Revealing features of different optical shaping technologies by a point diffraction interferometer

Nikolay Voznesenskiy[a], Mariia Voznesenskaia[a], Diwaker Jha[a], Heidi Ottevaere[b], Małgorzata Kujawińska[c], Maciej Trusiak[c], Kamil Liżewski[c]
[a]Difrotec OÜ, Teaduspargi 13, 51014 Tartu, Estonia; [b]Vrije Universiteit Brussel, Department of Applied Physics and Photonics, Brussels Photonics (B-PHOT), Pleinlaan 2, 1050 Brussel, Belgium, [c]Institute of Micromechanics and Photonics, Warsaw University of Technology, 02-525 Warsaw, 8 Sw. A. Boboli St., Poland

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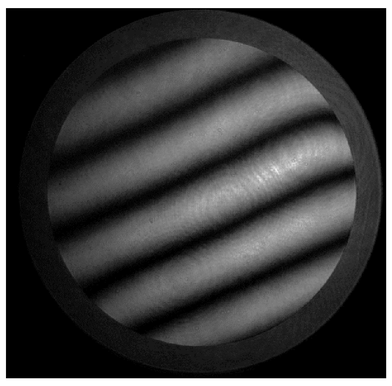
ABSTRACT

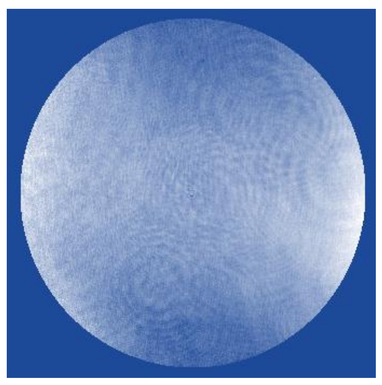
Phase shifting point diffraction interferometer (**PSPDI**) reveals **hidden residual defects** by mapping absolute profile deviations of several angstroms. Pixel-resolution imaging by PSPDI visualizes frequency ridges with nanometer heights or depths, providing an unprecedented view of the surface under test.

ACCURACY Peak-to-valley

Almost perfect spherical reference is inherent in the principles of point diffraction interferometry (PDI). At the same time, the errors in the wavefront emanating from pinhole diffraction do not exceed $\lambda \cdot 10^{-5}$ [1]. Difrotec's PSPDI, D7 realizes these advantages, on top of that it has a large numerical aperture, NA = 0.55, which allows it to test optical system in similar fashion as common industrial interferometers but with superior ***sub-nanometer absolute accuracy of the form measurement.***

Interferometer	NA during measurements	Measured absolute accuracy (nm)	
		68% assessment	95% assessment
PSPDI[7]	0.145	0.34, 0.27	-
PSPDI[8]	0.145	0.31, 0.22	-
Sommargren PSPDI[10]	0.14	0.27	-
PSPDI D7	0.48	0.39, 0.29	0.70, 0.56





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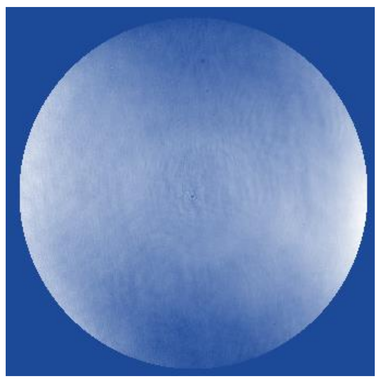

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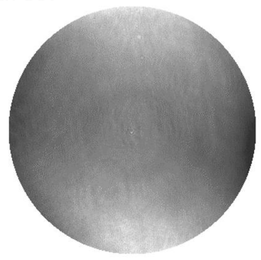
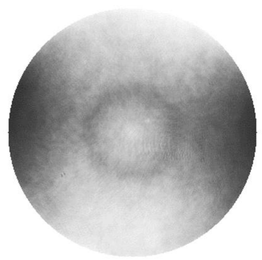
PSPDI APPLICATION

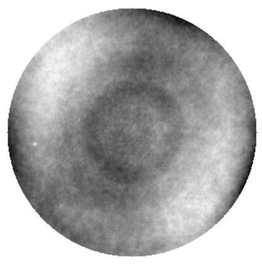
Shape forming information is obscured in the surface mapped by commonly used Fizeau interferometers. A PSPDI, such as Difrotec's D7 provides the highest confirmed accuracy and deepest investigation of a surface form. Such a system could analyze shape forming technology, namely, quickly distinguish between surface formed by diamond turning and lapping. For example, the cavity, EO B1002 (λ/20) is definitely formed by diamond turning as shown in Figures:



