Difrotec OÜ
Teaduspargi 13, 51014 Tartu, Estonia
Tel. (372) 59016617
www.difrotec.com

Measurement options of the D7

Welcome to observe new sights of your optics which you've never seen!

The D7 is compact phase shifting point diffraction common path interferometer for highest accuracy measurement of surface form and transmitted wavefront quality.

The D7 can help you easily detect the absolute figure of a surface or wavefront which in other kinds of interferometers is masked by the errors of a physical reference. **Absolute figure means that the measured form is counted from the absolute reference i.e. perfect spherical wavefront produced by diffraction of light by a sub-wavelength aperture.**

The D7 measurement options are:

- Standard options for **concave** surfaces and **curvature radius**;
- Advanced options for **concave, convex, flat**, **any asphere** surfaces and **curvature radius**.

Interferometer type/technology:

Patented two-branch common-path point diffraction common path interferometer

Performance:

Wavefront RMS repeatability: < **0.25 nm** (**λ/2500**)

Simple RMS repeatability: < **0.06 nm** (**λ/10500**)

Peak-to-valley **absolute uncertainty**: ± **0.7 nm** (± **λ/900**) ← **The world-record highest accuracy on the interferometers market**

Peak-to-valley resolution: **0.05 nm** (**λ/12000**)

Laser type and wavelength: **stabilized HeNe**, **632.8 nm**

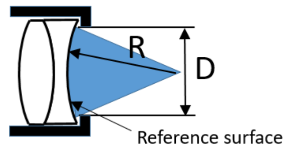
System clear numerical aperture (NA_s): **0.55 (f# 0.91)** ← **The highest numerical aperture for point diffraction interferometer**

Data acquisition: **phase-shifting interferometry** (PSI)

Definitions:

1. Below we define the **surface/wavefront under test** (SUT) **aperture** as follows:

- **for flats/quasi-flats/freeforms** through clear diameter **D**,
- **for spherical/asphere** through curvature radius R-number **R#** = **R**/**D**,
- **for Fizeau transmission sphere** (**TS**) through **f#** (usually very close to **R#** of the **reference surface** of the **TS** – the first surface facing SUT).



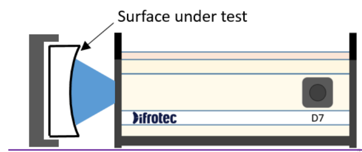
2. **Wavefront RMS repeatability** (WRMSR) is evaluated as RMS + 2σ of wavefront differentials between 10 wavefronts and their average using PSI measurements, with 5 frames each, of **a test cavity** (TC) with **R# = 1.04**, thereby evaluating repeatability of **single** PSI measurements**, without averaging**.

3. **Simple RMS repeatability** (SRMSR) is evaluated as RMS + 2σ of **a series of RMS** of 10 PSI measured wavefronts.

4. **Peak-to-valley** (P_V) **absolute uncertainty** refers to **absolute measurements of a surface/wavefront figure,** it is assumed equal to ± WRMSR using 8 PSI measurements of SUT rotated around the optical axis at different angles for each measurement and comparing wavefronts returned back to the initial angle respectively. For symmetrical errors a similar procedure is used based on 5 measurements of TC laterally displaced at up to 10 % in different directions within the system clear numerical aperture NA_s.

Standard options:

1. **Spherical**:
   - **Concave** with **R# ≥ 0.9**, is **measured without any accessory,** P_V **absolute peak-to-valley uncertainty** is ± **0.7 nm** (± **λ/900**),



   - **Minimum curvature radius R_{min}** = **15 mm,**
   - **Maximum curvature radius R_{max}** is **unlimited**[1],
   - **Measured diameters** correspond to the ratio **D = R/R#**,
   - **Reference surface of Fizeau TS** is **certified** with P_V **absolute uncertainty** ± **0.7 nm** (± **λ/900**); parameters available to measure are given below in the table **Parameters of Fizeau transmission spheres**, where optical data and dimensions of TS mounts are taken into account.

   - **Curvature radius** measurement **R,** accuracy **1 ppm.**

2. **Mid-spatial-frequency features** visualization, e.g. diamond turning features reveal.

3. **Parameters of Fizeau transmission spheres[2] the D7 measures in the standard set-up configuration:**

F/ #	Rcv (mm)	D (mm)	Manufacturer	Model
3.30	72.1	Ø 21.8	Zygo	6525-0126-01
4.80	109.6	Ø 22.8	Zygo	6525-0125-01
1.50	77.50	Ø 51.7	Zygo	6056-0122-XX
2.00	112.00	Ø 56.0	Zygo	6056-1023-XX
1.50	121.20	Ø 81.0	Zygo	6024-0430-XX
1.50	121.21	Ø 80.9	Zygo	6024-0394-01
1.79	87.08	Ø 49.6	Zeiss	F-Aplanar 1" f/1,79
1.00	75.53	Ø 75.7	Zeiss	F-Aplanar 4" f/1,0
1.50	122.32	Ø 82.3	Zeiss	F-Aplanar 1" f/1,5
1.82	86.56	Ø 47.5	JENOPTIK	2"-f/1,8
1.51	125.07	Ø 83.2	JENOPTIK	4"-f/1,5
1.50	62.70	Ø 39.6	CVI	TSC-50.8-1.5
1.50	121.90	Ø 81.3	CVI	TSC-101.6-1.5
1.50	120.35	Ø 81.4	CVI	09 LTS 415

