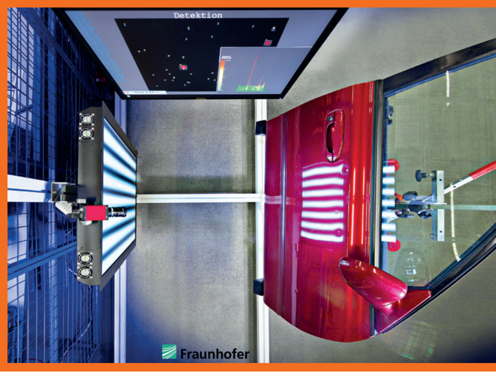
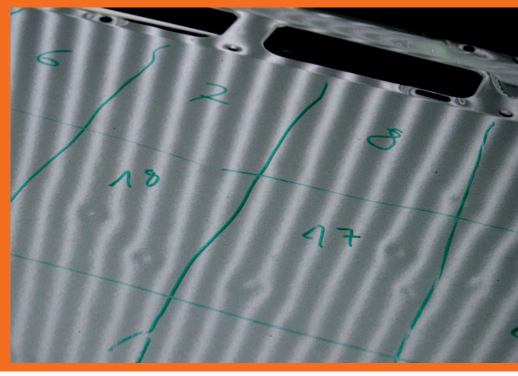
Fraunhofer IOSB

FRAUNHOFER INSTITUTE OF OPTRONICS, SYSTEM TECHNOLOGIES AND IMAGE EXPLOITATION IOSB





Brilliant Insights – Deflectometry for the inspection of (partially) specular surfaces

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

Fraunhoferstrasse 1
76131 Karlsruhe

Contact
Systems for Measurement, Control and Diagnosis

Dr. Jan Burke
Phone +49 721 6091-316
jan.burke@iosb.fraunhofer.de

Dr. Sebastian Höfer
Phone+49 721 6091-436
sebastian.hoefer@iosb-extern.fraunhofer.de

www.iosb.fraunhofer.de

For surfaces used in the manufacturing industry or surfaces that just need to look "nice", such as car body components, specular (directional) reflection often plays a critical role. However, in practice, the inspection of specular surfaces poses special challenges. On the one hand, most established surface inspection methods, such as fringe projection, rely on diffuse reflection. On the other hand, the results of such methods cannot simply be used for the assessment of specular surfaces without additional effort, because the customer assesses the quality on the basis of specular reflections of the environment by the surface inspected. Deflectometry closes this gap in inspection and measurement technology and offers the option of defining and monitoring objective quality criteria with simple means.

In general, the term *deflectometry* refers to all procedures used to acquire topographical information on specular surfaces by the automatic analysis of reflections of known scenes (see Figure 1). Conclusions about the topography of the surface can be drawn from the deformations of the reflected pattern.

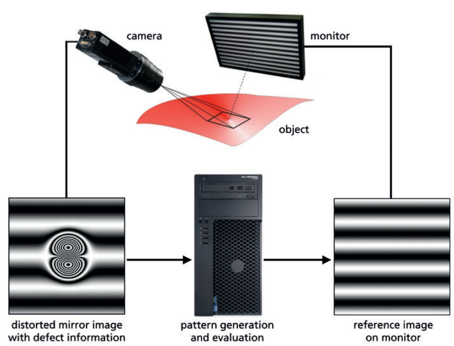


Fig. 1: Principle of deflectometry.

Figure 2 shows a simple measurement set-up, consisting of a monitor and a camera. For inspection, the test object is positioned such that its entire surface appears covered with fringes as viewed by the camera.

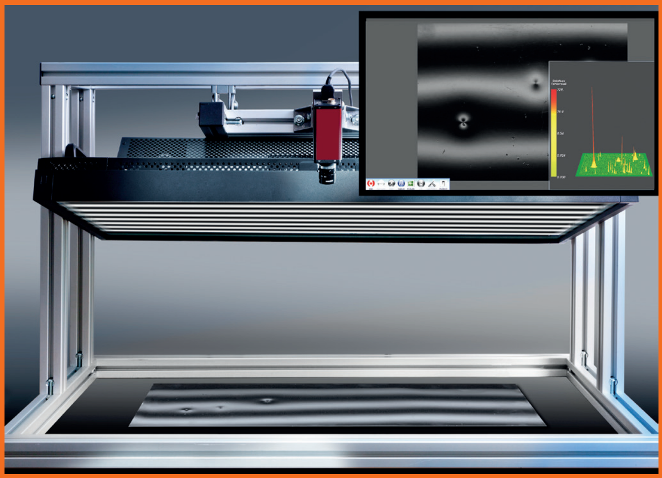


Fig. 2: Measurement set-up for deflectometric inspection.

