Flexible Optical Injection Moulding of optoelectronic devices

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Report on functional optical characterization

Work Package 4

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Executive Summary

This report is part of the deliverables of work package 4 Measurement system design, specifications and requirements. This report provides an overview of the functionality features to be analysed on the manufactured component, and the developed methodologies for the complete optical evaluation in an off-line environment.

A complete prototype for optical functionality testing has been developed and is currently working in an off-line environment for the FOT (Fibre Optical Transceiver) component. This system will be complemented with the off-line OCT (Optical Coherence Tomography) system in order to determine what prevents a component from being validated in the optical functionality testing.

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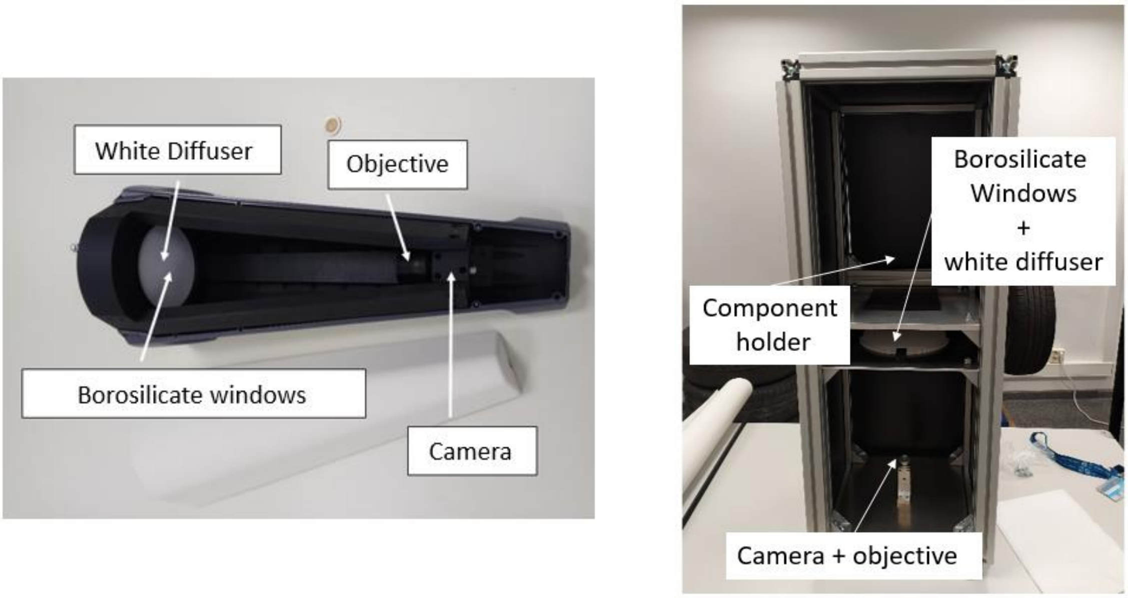
1 Optical functionality system

1.1 Definition

In order to perform the optical functionality testing we have developed a measuring system. Currently, it is already working in an off-line environment in order to set-up the equipment for the in-line environment. This functionality test is based on a go – no go statement that will determine in the pilot line if the component fulfills, or not, the optical requirements established by the end user. In order to evaluate why the component does not fulfill the optical requirements, we will need to resort to the OCT offline test.

The optical functionality test was developed in two different configurations. Figure 1 (a) shows the first prototype which was conceived to have a horizontal configuration. In order to make this prototype more suitable to an industrial environment we updated it to a vertical configuration, as seen in Figure 1 (b).



(a) (b)

Figure 1 (a) Horizontal configuration of the functional offline testing. (b) Vertical configuration of the functional offline testing.

The developed system consists on a diffuser, a camera and a sample holder. It has a strong potential to perform optical functionality testing of an emitting component.

1.2 How it works

The optical functionality test is performed as follows: an emitting component is placed on the component holder and switched on. Then, the diffuser surface is illuminated by the photonic component under test and the camera registers the illumination distribution at the surface plane. The camera is connected to a computer, where the testing software will be run in order to evaluate the validity of the component. An example of the recorded illumination distribution of an emitting FOT component is shown in Figure 2.

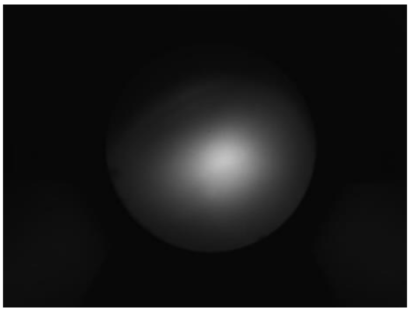


Figure 2 Illumination distribution corresponding to a component to be tested.

Once the recorded illumination distribution is available and loaded to the evaluating software, the validation test is performed in order to determine if the tested component passes the go – no go threshold.