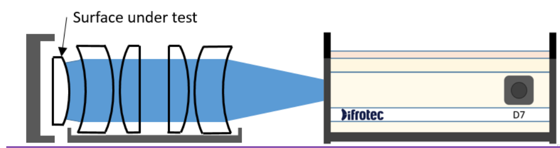
[1] Depends on room and mount availability at customer's facility

[2] The parameters of the transmission spheres are taken from: http://www.diffraction.com/Fizeau_spheres.php

Advanced options (further extension customized):

1. **Spherical:**
   - **Concave with 0.58 ≤ R# ≤ 0.84** are measured using an accessory beam diverger,
   - **Unlimited maximum curvature radius**,
   - **Fizeau TS absolute testing**:
     - **Reference surface and wavefronts** are measured for **all existing TS**,
     - **Retrace error** of TS are measured and displayed in the form of ***Retrace matrix*** vs. ***fringes direction and number*** for **all TS existing** on the market,
     - P_V **absolute uncertainty** is better than ± **λ /350**.

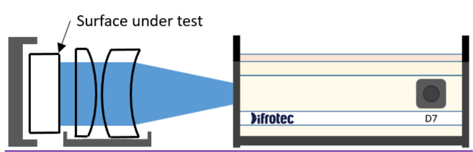
   Convex are measured through the accessory DA-1 having two identical parts placed opposite to each other and working as a beam converger:



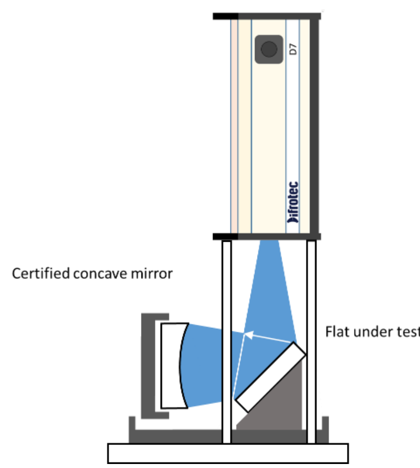
   - **Convex** within the range **2.5** ≤ **R#** ≤ **5.55**, and higher **R#** is possible depending on customer requirements,
   - **R** ≤ **400 mm** and D ≤ **150 mm** in accordance with the ratio **D** = **R/R#**,

   Flats D ≤ **150 mm** are measured in the following configurations:

   Through DA-1 having only one part working as a collimator:



   In the SDA-1 set-up:

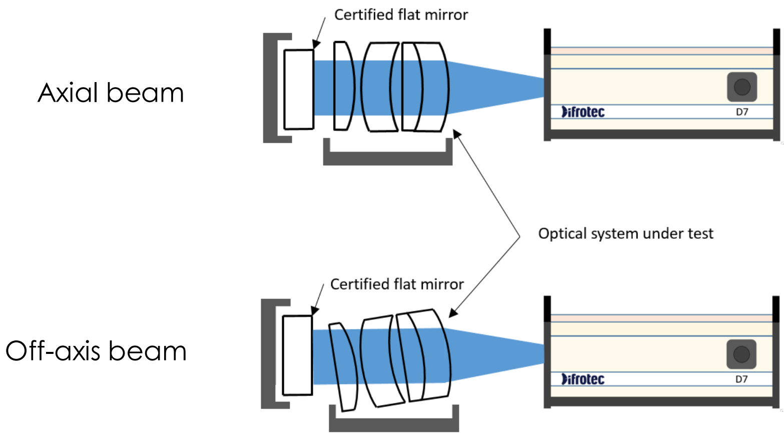


   - **Absolute flatness uncertainty** is ± **0.8 nm** (± **λ /800)**.

2. **Concave** and **convex:** P_V **absolute uncertainty** is ± **1.8 nm** (± **λ /350**).

3. **Freeforms** with **D** ≤ **150 mm**: P_V **absolute uncertainty** is ± **1.3 nm** (± **λ /500)**.

4. **Optical system wavefront** testing is performed for the **axial** and **off-axis** beams:



   – P_V **absolute uncertainty** is better than ± **1.0 nm** (± **λ /630)**.

5. **Asphere** measurements:

– Measurements are performed using various sub-apertures for which the test part is individually installed with the help of a **6D automatic stage** providing linear and angular movements with 50 ppm accuracy. A set of sub-apertures is superimposed on fringe patterns by the control software on-line. Installation parameters of the test part for each sub-aperture are saved in PC memory in order to provide correct stitching after phase retrieval.
– The **stitching accuracy** is better than **10 nm**.
– Asphere **departure** is up to **200 microns**.
– Range of **R** and **D** is similar to all mentioned spheres, P_V **absolute uncertainty** is ± **λ /200**.

6. **Curvature radius** measurement:

   – For **0.5 mm** < **R** < **2 mm** **absolute uncertainty** is < **5 ppm**.
   – For **2 mm** < **R** < **3000 mm**:
      - For concave **absolute uncertainty** is < **5 ppm**;
      - For convex **absolute uncertainty** is < **10 ppm**;
   – For **R** > **3000 mm** **absolute uncertainty** is to be customized.