3D Measurements of Surface Topography and Vibrations

3D Measurements of Surface Topography and Vibrations. On a (Sub)micrometric Scale by Interferometric Microscopy and Laser Doppler Vibrometry. The French company Fogale Nanotech, specialist of high precision dimensional measurements, has also developed a pool of competences in the field of optical measurements, in particular in the interferometric and vibrometric techniques. Microelectronics, aeronautics, glass industry, iron and steel industry, characterisation of optical systems are some of the areas where Fogale measurement systems are already well established.

Combining vision and interferometry, the microscopy by white light interferometry brings a very effective solution to surface measurement on all types of samples (absorbing, transparent, curved, etc.) and becomes essential when these are fragile or deformable. These systems allow to visualise the surface in topographic form (3D) or as profiles (2D) and supply among others quantitative results like the statistical parameters of roughness, texture analysis, etc.

These systems are particularly well adapted to the field of microtechnology and the study of microelectronic mechanical systems (MEMS) and also offer the possibility to measure the thickness of transparent films or the reflectivity spectrum of an observed surface.

The automated displacements associated with the very efficient stitching algorithms allow to easily analyse flat or cylindrical surfaces of up to 8 mm by 6 mm with a resolution of 0.1 nm vertically and 0.3 μm to a few microns laterally.

In contrary to the mechanical scanning techniques, this method allows to catch the surfaces in 3D without the problems inherent in mechanical systems like hysteresis and play.

Measurement Principle

Fig. 1 shows the measurement principle: the beam issued by the source (So) is split by the beamsplitter (Sp) into two beams: one part reflects on the beams: one part reflects on the reference mirror (M), the other on the sample. After reflection, these two beams are brought together and captured on a CCD camera (C) through a lens (L). A path difference (d) between the bright beam reflected in a point A on the sample (distance 1) and the equivalent bright beam which reflects on the mirror (distance 2), creates an interference and the intensity I(A) is measured.
By moving the sample up or down with high precision, the interference fringes are recorded on every pixel of the CCD camera.

These fringes contain the height information and are computed into a digital surface model.

**A new Range of Profilometers**

The technique of optical interferometric microscopy has been used for many years by Fogale and a first version of the microscope Microsurf 3D has been produced over eight years ago. Now it is completely redesigned with a new hardware architecture, sensors and software. The collaboration with the IEF (Institut d’électronique fondamentale) has allowed to develop some new algorithms of treatment of interferograms which include various refinements to allow a completely automatic and fast measurement, e.g. measurements in perturbed environment, for micromechanical trials, on fractured surfaces, or of step heights. This partnership has also enabled the realisation of vibrational measurements. This allows to extend the applications of the 3D profilometry to the space-time characterization of dynamical systems like MEMS and other dynamic objects of which we wish to know the dimensional properties as a function of time.

These new developments have come with a very versatile new user interface designed to apply various evaluation steps to the measured topography (flattening, filtering, marking, defect correction) and to extract the required information (any 2D and 3D profiles, roughness parameters, step heights, lateral dimensions, deflections, etc.).

The three interferometric profilometers are commercialised under the names: PhotoMap 3D, MicroSurf 3D and ZoomSurf 3D. Each system has been designed to answer specific economical or technical requirements. The PhotoMap 3D is a basic but upgradeable system. It brings the technology’s performances of interferometric microscopy within the reach of everyone.
sensor can also be used in an autonomous way. This configuration was used by CNES for the control of the solar panels of the American Hubble satellite. The MicroSurf 3D system is based on a standard optical microscope and offers two functions in the one apparatus (profilometry 3D as well as classic microscopy). The system is modular and can be adapted to existing microscopes.

Fully automated, ZoomSurf 3D is a profilometer equipped with motorised tables X, Y and Z. It has been chosen by many European headquarters of technology specialised in the study and the fabrication of microsystems. The complete automation of this profilometer allows to measure with the same high precision surfaces which exceed the measurement field and which can go up to 100 x 100 mm².

The stitching procedure automatically compensates the inclination and vertical differences of the sample between two displacements.
... for many Application Fields
The detection and analysis of roughness or abrasion, the study of materials and their aspect (like shining) are the most common applications. The measurement in Fig. 2 is an example for the three dimensional representation of a glass engraving. The image size of 2 x 2 mm² is obtained by stitching together several measurements. The object contrast is obtained here by light encoding the different height levels since the traditional vision techniques don’t allow to obtain a contrasted image of the engraving on the original material (here: optical glass). An other application example is the quality control of the micro structure of a printing cylinder (Fig. 3).

More and more applications can also be found in the field of dynamic objects like MEMS and MOEMs. By using bright stroboscopic light sources the vibration modes of micro mechanical devices can be measured and studied in real time with the same procedures as for the measurements of 3D static profiles. So fig. 4 represents the fundamental vibration modes of a membrane. Perfectly flat in the relaxed mode, it presents, according to the frequencies, some characteristic deformations which allow the producers to localise the regions where rupture could occur. This allows to predict the reliability and life expectancy of the design. New range explored: the three dimensional image of bacteria on their culture medium. Here the white light interferometric profilometry provides the biologist a new analysis technique for the detection and non-invasive study of micro organisms as well as other biological samples like hair etc.

The latest development which has also been made in collaboration with an University is the Laser Doppler Vibrometer option which can be added to the previously mentioned microscopes or used on it’s own. It provides a punctual vibration amplitude measurement from 1 KHz to 2 MHz with amplitudes ranging from 0.01 to 40 nm.

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