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Optical Components

Joachim H. Wendorff*

Organic polymers have the distinct advantage that they can easily be processed into complicated three-dimensional parts, thin films or fibers, thin coatings on substrates. Moulding in the molten state, spin-coating from solution or casting from solution are just some of the possible processing methods. Polymers are thus extremely well suited for the manufacturing of optical components, particularly for optical communications. Polymers possess the aditional advantage that the relation between their chemical structure and relevant optical properties (refractive index, birefringence, absorption, nonlinear optical properties) is rather transparent and can in many instances already be predicted by molecular modeling techniques. This contribution describes the use of polymers in optical components, taking as examples amorphous polymers as well as liquid crystalline polymers. It also addresses a set of problems related to the organic nature of the polymers such as dimensional instability, chemical degradation, water uptake, physical aging.

**Correspondence*: Prof. Dr. J.H. Wendorff
Fachbereich Physikalische Chemie
Philipps-Universität Marburg
D–35032 Marburg (Lahn)

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Effect of Structure on the Scattering Losses of Polymer Optical Fibre Materials

Manfred Dettenmaier*

Abstract. Since scattering of light, together with absorption, contributes to the total loss in optical fibres, it is important to study the scattering behaviour of polymers as a function of their molecular and supramolecular structure. Light-scattering of glassy homopolymers results from anisotropy and density fluctuations. The two contributions have been studied in detail. Particular attention has been given to long-range density fluctuations which depend on the thermal history of the material. Glassy polymer mixtures and copolymers exhibit additional scattering from concentration fluctuations. This contribution has been estimated theoretically. Experiments conducted on a semicrystalline polymer indicate that transformation of a spherulitic into a fibre morphology is an interesting method to reduce the scattering loss of melt-crystallized polymers.

1. Introduction

Optical fibres for long-distance data transmission are manufactured from highly purified inorganic glasses which exhibit much lower losses (≤0.5 dB/km) than polymer fibres (≥ 100 dB/km). For data transmission over shorter distances, however, polymer optical fibres represent a low-cost alternative with better mechanical properties and less complex engineering solutions to the problem of fibre connection. Polymer optical fibres are likely to find diverse applications as local area networks, short data links, light pipes for automotive dashboard displays, *etc.* Since scattering of light, together with absorption, contributes to the total loss in optical fibres, it is important to study the scattering behaviour of polymers as a function of their molecular and supramolecular structure. Scattering of light results from fluctuations of the refractive index which may be caused by anisotropy, density and concentration fluctuations. The amount and angular dependence of the scattered light are governed by the amplitude and correlation length of these fluctuations, respectively. The scattering loss is obtained by integration of the intensity over the whole angular range. In order to fully exploit the great potential of polymer optical fibres, interest has been focused on the scattering behaviour of such diverse systems as glassy homopolymers, polymer mixtures, and copolymers, as well as semicrystalline polymer fibres. The information obtained from the theoretical and experimental studies may be used to improve specific physical properties of future core and cladding materials while keeping their scattering losses acceptable.

**Correspondence*: PD Dr. M. Dettenmaier
Max-Planck-Institut für Polymerforschung
Postfach 3148
D–55021 Mainz

2. General Considerations

Fig. 1 shows the structure of an optical fibre in which light propagates by total reflection at the core-cladding interface. The attenuation of light along the fibre is given by the equation

$$I = I_0 \, e^{-\sigma l} \quad (1)$$

where
I_0 = intensity of incident light
I = intensity of light after propagating a distance l
σ = attenuation coefficient

Instead of σ, the loss coefficient

$$\alpha = -\frac{1}{l} \, 10 \log_{10} \frac{I}{I_0} = 4.343 \, \sigma \quad (2)$$

is frequently used to express the loss of the fibre in units of dB/km.