FRAUNHOFER INSTITUTE OF OPTRONICS, SYSTEM TECHNOLOGIES AND IMAGE EXPLOITATION IOSB

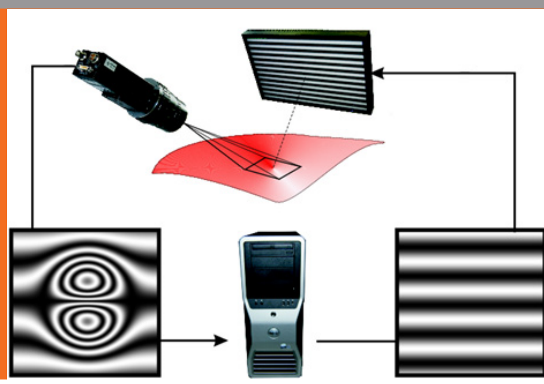

Fig. 1: Deflectometric inspection principle.

Brilliant Insights – Deflectometry for the inspection of specular surfaces

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For surfaces used in the manufacturing industry or surfaces which just need to look good, such as, e.g., car body components, specular (directional) reflection often plays a critical role. However, in practice, the inspection of specular surfaces imposes special challenges. For one thing, most established surface inspection methods such as stripes projection depend on diffuse reflection. And for another thing, 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 in the surface. Deflectometry closes this gap in inspection and measurement technology. In this context, Fraunhofer IOSB offers solutions especially for the quantitative inspection of specular surfaces.

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 Fig. 1).

Conclusions about the topography of the surface can be drawn from the deformations in the reflections.

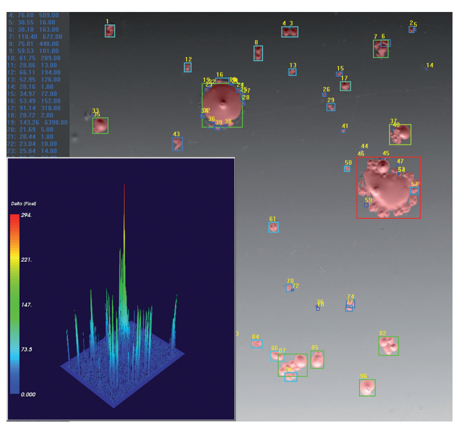
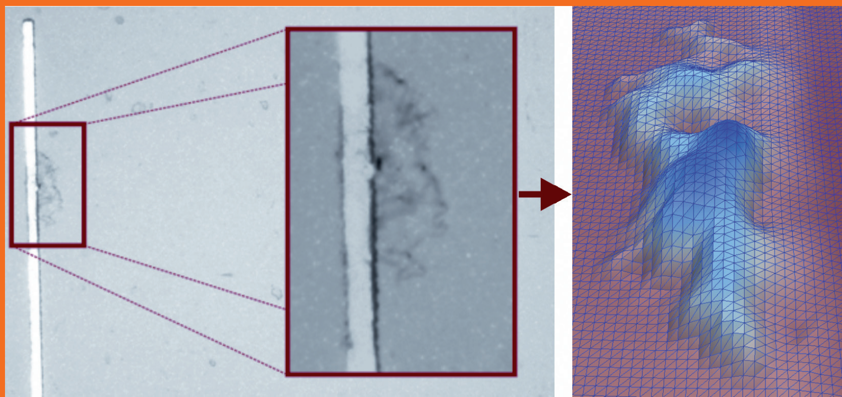


Fig. 2: Inspection of a coated surface: defects of different size and shape are detected and assessed.



