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Microoptics based, integrated, full-field measurement systems

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The high quality refractive and diffractive microoptical components allow to create new solutions in optical metrology. Most of the required optical functions such as the light guiding, deflection, beam splitting and reflection of the beam are realized by special micro-optical components - designed and developed for a given application. This allows for a very compact design and the array arrangement of a large number of independent devices on a wafer. The development of technology that integrates these components with optoelectronics and mechanical assemblies is one of the biggest challenges in technology of modern measurement systems.

To present the main trends and different approach to the system construction we describe 4 examples of highly miniaturized and integrated devices.

Matching the size of measurement system to measured objects seems very natural approach in the case of microstuctures. That is allowed by both: miniaturization of mechanical components and use of microoptical elements. This case is very well illustrated by the device 1 from Fig. 1 i.e. on-chip confocal microscope [1]. In this millimeter size chip, the light-source is integrated with electrostatically driven x-y and z movable mechanical MEMS stages. The stages integrates polymeric refractive microlenses allowing for 3D scanning of 100 μm^3 volume. The miniaturization of the scanner results also with high speed/frequency scanning. Another good example of miniaturization of optical design is scaling of interferometric devices and approach presented in [3]. This technology has been used in the device 2: MOEMS probe from SS-OCT endomicroscope for early detection of stomach cancer [4]. Here, the common path Mirau interferometer is a passive device connected with a light source and detection module by an optical fiber circuit. The Mirau micro interferometer is fabricated by wafer-level vertical stacking and bonding of silicon-glass components. The MOEMS probe is connected with robotic arm, which allows the 3D scanning of tissue. In device 3 the core technology of the measurement system is a microoptical probing wafer based on micro lenses and diffractive optical elements (DOE). The idea of using array of 25 interferometers in optical measurement platform allowed to develop a new approach towards microsystems characterization at wafer level under EU project SMARTIEHS [5]. Presented diffractive version of Twyman-Green interferometer is applied to measure shape and deformations on smooth surfaces of static objects and for object vibration analysis to find the resonance frequency and mode distribution [6]. The system presented as 4th device in Fig.1 consist a miniaturized grating interferometer for in-plane displacement measurements. This hybrid approach integrates a monolithic polymer block for a light propagation MEMS phase shifter and emitting/detection platform.

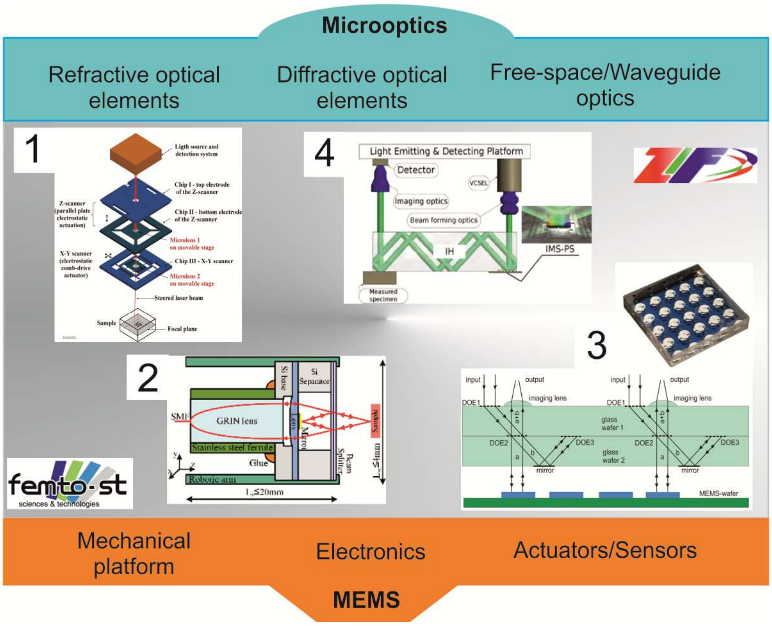

Fig. 9. The role of microoptics in development of integrated, full-field measurement systems: (1) on-chip scanning confocal microscope with 3D MEMS scanner, (2) MOEMS probe based on Mirau micro interferometer, (3) array of Twyman-Green interferometers based on diffractive optical elements, (4) miniaturized modular grating interferometer with active phase shifter.

The presented examples of miniaturized measurement systems may be used as stand-alone devices, sensors integrated with smart mobile devices or can be integrated into arrays of sensors in required configuration to fulfill demanded functionalities.

References

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