ESCORT SM OEM-SPECTROPHOTOMETER:
HIGH-PRECISION CONTROL AND OPTIMIZATION OF THIN-FILM OPTICAL COATING APPLICATION

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High-precision monitoring of optical thickness for each layer is necessary while applying modern thin-film optical coating with the number of layers up to several hundreds. It is also important to have a tool to control application process in order to obtain layer thickness corresponding to design value. Authors offer to solve the problem connected with monitoring and control of applying thin-film coatings using ESCORT SM precision OEM spectrophotometer. ESCORT SM OEM spectrophotometer provides a reliable support for the processes of optical coating application by quick and precise measurement of transmission or reflection spectra for the coating being applied, which are necessary to control and optimize the process.

Today, two types of measurement systems are used for optical control and monitoring of technological processes used to apply optical coatings. The first type is based on monochromators, when the measurement is carried out using a single wavelength (single-wave monitoring and control). The second type is based on spectrometers used for measuring the whole spectrum within required spectrum range (multi-wave monitoring and control).

ESCORT SM OEM-spectrophotometer offers complex technical solution based on two measurement channels – single-wave and multi-wave, which operate simultaneously and synchronously, with the possibility of both internal synchronization and external one that may be governed by the vacuum plant.

For high-precision monitoring and control of optical thin-film coating application, it is necessary to solve several measurement problems connected

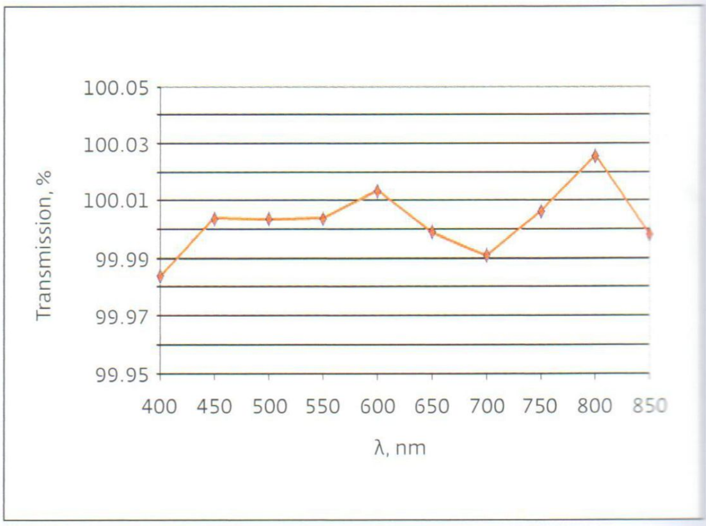

Fig.1. Photometric precision of a single-wave channel while measuring a base line (average value by 10 measurements). Single measurement time is 40 ms

Metrological characteristics of ESCORT SM OEM-spectrophotometer

Parameter	Value	
	Measurement channel	
	multi-wave	single-wave
Spectral instrument	Spectrograph	Monochromator with double dispersion
Focal distance of the spectral instrument	125 mm	225 mm
Spectral range	380–1100 nm	380–850 nm
Spectral slits	Fixed slits of 0.04 mm thick	Variable slits with thickness 0.2–2 mm
Spectral range being selected	1.35–3.4 nm	0.3–3 nm
Minimum measurement time	2 ms/spectrum	2 ms/point
Minimum pitch of spectral scanning	0.37 nm/pixel	0.1 nm
Absolute error of wavelength setting	±0.4 nm	±0.2 nm
Repeatability of wavelength setting	±0.2 nm	±0.1 nm
Interfering irradiation level	0.1% (λ = 450 nm)	0.005% (λ = 400 nm)
Photoelectric noise	±0,07%	±0,015%
Photometric accuracy	±0,5%	±0,2%
Photoelectric repeatability (precision, repeating accuracy)	±0,15%	±0,05%
Radiation detectors	CCD array	Photo-electronic multiplier
Irradiation input into spectral instrument	Optical fiber	
Synchronization type	External, internal	
Ports for connecting additional external devices	Ethernet, USB, RS 232, VGA	
Dimensions	483×600×177 mm	
Weight	25 kg	
Energy consumption	100–240 V, 50–60 Hz, 100 V·A	

with this process. The main measurement problem may be formulated in such a way: measurement precision and repeatability required for control of the deposition process should be enough to obtain designed coating after finishing the deposition process. The second important task involves the need to measure preset value of regular-transmission factor or specular reflection factor, which is an important parameter responsible for the final product quality. Solving of this problem will allow controlling the application process most precisely in order to obtain parts with claimed properties. The third measurement problem is to obtain the measured spectra with their connection with the actual deposition time in order to define the exact time for application finishing.