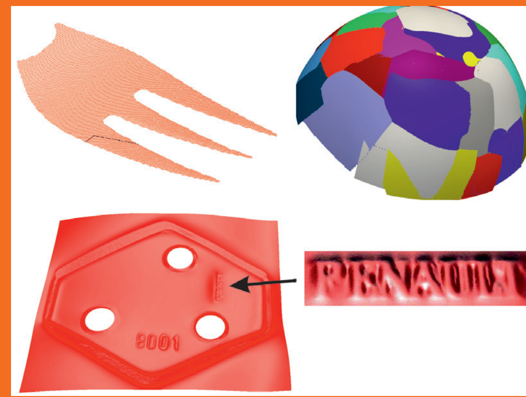


Fig. 3: Reconstruction for the measurement of local coating defects.
Fig. 4: Combined reconstruction consisting of several deflectometric reconstructions.

Deflectometric approaches can be classified according to the additional knowledge used:

a) In the simplest case, the camera observes a reflection of a previously known single pattern. The subsequent analysis classifies the results as »ok« or »not ok« by direct comparison with the nominal surface quality.

b) By coding every single point of the pattern e.g. by means of an image series it is possible to create what is known as a deflectometric registration of the monitor positions in relation to the individual observation rays. This approach makes qualitative surface inspection possible by applying »conventional« image processing methods on the deflectometric registration.

As an example, Fig. 2 shows the analysis of curvature equivalent features of spatial defects on coated metal surfaces. It is easy to identify the excellent signal-to-noise ratio of these feature images (illustrated as a 3-D profile). This methodology is especially suitable for the fast and reliable inspection of coated metal sheets.

If, in a further step, a system calibration as well as at least one surface point is known, a complete reconstruction of the specular surface can be accomplished. From a mathematical point of view, this reconstruction is equivalent to the solution of a non-linear partial differential equation, for which several reconstruction approaches exist. The solution to this reconstruction problem is the precondition for using deflectometry to measure specular surfaces. Such reconstruction approaches have been developed at Fraunhofer IOSB.

In consequence, two possible applications emerge: the measurement of local topographical defects and the generation of 3-D models of large objects with complex shapes. In so doing it is easily possible to achieve a height resolution for topographical structures to an accuracy of few µm.

The Figures 3 and 4 show examples for both strategies. Used in this way, deflectometry becomes a measurement system for specular surfaces which permits the quantitative assessment of undulations or local defects for example.

As they occur in industry, objects are often large or with complex shapes. In order to inspect their entire surface, they are tiled into measurement patches. The individual measurements acquired can then be combined to form a complete reconstruction of the surface. An industrial robot is used for the mechanical positioning of the sensor head which consists of a screen in combination with a camera (see Fig. 5).

In summary, the approaches and solutions for the deflectometric inspection of specular and partially specular surfaces achieved by Fraunhofer IOSB show that deflectometry is now suitable for applications in industrial quality inspection. For the first time, an optical inline measuring method is available for such surfaces. It complements conventional approaches to qualitative inspection with a quantitative measurement approach and enables robust recognition and assessment of defects.

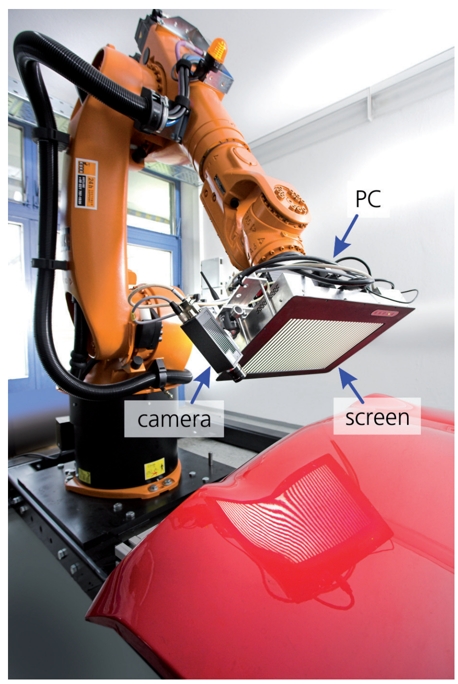


Fig. 5: Deflectometric inspection system for the inspection of large objects.