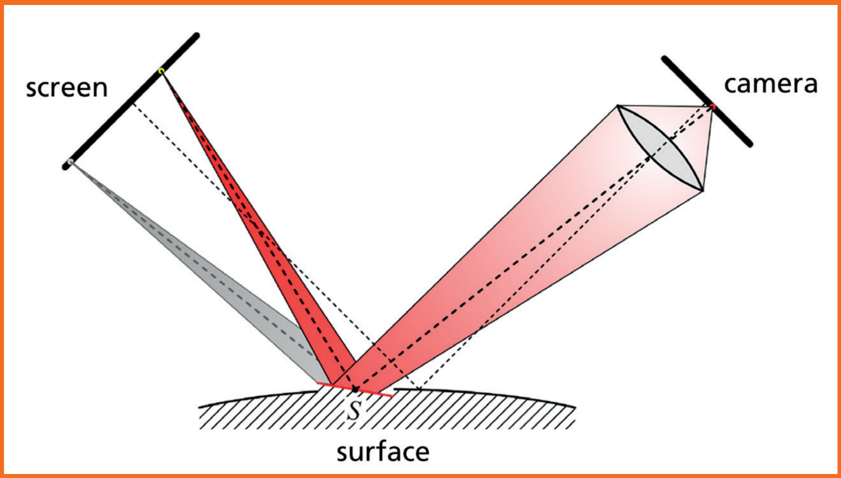


Fig. 3: Deflectometric measurement principle: the slope of a surface element S causes shifts and distortions of the observed test patterns.

Deflectometry is fundamentally different from fringe projection, where a projector illuminates the test object with a structure and a camera observes it from an angle, so that the shifts and/or distortions of the pattern encode the height of the surface.

In deflectometry, the surface to be inspected is used as a mirror for a self-luminous or illuminated reference pattern, and the distortions observed are a consequence of irregularities of the specular surface. Figure 3 clarifies this principle: when the slope of a surface element changes, the camera "sees" a different portion of the reference screen at the same pixel position, i.e. the pattern has shifted/distorted.

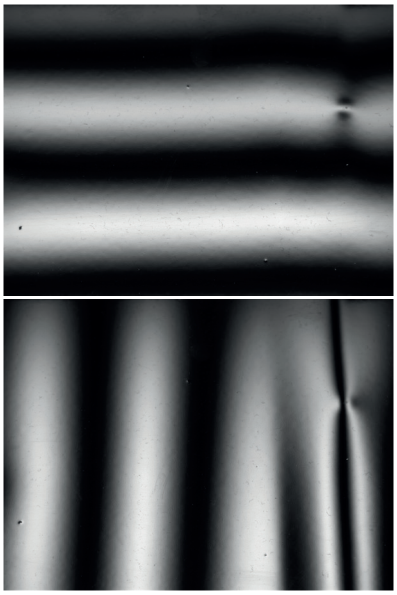


Fig. 4: Examples of slope measurements in vertical and horizontal directions. In addition to round defects that are visible in both fringe sequences, the measured metal sheet has vertical kinks that only become detectable with a vertical reference pattern.

By displaying, recording and processing of custom pattern sequences, it is possible to measure angle changes of a few millidegrees reliably. This means that even a simple and compact deflectometric set-up outperforms the human eye significantly, and is therefore excellently suited as a system for automatic and objective surface inspection.

For complete acquisition of the surface structure, the slopes in both the horizontal and vertical directions must be measured; mathematically speaking, these are the partial directional derivatives. Therefore, a deflectometric measurement is mostly carried out with two pattern sequences, one with vertical and the other with horizontal fringes. Figure 4 shows an example for the interplay of the two measurements to detect slope structures in any direction.

The combined slope information allows the calculation of the surface curvature. This quantity is equivalent to the rate of slope changes. It is a very good indicator for the detection of surface features such as bumps or dents that the human eye perceives as blemishes. The curvature map shown in Figure 5 is an example of the information that can be obtained from the combined slope data.

Even the apparent "noise" in the centre of the image holds information: the so-called "orange peel" is a waviness of the surface, and deflectometric data can contribute vitally to adjust this waviness to the desired level. Since the deflectometric technique always produces two-dimensional data, such structures can also be analysed for their direction and wavelength.

The procedures for deflectometric inspection of specular and partially specular surfaces offered by Fraunhofer IOSB are suitable for a wide variety of tasks in industrial quality control. Thus, an optical inline measurement method is available for such surfaces for the first time. It complements conventional approaches of qualitative inspection with a quantitative measurement approach and enables robust recognition and assessment of defects.

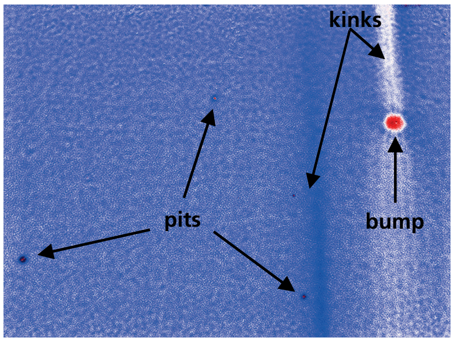


Fig. 5: Result of curvature calculation based on sequences of fringe images as in Figure 4.