This threshold is set from a comparison of the value between the nominal and the recorded distribution of the value of one of the following parameters:

- Scale value of the image (energy threshold)
- The size of the illuminated area
- The shape of the illuminated area
- Sharpness
- FWHM (Full Width at Half Maximum) from the bright zone

The detailed description of the method is included in deliverable 4.1 in order to protect the confidentiality of the optical functionality test in the current deliverable.

This optical functionality testing is easily adaptable to test any of the three different demonstrators that will be developed in this project.

As commented before, to understand why an emitting component under test does not fulfill the optical requirements when the test result is a no go, it is necessary to resort to the offline test provided by an OCT system.

As it will be detailed in the next section, the OCT system will allow the user to know if the optics of the component are well manufactured or if any connections have been damaged during the manufacturing process.

2 Offline testing

2.1 Description of the method and device

OCT is a non-destructive, non-contact optical measurement technique. It is already well established in the medical field and increasingly gains importance in several industrial applications. The basic measurement principle is sending low coherence light through an interferometer, which has the sample under test at the end of one interferometer arm. Light that is reflected back from various positions along the depth of the sample is analysed and a tomographic depth scan at the present sample position can be calculated. By scanning the beam over the sample, a 3D-volume can be imaged. Figure 3a shows the basic principle of the OCT systems applied in this project (spectral-domain or SD-OCT). This variation of OCT works with a spectrometer, which leads to faster acquisition time and higher signal to noise ratio.

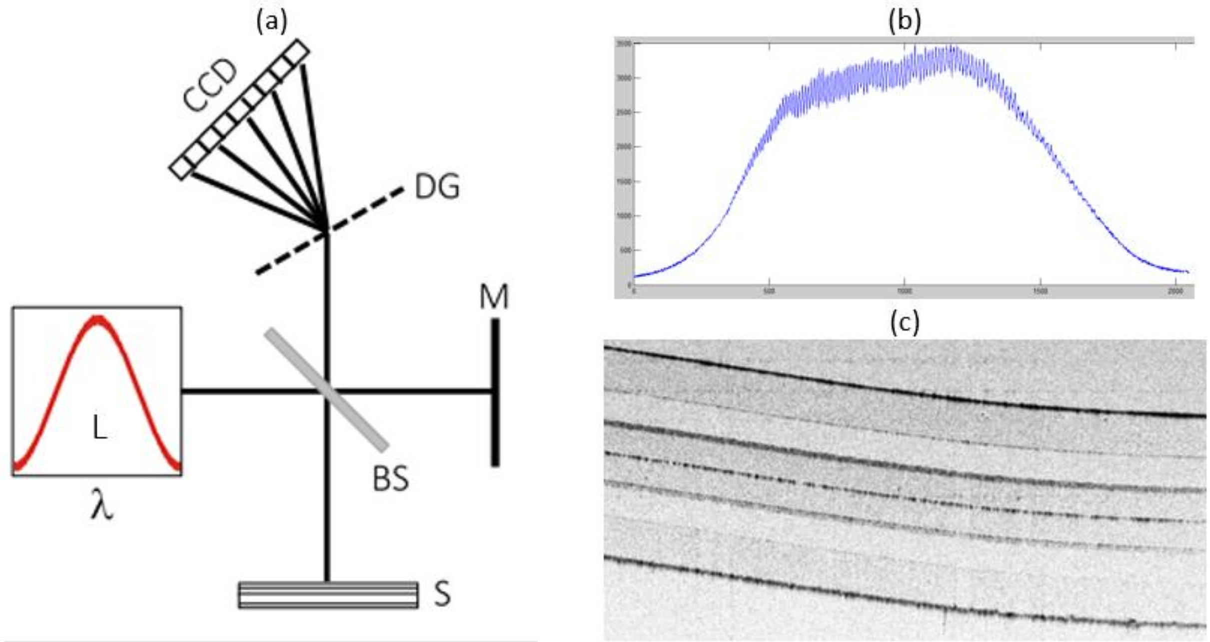


Figure 3: Spectral domain OCT: (a) principle setup: L ... broadband light source, BS ... beamsplitter, S ... sample, M ... reference mirror, DG ... diffraction grating, CCD ... sensor for detecting the interferogram. (b) typical interferogram of an SD-OCT-setup, with wavelength on the x-axis and intensity on the y-axis (all a.u.) used to reconstruct a cross section.(c) Cross section of a multi layer foil reconstructed from the interferogram in (b). The dark horizontal lines mark the positions where light is reflected, hence where there is an interface between two layers of differenz material.

The spectrometer obtains a so called interferogram, which is displayed in Figure 3b. This interferogram is then processed into the spatial dimension, resulting in a depth scan. Several depth scans are then combined to get a cross section of the sample under test. Figure 3c shows a cross section of a multi-layer foil.

The complete OCT measurement system built in this project also comprises all electronic and computer parts necessary for signal processing and control of the whole measurement process. The majority of the components are all built into a 19” housing (Figure 4), which is connected to the probe head (Figure 5) by an optical fiber and electrical cables for the scanning device.

