DEEP 3D OPTICAL METROLOGY

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KEY WORDS: optical profiler, confocal, interferometry, thickness, deep focusing

In recent years, increasing attention has been paid in the field of optical profiling to the metrology of stratified media. Two features are of particular interest in this regard: layer thickness and the profilometry of deep surfaces [1,2,3]. One of the tasks that is most difficult to carry out with most optical imaging profilers is measuring surfaces located behind thick plates (for instance, measuring encapsulated photodetectors, encapsulated microdisplays and devices kept in cryogenic environments) or deep inside refractive media (for instance, measuring pits at different levels in new generations of optical disks for massive data storage).

The main techniques that can be used to perform these measurements are VSI and confocal profiling. When one wishes to measure beneath a layer, the beam is focused out of its original focal position. Because confocal technique is based solely on focus position, this effect introduces a shift in the peak position that must be taken into account for correct profilometry. VSI profiling, however, is based on the detection of maximum fringe contrast. As the measurement beam propagates through a refractive medium, the peak of the correlogram is located at an axial position in which the beam is not focused. Therefore, the lateral resolution achieved with deep VSI profiling will be considerably worse than that achieved with confocal profiling. Furthermore, with these techniques the rays impinging on the sample at different incident angles are focused at different axial positions due to refraction index mismatch, which leads to spherical aberration that degrade image quality and optical sectioning capability. The negative effect of spherical aberration can partly be corrected using techniques such as the one proposed by Escobar et al. [4].

We review several deep 3D profiling applications that do not have an optimum solution with existing optical profilers. We compare the results obtained with VSI and confocal profiling in terms of their vertical accuracy and lateral resolution, and propose solutions to improve these applications.

[1] S. K. Debnath, M. P. Kothiyal, J. Schmit and P. Hariharan, "Spectrally resolved phase-shifting interferometry of transparent thin films: sensitivity of thickness measurements" *App. Opt.* **45**, 8636-8640 (2006)
[2] C. Cadevall, R. Artigas and F. Laguarta, "Development of confocal-based techniques for shape measurements on structured surfaces containing dissimilar materials" *Proceedings of the SPIE* **5144**, 206-217 (2003)
[3] C. Cadevall, C. Oriach-Font, R. Artigas, A. Pintó and F. Laguarta, "Improving the measurement of thick and thin films with optical profiling techniques" Submitted to *Optical Metrology* (2007)
[4] I. Escobar, G. Saavedra, M. Martínez-Corral and J. Lancis, "Reduction of the spherical aberration effect in high-numerical-aperture optical scanning instruments" *JOSA A* **23**, 3150-3155 (2006)