These problems are solved using ESCORT SM OEM-spectrophotometer integrated into hardware and

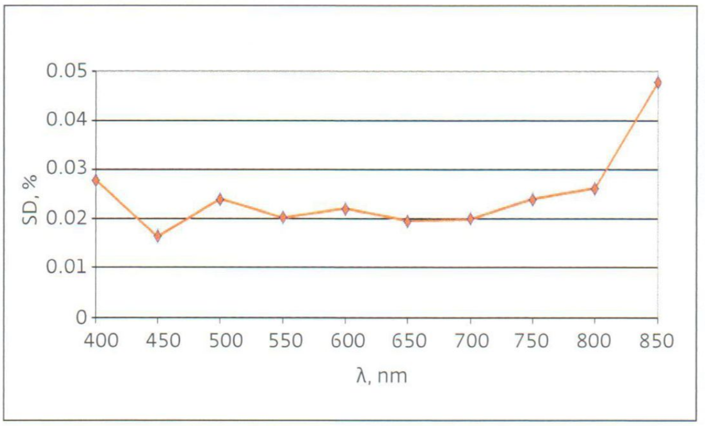

Fig.2. Photometric repeatability (RMS) of a single-wave channel while measuring a base line (average value by 10 measurements). Single measurement time is 40 ms

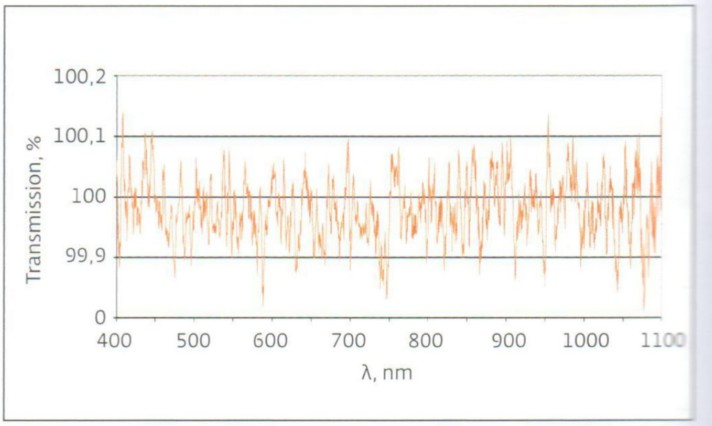

Fig.3. Noise at multi-wave channel during single measurement of abase line during 40 ms

software system "Vacuum plant for applying optical coatings".

While measuring spectra, absolute error and reproducibility of measurement results for ESCORT SM OEM-spectrophotometer is comparable with one of stationary laboratory Hi-End spectrophotometers. At the same time, high accuracy is achieved within several milliseconds allowing to obtain coating spectra directly during its deposition, particularly, for the substrate installed in the vacuum chamber drum and rotating with high speed.

Construction of the measuring circuit both for single- and multi-wave channels in ESCORT SM OEM-spectrophotometer is based on measurement of the absolute value for the required parameter allowing its monitoring and control directly using design coating data. Most modern single-wave control systems are based on measurement of the time-varying signal; so you can monitor and control application of coating layers only with optical thickness, which is divisible by one fourth of the monochromator tuning wavelength selected for monitoring.

Hardware synchronization in ESCORT SM OEM spectrophotometer of the measured spectrum with a timing diagram of the vacuum unit allows to accurately calculate the time until the end of layer application and to get the layers with thickness different from the calculated value within the absolute measurement error. Table 1 contains basic metrological characteristics of ESCORT SM OEM spectrophotometer.

