

Microoptics Metrology

Introduction

Microoptics is becoming widely used in common life. The use of microlenses increases the light efficiency of portable microprojectors such that we can buy for home cinema. The use of Fresnel lens to concentrate the light of a high power white light LED leads a very small and compact design with a high light efficiency and throughput and low consumption, being the ideal situation to replace the flashlights in a digital still camera. Other designs for biomedical applications improve the imaging properties of endoscopes and «lab on chip» devices used to compare tissue samples or chemical substrates. Alternatively, optical couplers like VCSEL for telecommunications and microlenses to concentrate light in a microscopic waveguide open the field of microsystems known as MOEMs.

The use of the microoptics, the surface quality, reliability and final cost determine the technology used for its fabrication. Commonly lithographic, reflow process and replication are used. Lithographic fabrication was originally developed for microelectronics for the generation of structured coatings or surface profiles. A laser or an electron beam

can be used as a writing pen to generate special illumination designs, which will be impressed in the substrate by a reactive ion process after the photoresist layer development. Lithography is useful for waveguide optical structures, free-space microoptical elements and diffractive optical elements manufacturing. On the other hand, reflow process gives high quality results and simple process. Small cylinders are fabricated using a conventional lithography process. Due to surface tension under a melting process small planoconvex

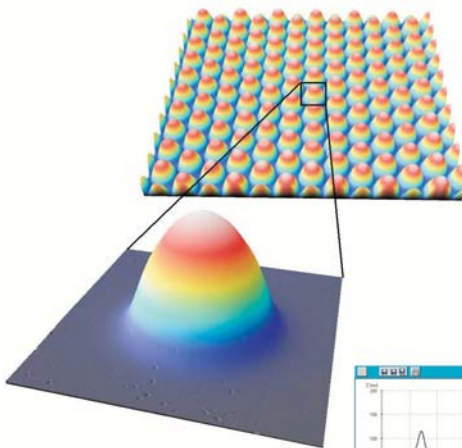
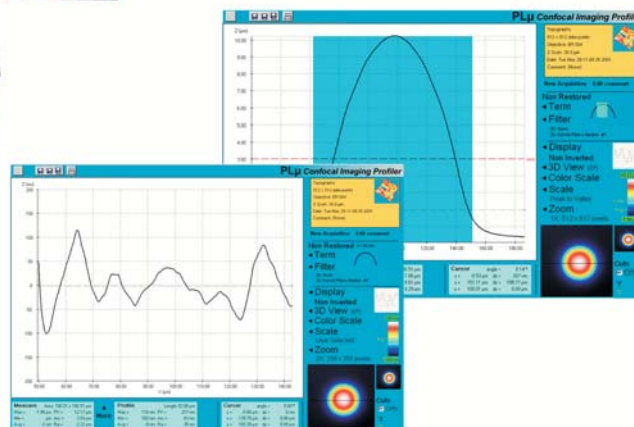
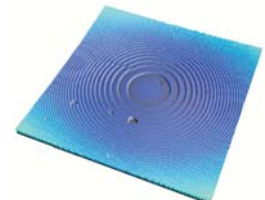


Figure 1: Replica of a microlens array on borofloat glass. A single lens can be used to adjust radius of curvature and deformations.



PLμ 2300 Optical Imaging Profiler



Fresnel 3D

lenses of high quality results. Reflow is used to generate refractive components.

Lithography and reflow process are extremely accurate, but the increasing number of applications of microlenses pushes the manufacturers to use the replication technologies for high volume production. Usually a high quality master is used to generate a replica on either, fused silica or an epoxy on glass using ultraviolet embossing.

Microoptical components have two important requirements for metrology: non-invasive and high accuracy. Contact profilers have the problem of being destructive but are able to profile a full lens regardless of the reflectivity and the local slope. For moderate aspect ratio features or

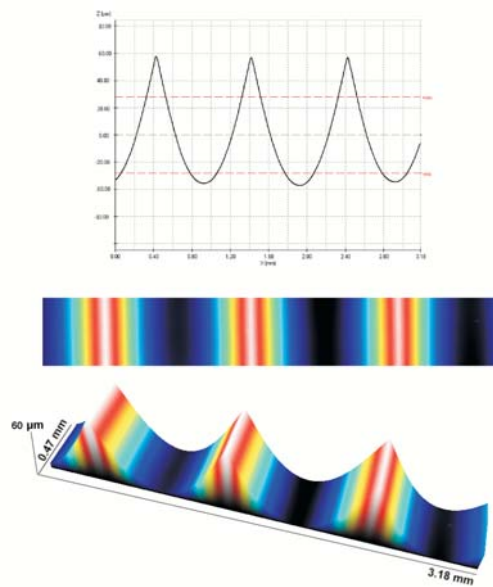


Figure 2: Linear lens array. Replica of an array of cylindrical lens on an epoxy material from a ion etching master. To measure it, a 50X, 0.8NA Objective with the topography stitching measurement was used. The total field of view of the sample is 0.4 x 3.18 mm. The local slope of the surface reaches more than 30 degrees. This requires to use topography stitching in order to see a full set of lens. The pitch of the lens is 1.0 mm and the total height is more than 90 μm .

