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Characterization of Side Emitting Polymeric Optical Fibres

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Abstract

The main aim is evaluation of illumination intensity for side emitting plastic optical fibres in dependence on the distance from light source. The special device for measurement of light intensity on surface and cross section at various distances from light source is described. The dependence of surface and cross section light intensity on the distance from light source is expressed by the exponential type model with two parameters; it is illumination intensity in the input into fibre and fibre attenuation factor. For textile structures with optical fibres the illumination intensity is evaluated as well. It was found that illumination intensity of textile structures is very different. It is dependent on the trajectory of optical fibre in textile structure. The highest illumination intensity is for straight fibre in textile with lower waviness.

Keywords: Polymer Optical Fibres; Side Emitting; Attenuation Factor; Light Intensity

1 Introduction

The main role of polymer optical fibres is to transmit light or optical signal to a specified spot. Optical fibre is dielectric waveguide transferring light or infrared radiation across its axis by the mechanism of total internal reflection on the interface of two materials with different refractive indices. Standard optical fibres (see Fig. 1) consist of a light guiding core with refractive index n_{core} and a cladding with lower refractive index $n_{cladding}$.

Total internal reflection of electromagnetic waves occurs at the boundary between core and cladding under the condition that the angle of incidence is greater than or equal to the critical angle. Under this condition, electromagnetic radiation is confined and propagates along the fibre. Optical fibres are usually silica glass or polymeric. The core has characteristic intrinsic absorption and scattering of the light which leads to light attenuation in dependence on distance from source. In addition to this intrinsic light loss, impurities, defects and geometrical imperfections of the

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core lead to light absorption and scattering. These effects depend on the wavelength of the light as well.

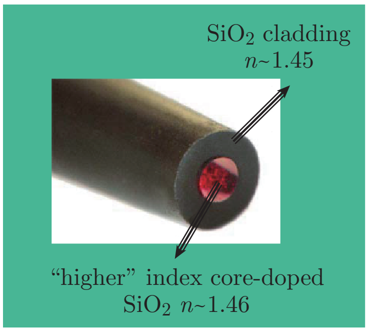

Fig. 1: Structure of optical fibre [1]

Plastic or polymer optical fibre (POF) is usually a fibre type optical waveguide [1]. POF has sheath (or cladding) core structure and refractive index of cladding should be lower than that of core, i.e., $n_{cladding} < n_{core}$. Usually, polymethylmethacrylate (PMMA, refractive index n = 1.49) and fluoropolymers with refractive index n ~1.35 to 1.43 are used as core and cladding polymers, respectively [1-5]. Compared to silica used as core material for glass optical fibre, PMMA is very ductile and cheap. Therefore, it is possible to make optical fibre with large core size, which is easy to be connected. Although POF has such advantages, the use of POF in data communication is rather restricted to the automotive field, mainly due to very high optical loss of POF. This is originated from the chemical structure of PMMA, which contains C-H bonds and their harmonic waves are main cause for the loss. In side emitting POF, the light leaks out from their surface.

For illumination purposes, light emission along the fibre is necessary. In this case, multimodal fibres are most likely to be used, since their larger diameter allows higher emission intensities to be obtained.

In the case of side emitting plastic optical fibres the light leaks out from their surface. Side emission occurs if the light incidence angle is smaller than critical angle. This effect can be obtained by the increasing of cladding refractive index, decreasing of core refractive index or by the change of incident light angle. It is possible to use multiple micro-bending of core or cladding; using additives causes reflection or fluorescence into core/cladding or creation of geometric asymmetry in the core/cladding system. There are various types of patented side emitting fibres and waveguides including methods of their preparation [2, 3]. In all cases the aim is to avoid total internal reflection, either by raising refractive index of cladding or lowering refractive index of core, or by changing the critical angle of incident light rays, e.g., by scattering. These include multiple micro-bending of the fibre, mixing of scattering or fluorescent additives into the core or cladding material, creating asymmetries in the core/cladding geometry, increasing the refractive index of the cladding above that of the core [8, 9]. Emission from side emitting optical fibres referring to a fibre design with scattering cladding is described in work [8] (Fig. 2).

Various commercial side emission optical fibres and light guides and methods for their manufacture were developed and patented [10, 11].

It was found that due to the transmission loss, the intensity of radiation emitted in any direction decays exponentially along the fibre axis with increasing distance from the transmitting end of the fibre [4].

If a uniform intensity of emitted radiation over the fiber length is required, a theoretical solution