ISSN 2672-0531

Middle Market Insight

중견기업이슈리포트

미들마켓 인사이트

2022 Vol.7

KIAT 한국산업기술진흥원

Utilizing Fiber-optic Sensor Technology in the Field of Micro Production

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KEYWORD
✓벤처캐피탈 ✓혁신성장 ✓M&A

New manufacturing methods and increasingly digitally controlled processes enable closely timed production with steadily decreasing tolerances. Fast, compact and highly accurate inline measurement technology is required to ensure product quality and process reliability.

Measuring in the production cycle

Process-integrated measurement technology must be versatile. It should measure rapidly – if necessary, within a given production cycle – so that non-productive times are reduced or avoided. Measurement results must often be highly accurate in order to reliably check the dimensional accuracy of precision-manufactured components even in the micro and sub-micro range. Integration into existing production processes and machines should be cost-effective, customer-specific and process-neutral.

For Industry 4.0 applications in micro-manufacturing, fionec's optical fiber based FDM sensor technology (Fig. 1) offers vast integration flexibility. The optical measurement technology allows first of all high achievable measurement speed. At frequencies of up to 20kHz, the sensors can be used to scan surfaces, for example standard-compliant roughness measurements are possible at 10 mm/second. This means that the sensors work up to ten times faster than comparable tactile systems.

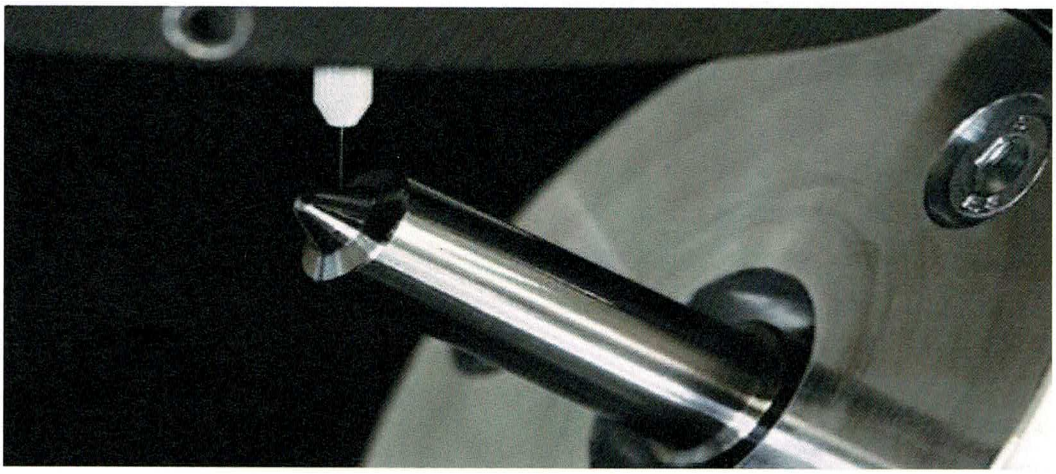
Figure 1 fionec FDM – Fiber Optical Distance Measuring System

⪢ Thanks to the fast recording of measured values and data transfer, measurements can be carried out in parallel with the main time, even in tightly timed production cycles. If required, components can also be subjected to 100-percent inspections. The critical quality parameters of all workpieces could completely be recorded, so that the process and quality can be monitored and controlled to the maximum.

○ High-precision miniature measurement technology

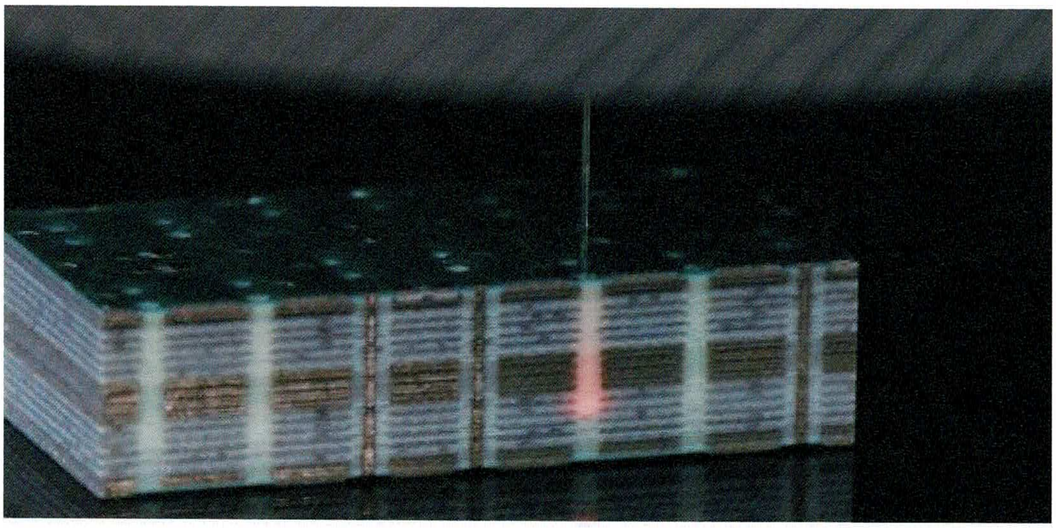
⪢ The design of the fibre-optic sensors is very compact. This makes it possible to miniaturize the measuring probe heads to diameters of only 50 μm. At the same time, the maximum achievable accuracy is in the lower nanometer range with a resolution of 0.1 nm. This allows for new metrological possibilities, especially if considering micro and precision manufacturing.