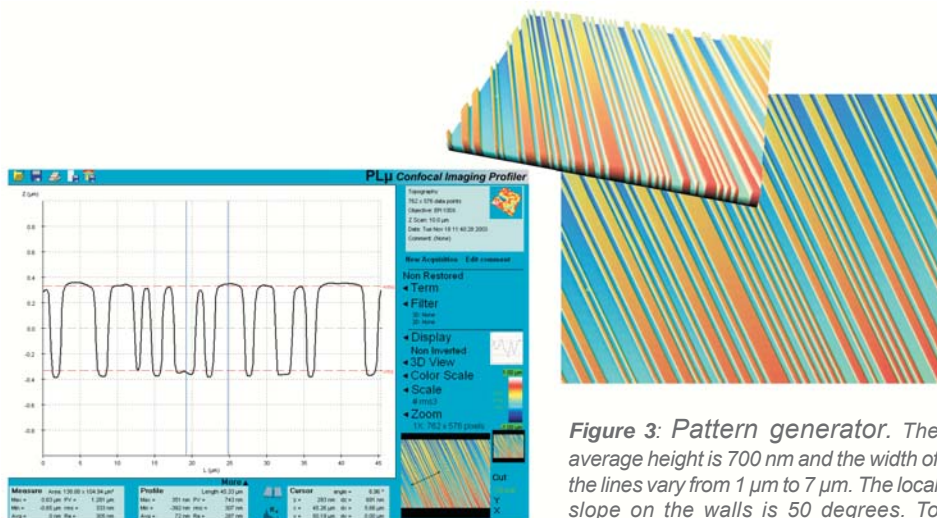


Figure 3: Pattern generator. The average height is 700 nm and the width of the lines vary from 1 μm to 7 μm . The local slope on the walls is 50 degrees. To perform this measurement a 100X, 0.9NA objective was used.

waveguides under a coating a white light vertical scanning interferometry is used. Nevertheless, interferometer designs limit the maximum measurable slope to the numerical aperture of the objective, which is usually under 0.5 for high magnification. PL μ confocal imaging profiler uses up to a 0.95 NA objective and high light efficiency, being able to measure flat surfaces with 1 nm repeatability and up to 70 degrees of local slope in optically smooth surfaces. Moreover, to evaluate a full lens or array of lenses, the topography stitching mode can be used. Typically, a high numerical aperture objective is related to a high magnification, which reduces the field of view to a few hundreds of μm . To increase the field of view, the PL μ software automatically drives a motorized stage and gets several single topographies. After data acquisition, the software

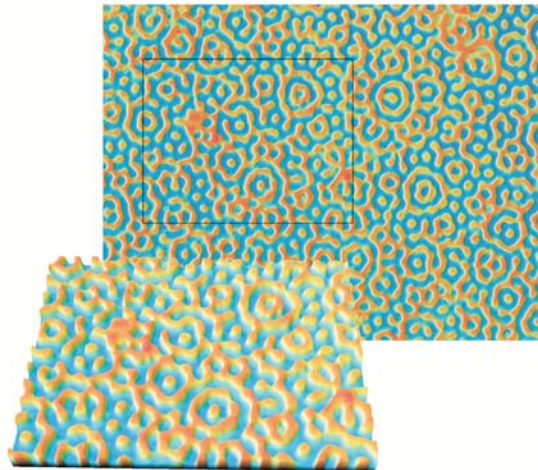


Figure 4: Optical diffuser made of random diffraction pattern. Measurement made using a 100X objective. Average height is 700 nm.

automatically composes a final topography with an extended field of view, keeping the original properties of a single field.

In comparison with interferential systems, PL μ can be operated without a vibration isolation table, and its high light efficiency and high numerical aperture objectives make it the ideal tool for testing and evaluating microoptical components, both in the design and production state. PL μ is a modular system that can be configured from its simplest setup in which single profiles and up to 35 profiles are acquired within the field of view of the objective. An optional

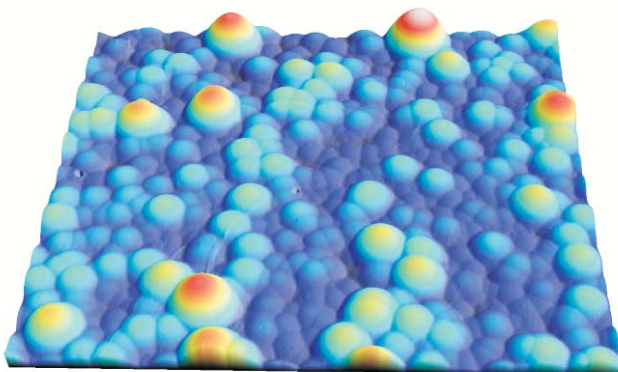


Figure 5: Optical diffuser made of random microlens on a epoxy substrate. Measurement made using a 20X objective and 10 x 10 single measurements. FOV: 7 x 5 mm.

motorized stage increases the measurement length up to 100 mm, while an optional PZT scanning device offers the possibility to get high contrast confocal images and three-dimensional topographies.

	10X Epi	20X Epi	50X Epi	100X Epi	150X Epi
Working Distance (mm)	17.3	4.5	1.0	1.0	1.0
Numerical Aperture	0.3	0.45	0.8	0.9	0.95
Field of View (μm) ⁽¹⁾	1400 x 1050	700 x 525	280 x 210	140 x 105	93 x 70
Spatial Sampling (μm)	1.82	0.91	0.36	0.18	0.12
Maximum Slope	14°	21°	42°	51°	70°
Rms (3σ) nm	<40	<20	<4	<4	<2

Table 1: Specification of the available objectives for PL μ confocal imaging profiler.

⁽¹⁾ The field of view can be increased up to 100 x 72 mm using topography stitching.

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