Application of microdisplays in optical metrology

S. Riehemann, G. Notni, P. Kühmstedt, and M. Palme

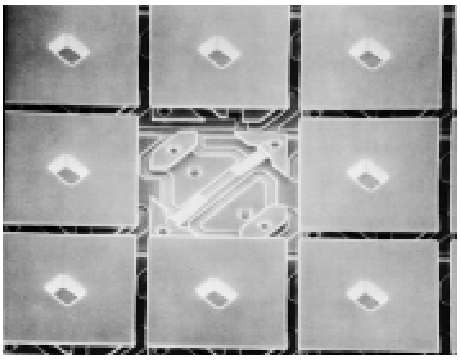
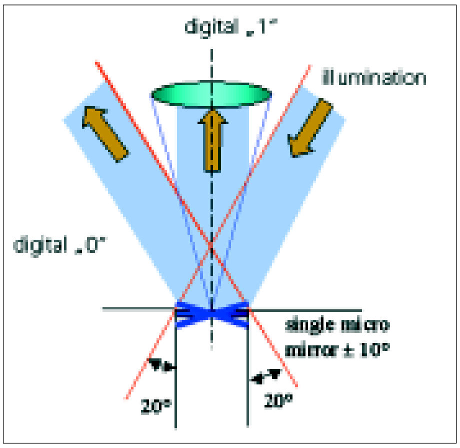

Fig. 1:
Digital Micro-Mirror Display (DMD), microscopic photo of the micromirrors (mirror size 16*16 µm², picture provided by Texas Instruments) and principle of the optical setup.

Principle and Potential

For display purposes, digital projection units nowadays step by step replace former used analog cathode ray tubes. These digital projection units are based on so-called microdisplays, which provide high resolution (computer video or HDTV resolution) on small areas (some square centimeters, pixel size 8–20 µm). Commonly used microdisplays are actually mainly based on two different technologies. The first one is the Digital Micro-Mirror Display (DMD) technique (see Fig. 1). In these displays, each pixel is a single mirror (e.g. size 16*16 µm²), which is electrostatically switched in dependence on the pixel information. The second technique, Liquid Crystal on Silicon Backplane (LCoS) (see Fig. 2), is very similar to a common LCD display, but the backplane is reflective.
The application field of microdisplays is – of cause – not limited to multimedia applications only. In optical metrology, they offer the possibility to provide an almost unlimited number of illumination patterns without changing slides or even the whole projector. Thus, new application areas in optical measurement techniques can be opened. For this purpose, high quality optical imaging systems are required: optical distortion reduction, high resolution, homogeneous illumination of the whole microdisplay, and high transmission rates are some of the necessary conditions to utilize these interesting new devices in optical metrology. Thus, optical design has to ensure these demands.

Concepts and Optical Design

As DMD displays have a mirror tilt of ± 10° (newer versions ±12°) they change the direction of incident light by 20°/40° (24°/48°, respectively), as can be seen in Figure 1. Thus, the illumination direction, the "on" and the "off" direction are separated by only 20° (24°), which has to be considered in optical design. Thus, the imaging system is quite large (length at least 120 mm), or a TIR-prism has to be used.

The principle optical setup for an LCoS display is quite different, as can be seen in Fig. 2. As the liquid crystal layer only changes the polarization direction of incoming light, a polarizing beam splitter is necessary to operate the display. This results – of cause – in a 50% loss of light intensity.
An optical design of an LCoS projector for optical metrology is shown in Fig. 3. In front of the beam splitter, optical filters are inserted to eliminate IR- and UV-light. This is important to protect the microdisplays against heat and high-energy rays (UV exposure can destroy the displays). On the side of the microdisplay, the rays of the imaging system can be assumed to be quasi telecentric.

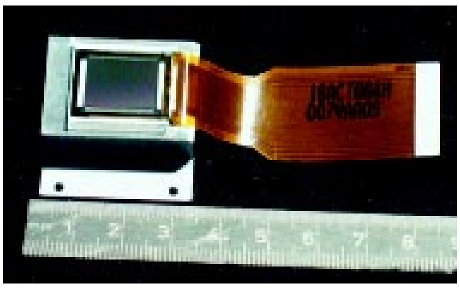
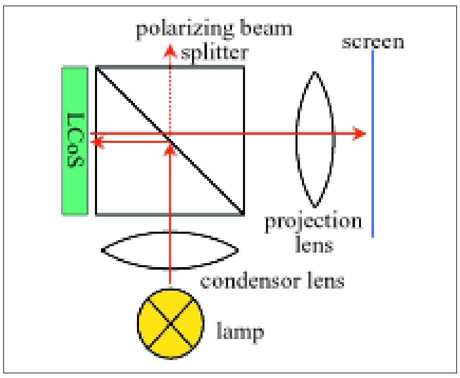

Fig. 2:
Reflective Liquid Crystal Display (LCoS), photo of the display and principle of the optical setup.

Realized Applications

Up to now, different applications of microdisplays in optical metrology have been realized, starting from the concept and the optic design, resulting in prototypes of the optics or in complete measurement systems. Some examples for completed products are given in the following list:

- 3-D measurement Systems, e.g. high speed 3-D digitizer "HSDig" /1/,
- Metrological Measurement Systems for Medical Applications , e.g. "kolibri-mobile" /2/,
- (Telecentric) measurement projection systems (see Fig. 3),
- Projection systems with automatic adjustable intensity distribution.

As the microdisplays offer a much wider variety of applications, this list can only illustrate some possibilities. But the developed concepts for optical design offer the possibility to adapt microdisplays quite easily to different tasks of optical metrology, in industrial and medical applications.

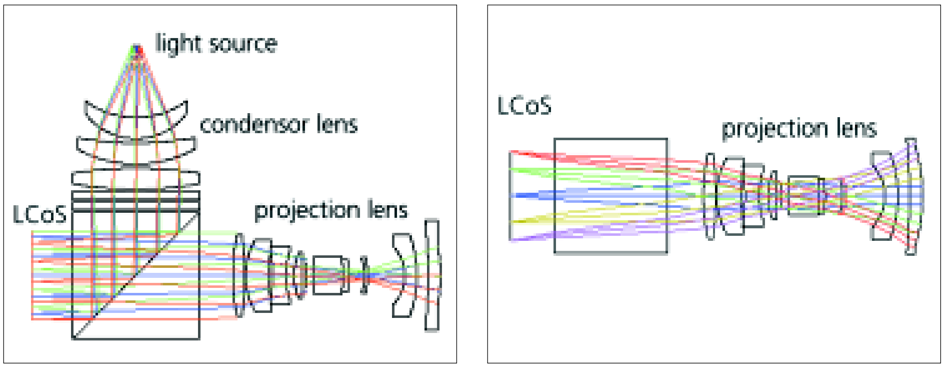

Fig. 3:
Optical design for a projection system for optical metrology (imaging distance 1600 mm) using an LCoS-microdisplay (15.4*19.2 mm², 1280*1024 pixel). Left side: illumination ray trace, right side imaging ray trace.

References

/1/ Kühmstedt P., Riehemann S., Gerber J., Notni G. "High speed 3-D-digitizer for CAD-CAM in industrial and dental applications" within this annual report

/2/ Notni G., Heinze M., Notni G., Reitemeier B., Fichtner D. "Optical 3-D-Scanning of extraoral defects using 'kolibri-mobile'" within this annual report