Fraunhofer IPM

Film-Inspect
Inline quality assurance of barrier layers

The Film-Inspect sensor ensures the quality of plasma coatings even on uneven surfaces in production. The sensor head is as small as a USB power supply unit.

100 percent inspection of ultrathin coatings

Ultrathin plasma coatings are increasingly applied to packaging materials as diffusion barriers. These coatings are more sustainable and cost-effective than conventional polymer composite materials. Correct application of the plasma coating, which is only 10 nanometers thick, is crucial in ensuring its barrier function. The Film-Inspect optical sensor inspects the quality of plasma coatings in the production line.

Inspection during production

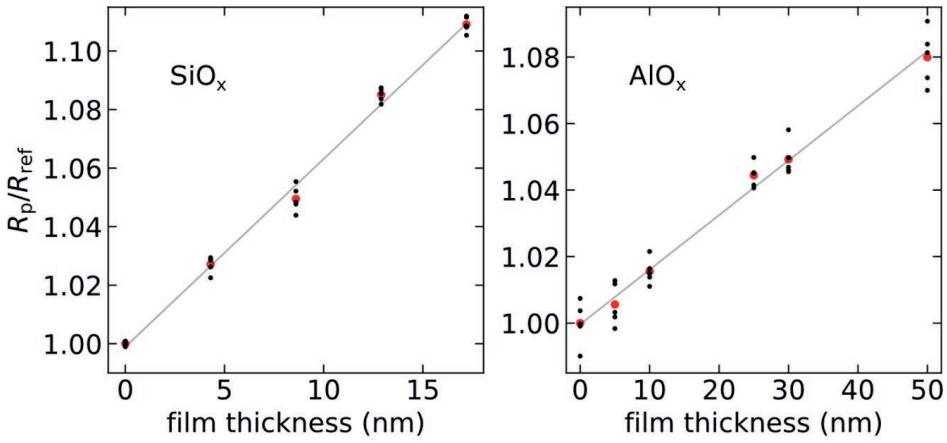
Despite enormous price pressure, food packaging is subject to stringent technical requirements. It must provide a good barrier against gas and water vapor diffusion while also being easily recyclable, not least in view of ever stricter legal requirements. Plasma coatings made of silicon oxide or aluminum oxide meet both requirements, provided they are applied accurately. Testing the quality of such layers is challenging because they are optically transparent and only 10 to 20 nm thick. Conventional sensing methods such as interferometry, ellipsometry or X-ray fluorescence fail when measuring ultrathin coatings on plastic packaging in a production environment.

Compact sensor, short measuring time

This is where the optical sensor Film-Inspect comes in: Film-Inspect measures the coating based on its specific infrared signature at a suitable wavelength of around 10 µm (Fig. 2): The chemical bond between atoms (e. g. the Si-O bond) can be excited resonantly by infrared light of the appropriate wavelength. The change in reflectivity that is caused by this effect is proportional to the layer thickness (Fig. 1). This measurement is carried out in just 0.2 seconds with an accuracy of up to ±1 nm (2σ, twice the standard deviation). The sensor head is no larger than a small USB power supply (20 × 40 × 80 mm³). This makes the Film-Inspect sensor significantly more compact

Technical data

- **Measurable materials** e.g. SiO_x, AlO_x, Si_3N_4
- **Measuring range (for SiO_x)** 0 to 200 nm
- **Measuring uncertainty** up to ± 1 nm (depending on the material composition)
- **Time per data point** 200 ms
- **Spot size** approx. 5 mm
- **Dimensions of sensor** 20 × 40 × 80 mm³
- **Working distance** 5 bis 10 mm
- **System integration** via Profinet and OPC-UA
- **Stand-alone application** incl. PC



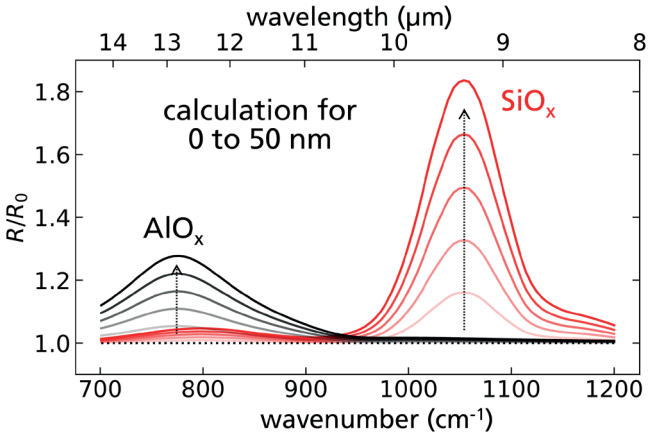
(2) Measured infrared signals for different coating thicknesses of silicon oxide (SiO_x, left) and aluminum oxide (AlO_x, right). The black dots indicate individual measurements. Average values are depicted in red.

and faster than typical infrared spectrometers (FTIR), which are at least the size of a desktop PC and typically require several seconds for a measurement.

Parallel implementation of multiple sensors

The sensor head is based on low-priced components, so that the parallel use of multiple Film-Inspect sensors is possible with no economic issues. The sensor electronics and software are designed precisely for this purpose. For example, up to eight sensors can be operated on a shared controller. Standardized interfaces such as Profinet and OPC-UA are available for communication. They allow the sensors to be integrated into an Industry 4.0 environment. For simpler applications with single sensors, a USB interface and evaluation software are available. Inline measurement of the layer thickness by means of Film-Inspect can be used to adjust the coating process. In addition, packaging material manufacturers may provide the data to customers as proof of quality.

Measurements can be taken on plane, but also on textured and curved surfaces as well as on moving objects. Apart from the inspection of plastic packaging, Film-Inspect also lends itself to the testing of comparable coatings that are used, for example, as corrosion protection on metals, to reduce friction on technical components or to optimize surface chemistry. New options for verifying the quality of coatings also enable manufacturers to tap into highly regulated markets such as medical technology or aerospace thanks to Film-Inspect.



(1) Calculated thin-film reflectance of silicon oxide (SiO_x, red) and aluminum oxide (AlO_x, black) on a polymer substrate, normalized to the plain substrate. The curves show increasing reflectivity with increasing film thicknesses of 10, 20, 30, 40 and 50 nm.

Contact

Dr. Alexander Blättermann
Group Manager Optical Surface Analytics
Phone +49 761 8857-249
alexander.blaettermann@ipm.fraunhofer.de

Dr. Benedikt Hauer
Project Manager
Phone +49 761 8857-516
benedikt.hauer@ipm.fraunhofer.de

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-Köhler-Allee 301
79110 Freiburg, Germany
www.ipm.fraunhofer.de/en