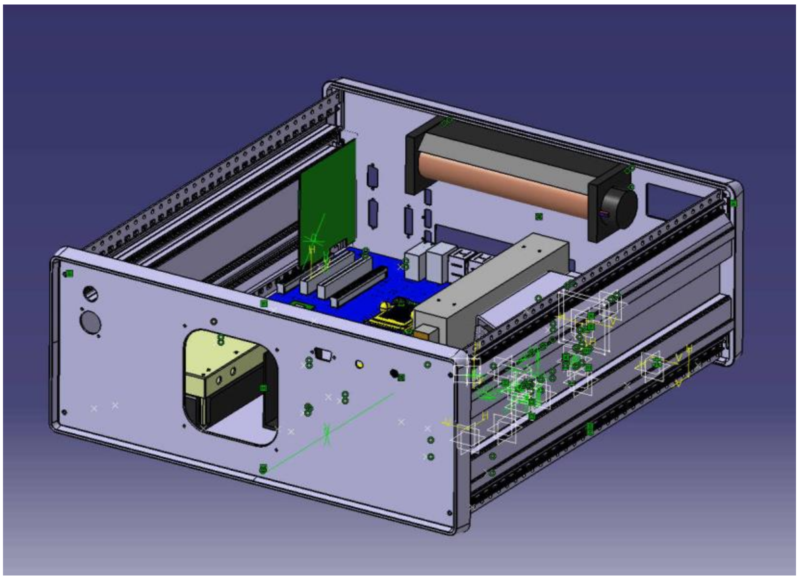


Figure 4. CAD model of OCT components built into a 19" housing.

Figure 5 Single point probe head of an OCT setup. Length is around 15 cm.

2.2 How it works

The light beam is sent through a sapphire glass window directly onto the sample. By raster scanning, the beam 3D data of the sample under test is acquired. This data cube contains information of the internal structure of the sample, as a signal from every interface where the refractive index changes is obtained. Analysing such data allows extraction of useful information on the quality of the over-moulded product. In contrast to functional testing, which only gives a binary information (go – no go), this method can assign a more differentiated quality parameter. This parameter can be used to optimize the moulding parameters.

The whole process can be simplified in the following steps:

1. The 3D area has to be scanned, leading to 3D data cube of subsequent cross section images of the sample under test.

2. The active element and the surface of the injected material have to be found in the earlier measured cross sections. This allows to calculate the displacement of active part versus over-moulded optical component.
3. In addition to the displacement between active part and optical component, the bonding wires can be identified to determine if they were displaced during moulding.

2.3 Advantages and possibilities

With this non-destructive testing approach not only the functionality, but also the structure of the sample can be checked. This helps the user to learn more about why a certain part does not pass the functionality test. Potentially, it can also indicate reduced product quality even when it still passes functionality testing. This allows the operator to adjust moulding parameters to counter act these issues.

Moreover, OCT has the potential to detect even more details of the moulding material, such as heterogeneities, air inclusions, layered structures etc. See Figure 6 for some examples.

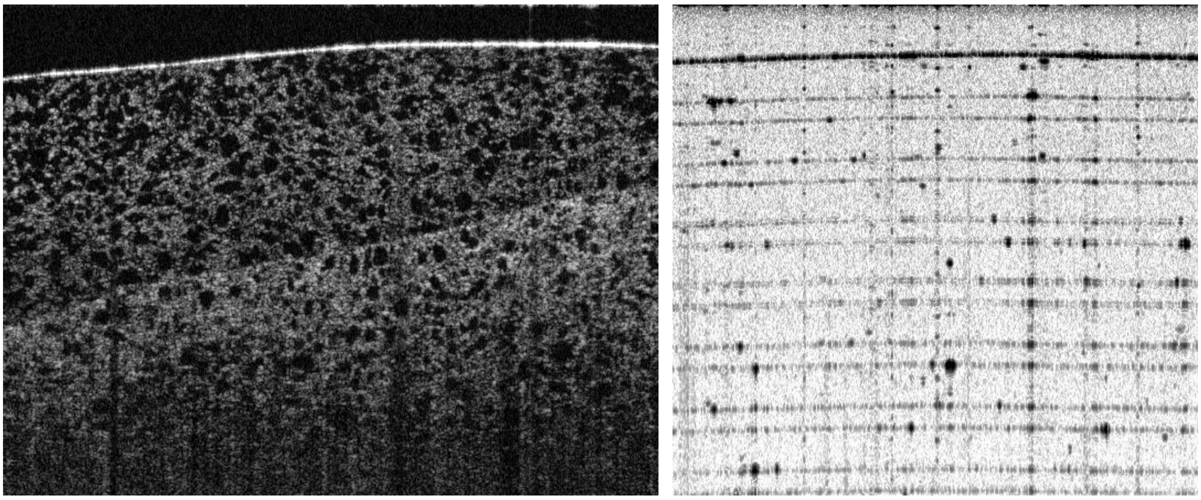


Figure 6 Other examples of typical OCT cross section images. Left: artificial tooth, with porous structure and interface between outer and inner layer. Right: adhesive tape roll, with tape and glue layers alternating in vertical direction.