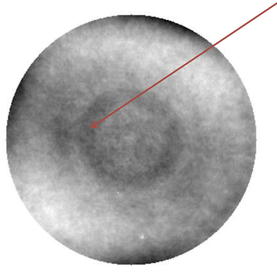
Simulated mapping by a Fizeau interferometer (with TS λ/40): the ripple is almost invisible



Absolute mapping by the PSPDI D7: the ripple is distinct



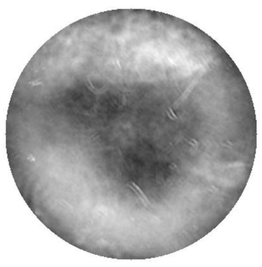
Measured at 0°



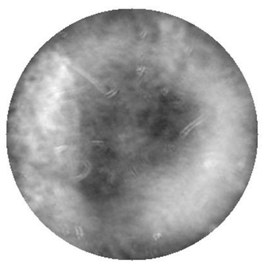
Measured at – 90°

Annular ditch depth **1.8 nm**

Cavity EO B1001H (λ/30): axially symmetric features are revealed by the PSPDI D7 – two ripples with amplitudes 2.5 and 1.0 nm



Measured at 0°

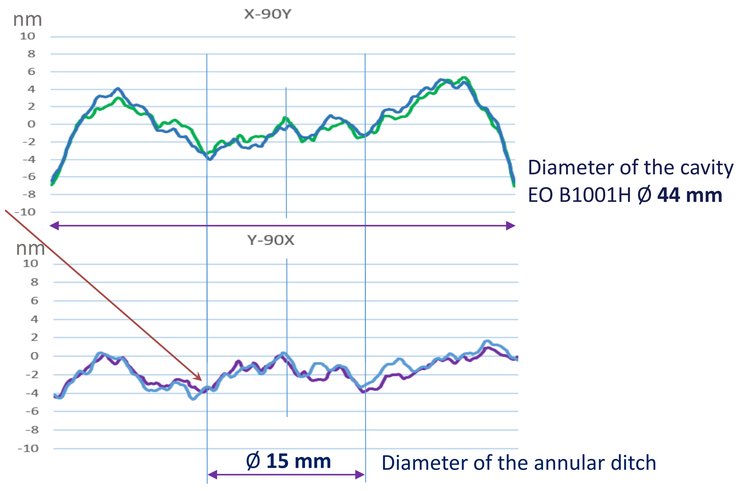


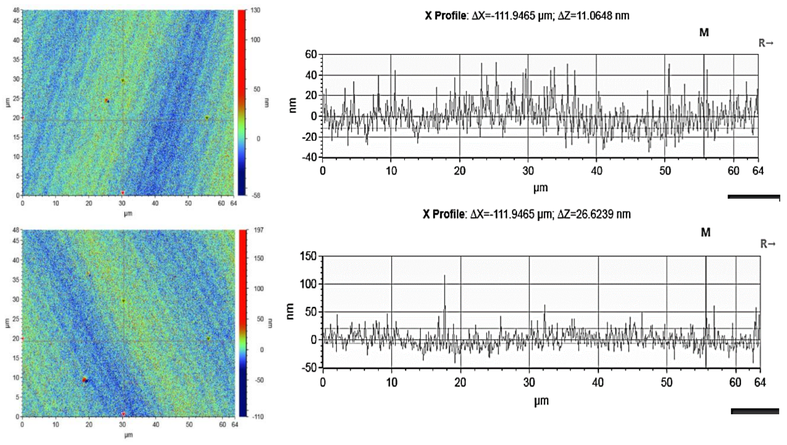
Measured at – 90°

Cavity of Warsaw University of Technology (λ/30) mapped by the PSPDI D7: result of lapping technology: scrappy peaks and valleys vary from 0.9 to 10.0 nm

WHITE LIGHT PROFILING

Profilers based on white light scanning interferometry can confirm manufacturing technology. They provide high resolution images of the test surface but have a very narrow field of view (FOV). Overall patterns residue from shaping technology in such images are incomprehensible. Common Fizeau interferometers have wider FOV but are limited in terms of resolution. PSPDI provides the best of both worlds, i.e. wide FOV combined with sub nanometer vertical resolution. Measurements of the cavity EO B1001H have been performed in Vrije Universiteit, Brussels using Bruker's Contour GT-I.





Maps of the cavity EO B1001H areas 48 × 64 µm and corresponding cross section plots; vertical resolution is 1 nm and horizontal scanning resolution is 1 µm.

CONCLUSION

Industrial PSPDI is an effective tool to inspect surface form and also helps assess final aspherization, light scattering, and optimal turning options. In standard configuration, absolute accuracy provided by D7 is 0.7 nm (peak-to-valley) for NA = 0.48 without Zernike fitting. This is orders of magnitude higher than the accuracy provided by Fizeau interferometers in general. Such PSPDI systems are also suited for DUV, soft X-rays, and EUV optics testing.

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