Figures 1-7 show examples demonstrating measurement precision made using ESCORT SM OEM-spectrophotometer.

High precision of the one-wave measurement channel permits to make measure preliminary deposition process for each material in order to define characteristics of this material being deposited in particular vacuum chamber. One-wave channel may be also used for traditional

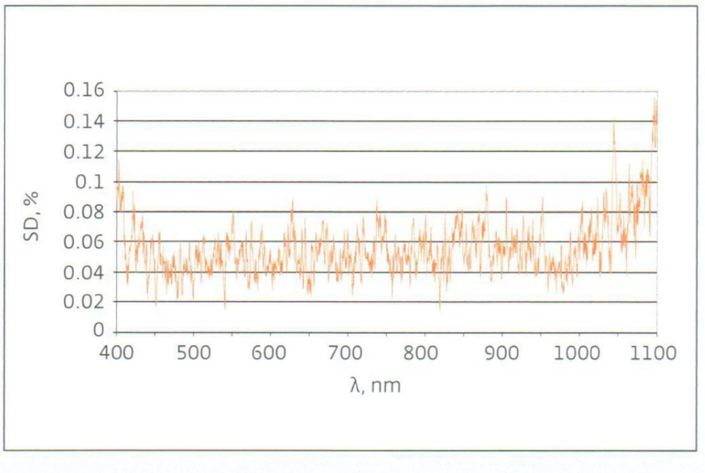

Fig.4. RMS from 10 measurements for each CCD pixel of the multi-wave channel while measuring a base line

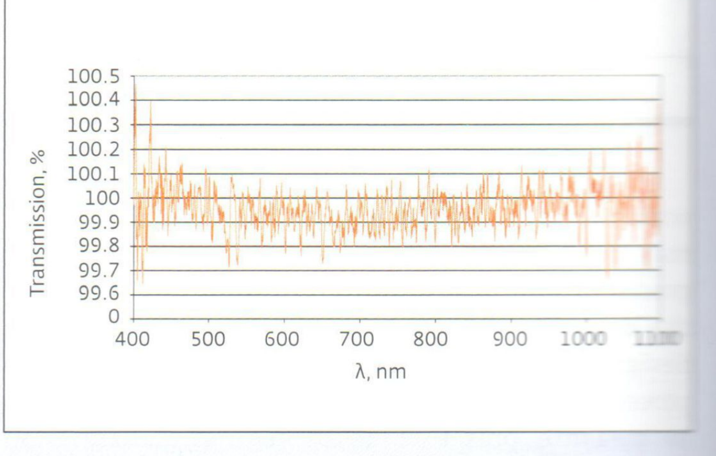

Fig.5. Photometric noise of the multi-wave channel across spectrum while measuring a substrate

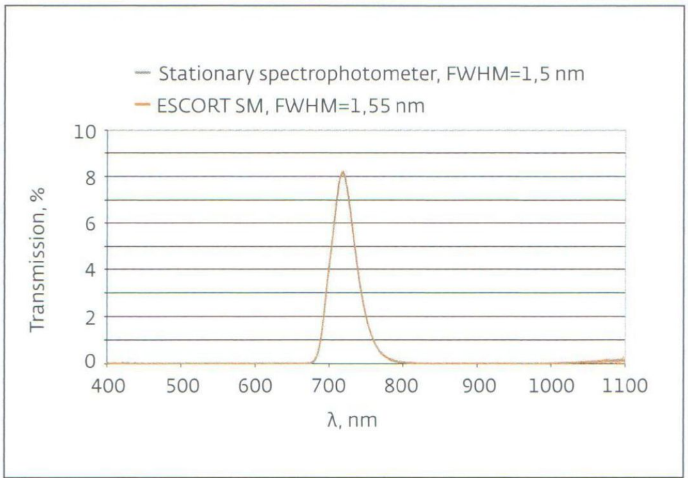

Fig.6. Transmission spectrum of UFS2 optical filter of 3 mm thick measured using stationary spectrophotometer MC 122 and using multi-wave channel of ESCORT SM OEM-spectrophotometer

