Parallel optical profilometry assisted conception of an opto-electronic illuminator using a VCSEL and diffractive optics*

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Micro-opto electromechanical systems (MOEMS) are of growing importance in the development of new miniaturised projection, imaging and detection technologies. Because of the increasing complexity of construction involving layers of electronics, optoelectronics and micro-optics, 3D geometrical shape characterization plays an increasingly important role in their conception and fabrication.

Recently we have developed a miniaturised structured light (MOEMS) projector for 3D shape measurement [1] by means of successive pattern projection. The MOEMS projector consists of an array of 12 vertical-cavity surface-emitting lasers (VCSEL) together with two planar static diffractive optical element (DOEs) arrays made in quartz. The first DOE consists of Fresnel-type elements for collimating each laser beam emitting at a wavelength of 850 nm and the second DOE serves to produce different structured light patterns. The availability of 12 lasers means that 12 different patterns can be incorporated into the same system, in this case consisting of the modified Gray codes and phase shifted gratings for 3D measurement.

Several challenges exist for the metrology of the system. In this paper we demonstrate how optical profiling using Coherence Scanning Interferometry (CSI) has played a vital role to ensure that the microsystem design has sufficient precision. The particularity of CSI is that it allows deep characterisation (<150 μm) with nm axial sensitivity on smooth surfaces over wide fields (mm). The first challenge was to align the laser sources to within 0.4 μm axially with the focal points of the collimating DOE's. With the bought-in VCSEL's laser emission spots varying in height with respect to the substrate by more than this value, it was necessary to measure the actual heights of the emission areas so as to be able to adapt the focal lengths of each DOE to the corresponding lasers. The second challenge concerned the quality of the fabrication of the DOE's which involved the use of several stages of masks in the surface etching procedure to make the 4 step levels necessary to achieve the 4 levels of phase to improve their efficiency. This required two separate optical masks that needed to be aligned laterally to sub-micron precision. Although the photomask equipment used in our clean rooms did not provide such precision, by using carefully designed alignment features on the masks and by fabricating several components, a suitably accurate DOE displaying little residue on edge features could be found by CSI (Figs. 1 and 2). Future designs will involve the use of sub-wavelength elements, requiring eliminating alignment errors through the use of a single mask, but requiring sub-wavelength structuration and metrology [2].

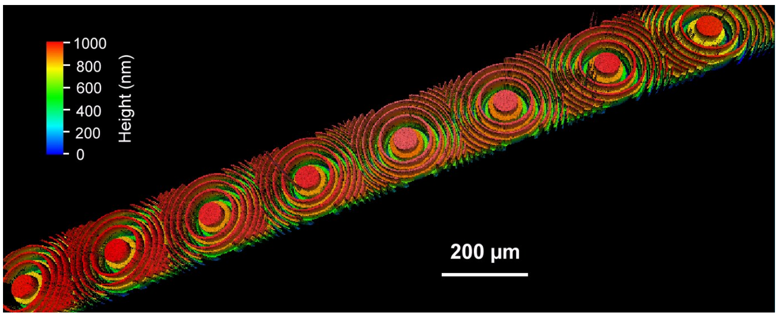

Figure 1: 3D view of array of collimating DOE's etched in quartz

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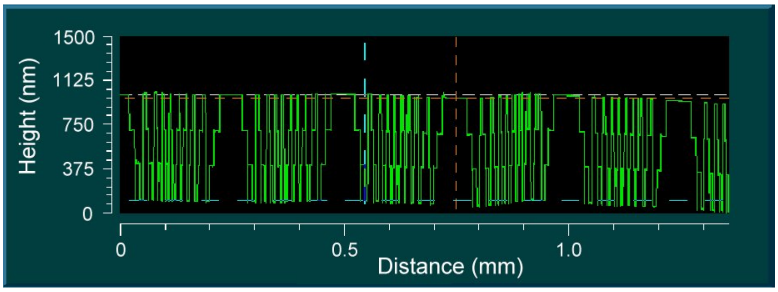

Figure 2: 2D profile from Fig. 1 showing 4 step levels

References

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