Figure 2 Roughness measurement in the injection hole of an injection nozzle with 50 μm probe.



The miniature measuring probes reach even the smallest of spaces from diameters of 0.1 mm. For example, roughness measurements are possible in micro-bores such as the injection holes of fuel injectors (Fig. 2) or microvias of multilayer PCBs (Fig. 3). Components with very small or narrow cavities, such as gear-flanks, stacked layer components or small gear wheels can also be measured.

Figure 3 Detection of copper layers in 125 µm microvias of multilayer boards.



The interferometrical sensor technology allows for surfaces inspections, distance and geometry measurements. The sensor delivers absolute values, gained contactless and of course wear-free. Another typical area of application is therefore surface measurements of lenses or even free-form optical components with complex geometries (Fig. 4).

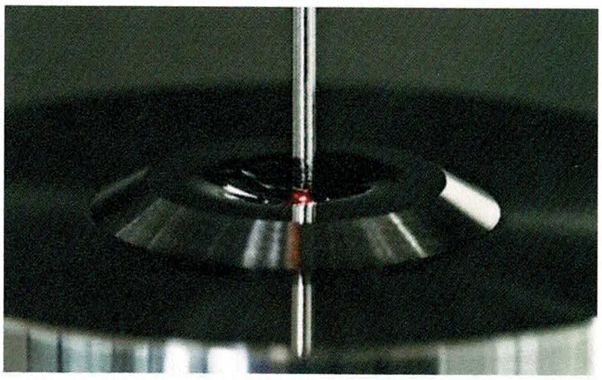
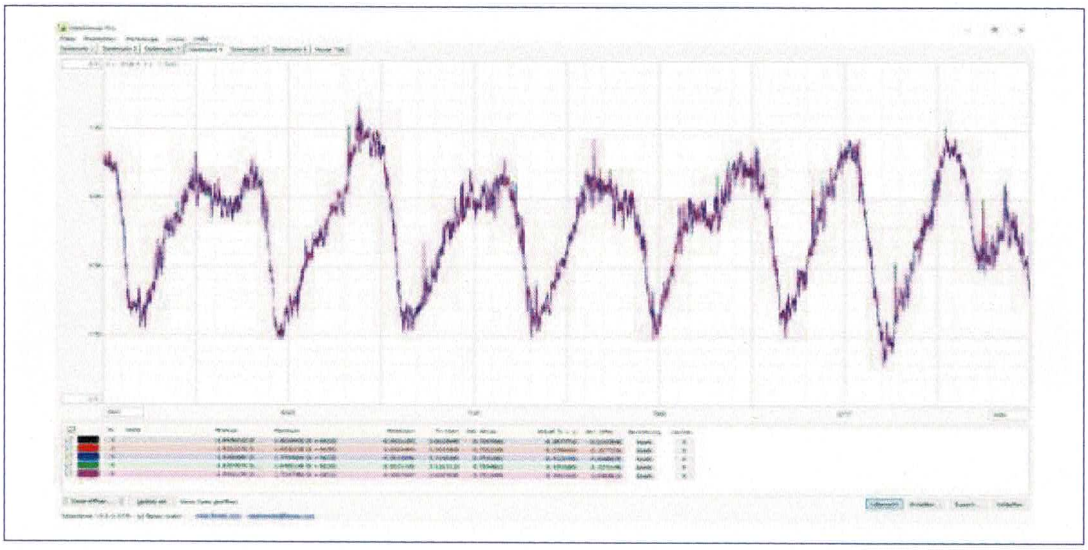


Figure 4
Optical testing of the surface quality of a molded tool with a complex free-form surface.

Technical surfaces are often a challenge for optical roughness measurements, as the reflective properties of the surface can vary significantly. Automatic exposure control optimizes the signal quality of the FDM during the measurement process, so that consistent, reliable and highly accurate values are achieved even with heterogeneous surfaces. Overall, the measurement technology has a very high repeatability (Fig. 5). It should be noted though, that the prerequisite for reliable and highly accurate results are lubricant-free, clean surfaces.

Figure 5 The fiber-optic sensor technology works with high repeatability. Above, 5 repeated measurements are shown in fionec's evaluation software "DataViewer".



Direct integration saves costs

In the case of autonomously operating measuring systems, a large part of the costs is related to the utilization of the precision kinematics. The system must normally achieve a better axes precision than the production kinematics when recording component position and dimensions, positioning and guiding the measuring probe. Only then a meaningful comparison of the nominal and actual values can be made.

Retrofitting of existing machines, offers an alternative. Due to their small size (Fig. 6), the micro-measurement probes from fionec can be easily installed in high-precision coordinate measuring machines, automated test units or submerged machine tools. In this technical symbiosis, machine-integrated measurements are comparatively inexpensive because the sensor technology can use the existing production kinematics.