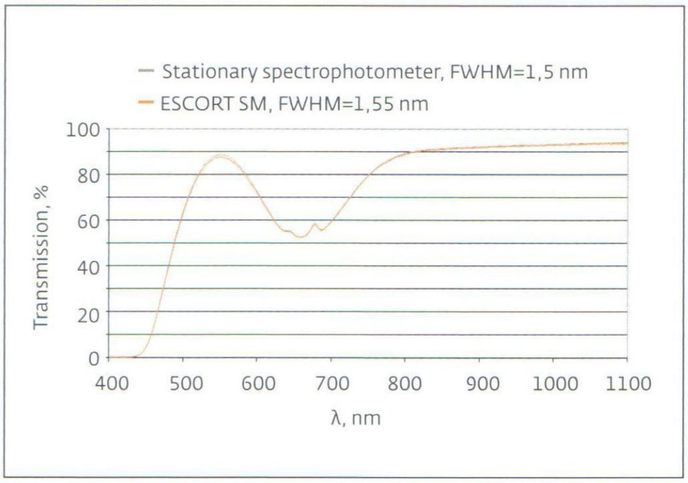

Fig.7. Transmission spectrum of GZS6 optical filter of 2 mm thick measured using stationary spectrophotometer MC 122 and using multi-wave channel of ESCORT SM OEM-spectrophotometer

control and monitoring algorithms at a selected wavelength.

There are following conditions for the measurement illustrated in Fig.5: the base line is the average value of 15 measurements made for the substrate. Measurements were made during tests using the vacuum chamber with optical channel length approximately 1800 mm. Measurement circuit with the base line measured at rotating substrate (substrate pass through the optic channel) ensures the least absolute error while measuring spectra of the optical coating applied then on the substrate.

Vacuum chamber, which is used as the basis of the complex for automated application of complex optic coatings, should have parameters and design able to apply coatings with stable parameters to obtain steady control of the deposition process. Solving the above-mentioned problems for the whole complex on optic coating deposition will allow to implement automated deposition of complex optical coatings without operator's participation during the entire deposition process. α

Toward a Blood Test for Alzheimer's

L.K.Wolf

Doctors might one day be able to predict whether a person will develop Alzheimer's disease with a few milliliters of extracted blood, according to a small study (Nat. Med. 2014, DOI: 10.1038/nm.3466). A team of U.S. clinicians and researchers, led by neurologist Howard J. Federoff of Georgetown University Medical Center, discovered a group of 10 lipids in blood that dip below normal levels years before a person exhibits symptoms such as memory loss.

Alzheimer's, which now afflicts about 5 million people in the U.S., has so far been impervious to drug discovery efforts. Many scientists believe that late-stage clinical trials of experimental compounds have failed because study participants had too much brain cell damage for effective treatment.

As a result, "we want to identify individuals at the earliest stages of disease and intervene then," when therapeutics might protect brain cells, says Mark E. Mapstone, a neuropsychologist at the University of Rochester School of Medicine who helped discover the new set of lipids.

To do so, scientists need techniques for diagnosing people with Alzheimer's before symptoms appear. Some methods are already under development, such as positron emission tomography and cerebrospinal fluid analysis. But a blood test, Mapstone points out, would be a lot simpler and less expensive.

To find biomarkers for a possible blood test, Federoff, Mapstone, and coworkers began their study with about 500 human subjects. Over a five-year period, they periodically drew blood from these people. During the study, 28 subjects went from having healthy brains to exhibiting impaired memory. When the researchers screened blood samples of those patients with mass spectrometry and compared the results to individuals from the study group who were cognitively healthy, they uncovered the 10 predictive lipids. After establishing these biomarkers, the team's mass spec experts analyzed fresh, unmarked blood samples from both subgroups. The researchers identified the patients who would eventually get Alzheimer's with 90% accuracy.

"These findings are really excellent in their predictive power," says Simon Lovestone, a psychiatrist at the University of Oxford. "But it's important to note that the study is relatively preliminary." The results will need to be replicated by other groups with much larger patient populations, he adds. "It's the start, not the end."

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