spot from the test sample on the Alignment Screen. Adjust the tip and tilt of the test part such that the alignment beam passes through the center of the alignment target.

   c. You should now see several sets of interference fringes on 4Sight's Live Video screen. Adjust the tip or tilt of the test sample just enough that the additional fringes are no longer visible. This should leave only the nulled fringes generated between the return flat and t-flat.

   d. Make the M2 (transmission) measurement.

   e. Save the file as C:\4D\Data\Transmission.h5.

4. Set up the M3 (front surface) measurement:

   a. Tilt the return flat far enough that fringes are no longer visible in the Live Video screen.

   b. Adjust the tip and tilt of the return sample until the alignment spot from the **Front** surface passes through the target on the Alignment Screen.

   c. Viewing the Live Video screen, null the fringes to align the front surface with the t-flat.

   d. Make the M3 (front surface) measurement.

   e. Save the file as C:\4D\Data\FrontSurface.h5.

5. Set up the M4 (back surface) measurement:

   a. Tip the test sample to align its back surface, and null the fringes.

   b. Make the M4 (back surface) measurement.

   c. Save the file as C:\4D\Data\BackSurface.h5.

6. Now use the homogeneity script to calculate homogeneity from the four measurements:

   a. In 4Sight's choose **File > Open**.

   b. Select the File Type **Python Scripts (.py)**.

   c. Locate and select the script **AccuFiz_Homogeneity_v1.py**. The script will open in 4Sight's script editing window.

   d. Near the top of the script is an area labelled, "Edit this section." Within this block, set the **Index of Refraction (n)** for the sample. If you have saved the files using different names and locations than the defaults, change them here as well.

   e. Choose **Tools>Run Current Script**. The homogeneity will be calculated, and the result will be added to the Measurement Stack with the name **Delta**.

Figure 3 shows a completed homogeneity measurement for a 2.8 mm thick transparent glass disk.
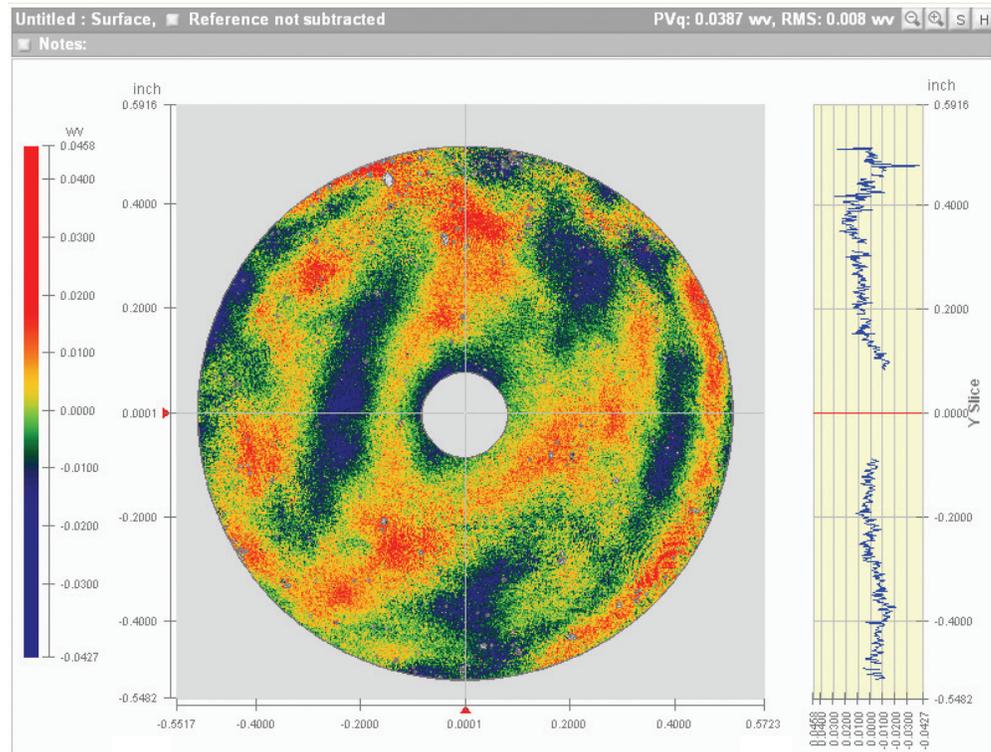
Figure 3. A homogeneity measurement for a 2.8 mm thick transparent glass disk.

Complete Characterization of Planar Optics

The AccuFiz makes it easy to measure homogeneity, transmitted wavefront quality, and surface shape of planar, focal, and aspheric optics. Standard features include touch-screen remote, fully motorized controls and Smart Zoom™ for repeatable lateral resolution at all zoom settings. Optional dynamic mode lets you measure despite vibration and air turbulence, without an air table. And a range of laser sources, aperture sizes, mounting components and accessories provides flexibility for a wide range of applications and budgets.