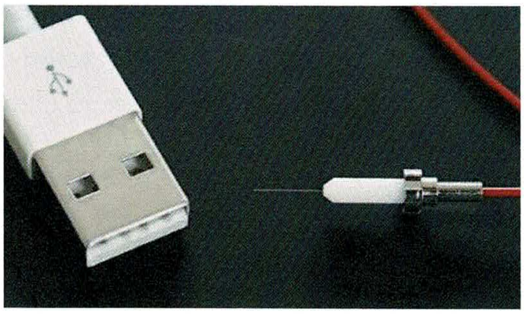


Figure 6

With a diameter of 50 μm, the micro-probes reach inner diameters from 0.1 mm and other hard-to-reach spaces.

Flexible integration and single-setup

- The probe is mounted, for example, in its own positioning unit or within a tool change, as is usual with coordinate measuring machines. When integrated directly into the production machine, the probe could be retracted into a parking position if necessary. This protects it from dirt or collision during the actual production process.

- The fiber patch cord of the measuring probe can be installed in a cable tow. Probe and sensor have both connectors so that the patch cord does not have to be replaced if, for example, a probe needs to be changed. Robust industrial-grade, bend-resistant or steel-sheathed versions of the cords are available. Electro-magnetic interference does not affect the fiber optical measurement, in contrast to inductive or capacitive sensors.

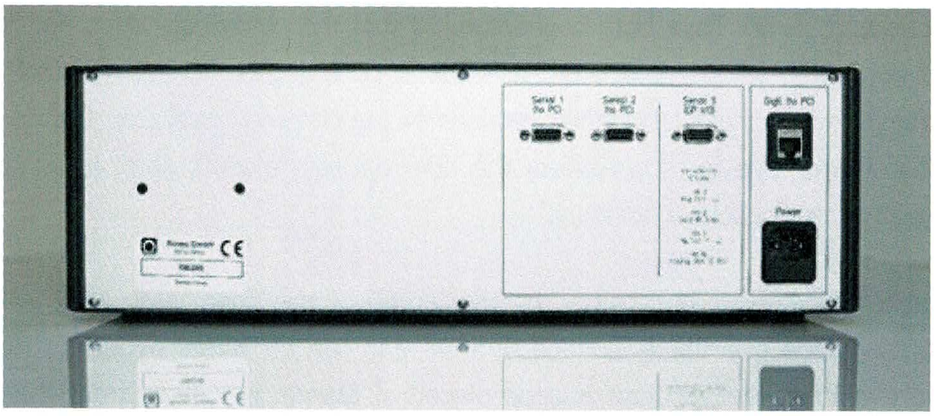
- Additional flexibility is provided by the length of the fiber patch cord connecting the probe and the evaluation unit, as this can be varied almost at random. The evaluation system can also be placed at greater distances from the actual measurement setup. For example, in sensitive production areas such as clean rooms, the probe can measure in a critical environment, while operating and data processing take place in nearby rooms with free access.

The great advantage of machine-integrated roughness, form and position measurements for precision manufacturing is the single-setup process. This means that production and measurement of the precision-manufactured components take place in one set-up. Measurement errors, deriving from the axes and from re-clamping are minimized, and the time and labour required for the re-clamping process are significantly reduced. At just a few grams, the lightweight sensor probe literally weighs hardly anything. Even with high-precision axes, some of which react sensitively to changes in mass, it is usually not necessary to compensate for an interchanged measurement probe.

Sensor connectivity

Cross-device communication (M2M communication) is ensured by integrated hardware and software interfaces (Fig. 7). On the one hand, TTL trigger signals can be used for synchronization, for example to link the measured value of the sensor system with the axis positions of the kinematics. The TTL signal can either come from the sensor itself or from an external pulse generator. Such an external pulse generator could be, for example, the control unit of a coordinate measuring system.

Figure 7 The integrated interfaces of the FDM series enable seamless integration into automated processes.



For data transmission in real time, on the other hand, a field bus is required, such as EtherCAT, PROFINET or SERCOS. This allows the production controller to request the current sensor values during the process and dynamically adjust the actuators accordingly. It is also conceivable to use the measurement data as a basis for direct CAD comparison. With the appropriate algorithms, the result can be fed directly back into the process and, if necessary, corrective steps can be initiated (closed-loop production).

The short control loops reduce nok parts and also the effort required for re-machining these. If the machine kinematics are sufficiently accurate, the "measuring machine" could replace stand-alone test stations in many cases.

From measured value to added value

The versatility and flexibility of fiber optic FDM measurement technology offers a whole new basis for integrated quality assurance in micro and ultra-precision manufacturing. The small size of the probe facilitates retrofitting and opens up new fields of application in the smallest installation spaces. Production and inspection of precision-manufactured surfaces and component geometries interlock directly and fit seamlessly into the existing manufacturing network. Critical quality data is output and processed quickly, non-destructively and with high precision. The result: optimized processes, fewer nok parts and proved product quality.