



1 True process optimization requires traceability over the entire value chain. This also applies to mass-produced parts.

2 A novel track & trace procedure relies on the individual surface microstructure as marker.



## TRACK & TRACE WITHOUT MARKERS

### Tracking components down to the last screw

Traceability turns out to be one of the cornerstones of digitalized production – and a major prerequisite for sustainable production and perfect documentation. Only unambiguous identification enables data acquired during the production process to be attributed to individual components or semi-finished products. An innovative track & trace procedure for mass-produced parts by Fraunhofer IPM generates an individual signature on the basis of a component's individual surface microstructure, with no need for additional markers.

### Consistency in digitized production

The quality of complex industrial products may depend on the quality of each and every component. For example, a single

faulty connector, even if it is worth only a few cents, may impair the performance and durability of a complex electronic control box in a car. As a consequence, if an assembled component fails its performance test, all the semi-finished parts already fitted are »guilty by association« and the entire potentially defective batch is rejected. This results in companies incurring high costs, often without learning any lessons for the future. The aim must therefore be to provide even the smallest of components and semi-finished products with a signature so that they can be traced along the production chain, preferably from the outset. This is the only way of ensuring that in-process inspection systems are capable of detecting and permanently rectifying recurring production errors. Seamless traceability by far exceeds the boundaries of a company's own production and enables to identify sources of error during production along the entire supply chain.

### Fraunhofer Institute for Physical Measurement Techniques IPM

Heidenhofstrasse 8  
D-79110 Freiburg, Germany

#### Contact

Andreas Hofmann  
Business Development Manager  
Production Control  
Phone +49 761 8857-136  
andreas.hofmann@ipm.fraunhofer.de

[www.ipm.fraunhofer.de](http://www.ipm.fraunhofer.de)



3

4



### Traceability at reasonable cost

There is one thing that the process of tracing mass-produced parts must not be: expensive. Many established marking methods fail at this first hurdle because they require additional costly production steps such as labelling with RFID or data matrix codes. By making use of the existing individual surface structure, the track & trace procedure developed by Fraunhofer IPM does not incur additional costs per unit and does not affect any component functions. It is not wise for manufacturers to engrave serial numbers on sealing surfaces or place barcodes on decorative items. Furthermore, while some components are simply too small to be marked, those that can be are at risk of having their markers counterfeited. None of these problems apply to the label-free tracking method developed by Fraunhofer IPM, because it makes use of the existing surface structure of components.

### Even mass-produced parts are unique

Viewed under a microscope, almost all technical surfaces reveal incidental characteristics like microstructures or interwoven colors that clearly identify the component in question. The sensor system uses a specially developed optical reader to take high-resolution images of defined areas on the component's surface. The specific structural patterns captured by the image and the way in which they are positioned

relative to each other is used to generate a numerical identification code, which is then stored in a database, combined with an ID. This entire process can be repeated to identify the component at a later date by taking an image of the very same component area and generating a new code. If matching this code to the existing database entries generates a match, the component is clearly identified by the respective ID. The sensor has been designed to enable a wide range of materials, from plastics to precision-machined aluminum, cast iron and varnished surfaces, to be identified in line with the rate of production using the same hardware.

### Identification without delay

Tracking components during production must not delay the production process. The label-free track & trace system by Fraunhofer IPM relies on a fast camera-based sensor system which records high resolution images of the surface microstructure with a CMOS image sensor. Based on these images, a component signature of each individual component is generated by means of a special algorithm. Reducing the image data to a simple bit sequence with low memory capacity need enables data matching in line with the rate of production. Tolerances when positioning the components are compensated by software on the basis of suitable geometric reference points. Interfaces to database systems are adapted according to customers' need.

### Perspectives

Consistent traceability without markers throughout the entire production process creates substantial added value. This is especially true for branches like automotive or medical technology where high quality standards prevail. Large amounts of measurement and process data, which can be attributed to individual components, open up the possibility of optimizing production processes.

Label-free tracking procedures are suitable for a broad range of technical surfaces, component size or price not being a limiting factor. Omitting the entire production step of labelling the components saves energy and material. Correlating data from the first production step until product recycling eventually helps to establish an effective product life cycle management.

**3** Even surfaces of very small punched parts can be used for label-free component identification.

**4** Characteristic incidental micro structures identify each individual part. As part of the label-free track & trace procedure, they are reduced to a simple bit sequence.