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< Machine tools need to function with accuracy down to the micrometer – pushing them to the limits of their capabilities. The wireless 3D sensor HoloPort is the first sensor that can map the entire topography of components in the machine tool itself to a fraction of a micrometer.

GROUP **GEOMETRICAL INLINE MEASUREMENT SYSTEMS**

Interferometry in machine tools

Precision components must be produced with an accuracy of a few micrometers. Modern processing machines are reaching the limits of their capabilities. A new portable optical sensor from Fraunhofer IPM ensures the component quality needed – the HoloPort sensor maps the entire surface of 3D structures with accuracy down to the micrometer in the machine tool itself.

In **MULTIWAVELENGTH DIGITAL HOLOGRAPHY**, the phase information in the light is recorded in addition to the spatial intensity distribution of the light that is usually recorded photographically. A coherent light source – typically a laser – is required in order to do this. When the surface of a test specimen is illuminated using laser light, its shape is stored in the phase distribution of the backscattered light wave. Using interferometric recording and subsequent digital reconstruction, this information is made accessible and can be used to perform three-dimensional measurements of surfaces. The fundamental principle underlying holography dates back to an invention designed by Dennis Gabor in 1948, for which he was awarded the Nobel Prize in Physics in 1971.

Precision components often need to be manufactured with a level of accuracy that even cutting-edge processing machines are unable to reliably deliver. Varying trajectories, light wear to tools, or errors in the internal calibration of sensors can lead to component geometries which lie outside of the specifications. Today, precision is generally ensured using tactile methods carried out with coordinate measuring machines in separate measuring rooms. The process is slow and complicated, and only random samples are possible. Before any deviations can be rectified, the workpiece must be repositioned in the machine. Fraunhofer IPM's new wireless optical sensor HoloPort offers a solution. HoloPort maps the entire component surface in the machine tool itself immediately after processing. The sensor is designed so that the spindle can grip it like a tool between two processing steps, enabling the contactless capturing of surface data without the need for any additional setup. Its interferometric accuracy even makes direct control of the machine tool possible for the first time. Development was financed by the foundation Baden-Württemberg Stiftung gGmbH as part of the Holo-Cut research project.

Complete quality control in the manufacturing process

HoloPort provides contactless, highly accurate measurements and operates so quickly and robustly that it can be integrated directly into the machine tool. The workpiece remains in place and the measurement data can be fed directly into a control loop for rectifying any deviations. HoloPort makes true 100-percent quality control in the manufacturing process possible for the first time. The sensor uses multiwavelength digital holography for inline 3D measurement and its axial length is no greater than that of a standard milling tool. It has an integrated energy storage unit and allows for wireless control and processing. The frequency-stabilized lasers needed for the multiwavelength digital holography, as well as the signal generation and processing systems, are integrated directly into the compact sensor head to make wireless operation possible.

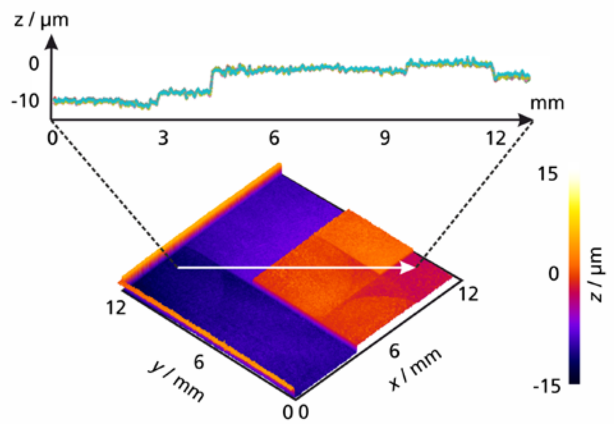
The system maps the topography even of rough object surfaces with interferometric accuracy. This means that the milling parameters and trajectory as well as the wear to the tool can be monitored and optimized via a control loop. All relevant dimensions and surface parameters are available within a fraction of a second. HoloPort offers a level of reproducibility better than one micrometer for height measurements. Real-time inspection means that the manufacturing process can be monitored and the quality of every individual workpiece is 100-percent guaranteed. Another advantage of HoloPort is that it can be integrated into existing production processes without significant expense – as it is used in the machine tool itself, costly handling processes can be dispensed with almost entirely.

Topography analysis in real time

The illustration to the right shows a casing cover to demonstrate the impressive accuracy with which HoloPort comprehensively maps both the depth and surface roughness of individual milling marks. Typically, 2D profile sections are used for characterizing the surface and therefore for inspecting the results of the milling. However, these 2D sections only provide a very limited description of the surface and are not sufficient for characterizing ridges or randomly occurring structural elements, for example. A number of standards address 2D surface analysis (ISO 3274, ISO 11562, ISO 13565-1, ISO 4287, ISO 4288, ISO 1365-2). The HoloPort sensor makes it possible to comprehensively analyze the surface topography measured, which in turn enables function-oriented and structure-oriented 3D analysis of the surface in accordance with the ISO 25178 standards. These standards define the 3D parameters Sa, Sq and Sz based on the established 2D parameters Ra, Rq and Rz.

Automated inline inspection

The portable sensor head HoloPort could be the key to enabling fully automated inline inspection of highly precise components on many manufacturing lines. As complicated handling processes are no longer necessary, the sensor also cuts costs significantly. It is designed so that it can be gripped in the machine tool directly by the spindle in the same way as a tool. This reduces the overall inspection costs for the process.



The HoloPort sensor comprehensively maps the surface and depth of milling marks. This graph illustrates the high level of measuring accuracy based on ten measurements of the surface data.

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