Sioux Technologies @ Physics with Industry 2020

Surface roughness and structure measurements on machined parts in the workshop

1. Company information

Sioux Technologies develops and produces state-of-the-art technology for the high-tech community. Sioux's strength lies in its unique combination of high-quality competencies in software, mathware, physics, mechatronics, electronics and assembly. With more than 700 engineers, Sioux supports or acts as the R&D department of leading high-tech companies.

The Physics and Optics department is involved in a wide range of projects ranging from imaging system and electron optics to particle detection and is often involved in the feasibility and concept phase of projects where the solution direction in unclear. Our group consist of physicists, most of which have a PhD.

2. Problem

Cleanability of surfaces strongly depends on surface roughness and structure. TNO has demonstrated that best cleanability of stainless steel does not only depend on Ra, but also on surface structure (Kastelein, TNO 2008). Therefore, control of surface roughness and structure is of utmost importance for parts to be used in the food & drug and semicon industries. This has resulted in considerable demand for inspection systems to measure surface quality.

Currently, advanced surface quality testing equipment in the nanometer range is based on lab microscopic techniques such as coherence scanning microscopy (a comparison of the techniques can be found in the table below). Stylus profiler techniques are relatively inexpensive; however, they typically provide a line-scan information with limited insight in surface structure. Several highly sensitive optical techniques are available, however at a price-range of >50k they are often not affordable for a mechanical workshop, resulting in a shortage of production volume in The Netherlands.

Sioux aims at developing an optical technique for surface roughness measurements of stainless steel and other materials with the following characteristics:

- Non contact
- Measurement of roughness and structure
- Scan area 1 -100 mm2
- Full height map of selected area
- Axial resolution: 0.2 – 2 um
- Lateral resolution 1-5 um
- Market price < 5 k
- Insensitive to ambient temperature, air flow and vibration

Technique	Rough-ness	Structure	Non Contact	Scan	Axial resolution	Lateral resolution	Price (€)
Required	Yes	Yes	Yes	Area	0.2 - 2 um	1 - 5 um	< 5k
Stylus Profiler (e.g Time TR-200)	Yes	Limited	No	Line	0.01 - 40 um (Ra)	2 um	~2k
Phase shift interferometry microscopy	Yes	Yes	Yes	Area	< 1 nm	> 0.5 um	> 50k
Coherence Scanning microscopy (e.g ZYGO ZeGage)	Yes	Yes	Yes	Area	~3 nm	~1 um	> 50k
Confocal Laser scanning Microscopy (e.g Keyence VK-X)	Yes	Yes	Yes	Area	~3 nm	~1 um	> 50k
Focus variation Microscopy (e.g. Burker Alicona InfiniteFocusSL)	Yes	Yes	Yes	Area	~0,1 um	~1um	?
Fiber-based low coherence interferometry (e.g. Novacam 3D optical profiler)	Yes	Yes	Yes	Area	0.5 um	2-20 um	?

Why we need help from the physics community

The envisioned technique faces challenges to cope with vibrations, temperature instability and ambient airflow and therefore is a multi-physics problem. Our own Physics and Optics department has limited expertise in surface roughness measurement. We would like to build this expertise in collaboration with the academic world and identify a good concept solution. Additionally, Sioux would like to intensify the relation with universities to support the translation of academic research into products.

Relevant physics disciplines

Based on our first hunch we expect that we need help from researchers in the optics domain, especially in the field of (1) techniques that support data rates of optical information like photonics and micro-optics and (2) metrology and 3D reconstruction .

Current situation (graphs, pictures, references etc.)

In general measurement of surface roughness characterization of even a small surface involves massive data acquisition, 10^8 data points and more are common. Regular techniques fix the position between sensor and object during the scanning of the surface. To do so a vibration free and temperature-controlled lab environment is required.

Possible solutions or directions toward solutions to the problem

We have a gut-feeling that micro/nano-optics and photonics may provide an interesting direction. Our rationale:

- Photonics can speed up data acquisition, resulting in ‘freezing’ a system in time
- Sensor miniaturization can offer high mechanical eigen frequencies with very low amplitude

Boundary conditions (e.g. technical, organizational, or budgetary requirements).

Boundary conditions include:

- 3D surface mapping of reasonably clean surfaces with low surface roughness
- Reliable and robust solution for usage in mechanical workshop
- Small tool in comparison with workpiece size
- Surface characterization within 15 seconds
- Production cost in order of max €1500