< Functional coatings, which are sometimes just a few nanometers thick, must be homogeneous and complete. ANALIZEsingle measures the layer thickness, elemental composition and elemental distribution during the coating process.

GROUP **OPTICAL SURFACE ANALYTICS**

Inline checks on thin coatings

Functional coatings are often applied to industrially manufactured components to protect against corrosion, to give them special finishes or as surfacers. These coatings need to fulfill stringent quality specifications if the components are later to be used in high-tech products. The ANALIZEsingle optical measurement system is the first of its kind to monitor the integrity, layer thickness, and elemental distribution of coatings during production.

Anyone who has ever painted a window frame will understand the difficulty involved in covering surfaces with a flawless coating. This becomes infinitely more difficult when applying coatings as thin as just a few nanometers onto components with highly complex shapes. A variety of techniques are employed to do this, such as sputtering, electroplating, and precipitation reactions using spray or immersion coating processes. Faults in the coating process are not simply an aesthetic problem, however. Coatings that are incomplete or not homogeneous may subsequently impair the functionality and quality of the entire end product. If we consider faulty coatings intended to protect against corrosion, or incomplete coatings of surfacers intended to ensure durable adhesion of paint onto car bodies, the logic of this becomes immediately clear. Yet it also holds true for coated electronic components, where wafer-thin layers of copper are employed for thermal conduction or contacting, since substandard coatings here may cause the components to fail.

As it is not always possible to reliably achieve a homogeneous application of coatings, the ability to continuously measure layer thickness is extremely beneficial for process monitoring and quality assurance. Popular techniques for determining elemental composition, such as X-ray fluorescence (XRF), energy-dispersive X-ray spectroscopy (EDS), glow discharge optical emission spectroscopy (GDOES), secondary ion mass spectrometry (SIMS), and X-ray photoelectron spectroscopy (XPS), are not suitable for use during the production process and also have limitations in terms of the elements which they can detect. Only X-ray fluorescence is suited to use on production lines. However, extremely thin layers, such as corrosion protection coatings measuring just a few nanometers, cannot be detected on the production line.

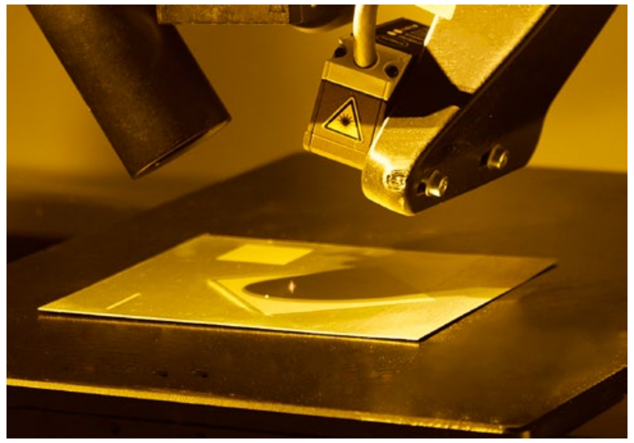
Material plasma gives insights into elemental composition and distribution as well as layer thickness

The ANALIZEsingle coating thickness measurement system has made it possible, for the first time, to perform spatially resolved measurements of chemical element distribution on component surfaces during production. This elemental analysis allows the thickness of nanometer-range coatings to be determined with an accuracy of ±10 percent. In order to determine the coating thickness at a given measurement point, a special form of laser-induced breakdown spectroscopy is used. All that this requires is a single laser pulse, which ablates material from both the coating and the component surface. The emission spectrum characteristics of the coating and component materials are then compared with one another, making it possible to calculate the coating thickness. At the same time, the spectrum provides information on the mixing ratio of the coating components, which allows checks to be performed on the homogeneity of the coating compositions. The spectrum is analyzed immediately after the measurement is performed, allowing the coating process parameters to be not only monitored, but also quickly readjusted if necessary.

Layer thickness determined in under a second

The ANALIZEsingle is positioned within the production line such that the sheet metal is fed around a deflection roller at the measurement spot. To enable more extensive measurement across flat surfaces, the intention is to further develop the measurement head so that it can be moved over the entire width of the production line. In the inline system, the number of measurement points per surface area is given by the repetition rate of the laser, of up to 100 pulses per second, and the feed rate of the conveyor, in the order of magnitude of a few meters per second. For example, 50 measurement points per meter are possible with a speed of two meters per second. Since small-scale differences in coating thickness are not always important, it is possible to perform averaging across several measurement points.
Even when this is done, the coating thickness is still determined in under a second. Measurement data are automatically saved and can be used as control parameters as well as to enable cross-process optimizations for the purposes of data collection in line with Industry 4.0 specifications.

LASER-INDUCED BREAKDOWN SPECTROSCOPY (LIBS): A short-pulse laser ablates just a few cubic micrometers of material from a surface. This material forms a mixture of charged particles, called a plasma, which emits a material-specific light spectrum, similar to a spark. Spectral analysis of the emitted radiation enables the elemental distribution of the ablated material to be determined. The tiny amount of material removed is not critical for the vast majority of applications. In exceptional cases, for example when coating extremely smooth surfaces, measurements can be performed in less significant areas such as on cutting edges.



Controlled material ablation via laser pulse is a prerequisite for high repeatability. Short-pulse lasers with high levels of pulse-to-pulse stability are employed.

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