Fiber Optic Sensing for Surface Roughness Detection

Article Overview

Fiber optic sensors enable fast, high-precision, non-contact measurement of surface roughness, suitable for microstructures and production-line inspection.

Overview

Fiber optic sensors for surface roughness measurement use light-based, non-contact technology to evaluate surface profiles and roughness parameters. These sensors typically consist of a light-emitting fiber and multiple light-receiving fibers arranged coaxially, allowing precise detection of surface variations by analyzing reflected light intensity and interference patterns . The technology is capable of measuring standard roughness parameters such as Ra (mean roughness), Rz (mean roughness depth), Rk (core roughness depth), and Rmax (maximum roughness depth) .

Working Principle

The measurement process generally involves:
o Calibration with reference samples to establish correlations between light intensity and surface gap distance.
o Determining maximum intensity positions for the reference surfaces to set the probe at optimal measurement distance.
o Monitoring the reflected light intensity from the target surface.
o Calculating roughness values based on pre-established correlations between intensity and surface roughness . This method allows on-line monitoring of machined surfaces in real time, making it suitable for integration into production processes.

Advantages

o Non-contact measurement avoids surface damage and is ideal for delicate or micro-structured surfaces .
o High speed and frequency: Fiber optic sensors can measure at speeds up to 10 mm/s and frequencies up to 20 kHz, significantly faster than tactile probes .
o Miniaturized probes: Diameters as small as 50 um allow access to micro-drilled holes and small cavities down to 0.1 mm .
o Automatic signal optimization ensures consistent readings on heterogeneous or technical surfaces .
o Standards-compliant: Measurements conform to DIN EN ISO standards for roughness evaluation .

Applications

o Precision turned parts and rotationally symmetrical components.

o Integration with CNC machines, coordinate measuring machines, or automated testing systems for inline quality control .
o Microstructure inspection using techniques like white light interferometry combined with fiber-optic probes.

Integration and Customization

Fiber optic sensors can be implemented as stand-alone measuring stations or integrated into existing manufacturing lines. Built-in hardware and software interfaces allow robotic loading, automated data acquisition, and real-time analysis, enabling high-throughput inspection without slowing production . Custom solutions can be developed to meet specific metrological challenges, including complex geometries or high-speed production environments. In summary, fiber optic sensors provide a highly accurate, fast, and non-destructive method for surface roughness measurement, making them ideal for modern precision manufacturing and quality assurance applications .

This paper utilizes the computer vision technique by employing uniform illumination of light on the polished surface.

Abstract A technique applicable to surface-roughness measurement in limited spaces is presented. The measurement

A fiber optic sensor probe for surface roughness measurement was designed and fabricated using the results obtained

The mean surface roughness of 343, 96, 25 and 9 nm was estimated at the sensing zone of the D-shaped sensors

Abstract This paper presents some aspects of design approach, modeling, and experimental measurement results of a

Measuring the microstructure non-destructively on real parts is challenging for optical techniques such as laser

The paper deals with the development of a fiber optic sensor for surface roughness measurement. A new method for

However, traditional fiber optic surface roughness sensors have low integration and low measurement accuracy. In order to solve

Firstly, a new model for surface roughness measurement is proposed, which is based on intensity-modulated fiber optic sensors and

We present a novel fiber optics sensor approach using an intentionally designed silica fiber that requires no additional

In order to solve these problems, we present high precision reflective seven-core optical fiber (SCF) surface roughness

We present a high precision fiber roughness sensor based on annular core optical fiber (ACF). The ACF has a cone

The description of the complete setup of optical fiber sensors, methodology, and machine learning algorithms are covered in this

A fiber optic sensor system is developed to probe the surface texture of corroded metals. The present work is based on

In addition, the manufacturing process of D-shaped sections on standard silica single-mode optical fibers with different

A fiber optic displacement sensor is proposed to estimate the roughness of metal surface using the intensity

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