Integrated WDM System for POF Communication with Low Cost Injection Moulded Key Components

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Abstract: Polymer Optical Fibres (POFs) systems are limited to bandwidth. To extend the bandwidth, integrated MUX/DEMUX-elements for WDM over POF are developed to use multiple channels. These realised key components are suitable for mass market applications.

OCIS codes: (060.1810) Buffers, couplers, routers, switches, and multiplexers; (230.4000) Microstructure fabrication

1. Introduction

Polymer Optical Fibers (POFs) offer many advantages compared to alternate data communication solutions such as glass fibers, copper cables and wireless communication systems. In comparison with glass fibers, POFs offer easy and cost-efficient processing and are more flexible for plug interconnections. The clear advantage of using glass fibers is their low attenuation, which is below 0,5db/km in the infrared range. In comparison, POF can only provide acceptable attenuation in the visible spectrum from 350nm up to 750nm, see fig. 2. The attenuation has its minimum with about 85db/km at approximately 570nm. For this reason, POF can only be efficiently used for short distance communication up to 100m. The disadvantage of the larger core diameter is higher mode dispersion [1,2].

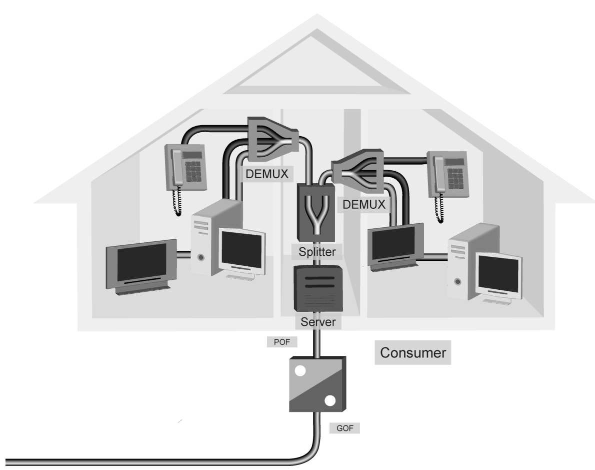

Fig. 1 In house WDM communication with POF

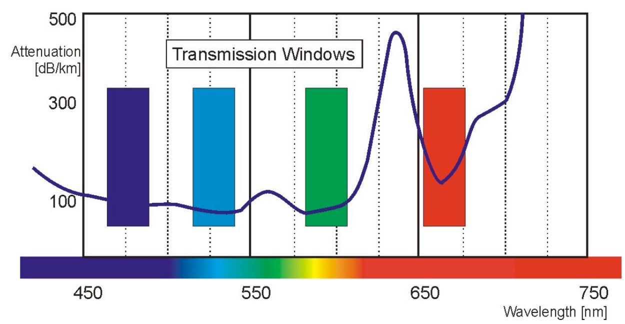

Fig. 2 Principle and attenuation of POF in the visible range [1]

Another sector where POF displaces the traditional communication medium is in-house communication [3-5], although the possibilities of application are not confined to the inside of the house itself. Today, copper cables are the most significant bottleneck for high-speed internet. “Triple Play”, the combination of VoIP, IPTV and the classical internet, is being introduced to the market with force, therefore high-speed connections are essential. It is highly expensive to realize any VDSL system using copper components, thus the future will be FTTH, including distinct WDM transmission channels for data, VOIP and IPTV (see fig. 1).

2. Motivation for WDM over POF

The standard communication over POF uses only one single channel [1,2]. To increase bandwidth for this technology the only possibility is to increase the data rate, which lowers the signal-to-noise ratio and therefore can only be improved in small limitations. This paper presents a possibility to open up this bottleneck. In glass fiber technology, the use of the WDM (wavelength division multiplexing) in the infrared range at about 1550nm has long been established [3-5]. This basic concept can also be assigned to POF. However POF shows different attenuation behavior, see fig. 2. For this reason, only the visible spectrum can be applied when using POF for communication. For WDM, two key-elements are indispensable: a multiplexer and a demultiplexer.

3. Basic Concept of the Demultiplexer

As mentioned before, a demultiplexer is essential for WDM. Several preconditions must be fulfilled to create a functional demultiplexer for POF. First of all, the divergent light beam, which escapes the POF, must be focused.. To get perfect results without any spherical aberrations, an ellipsoid mirror should be used.

The second function is the separation of the different transmitted wavelengths. In fig. 3, this principle is illustrated for three wavelengths (red, green, blue). The light is also not afflicted with any aberrations or attenuations of a focusing lens or other refractive elements, which are necessary for any other setup [6, 7]. One other characteristic of key elements for POF communication is the three dimensional approach to reduce transmission losses because of the large Numerical Aperture of the POF.

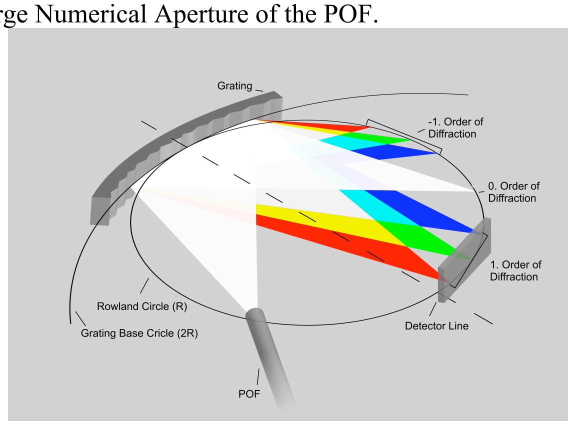

Fig. 3 Principle sketch of a Rowland Spectrometer

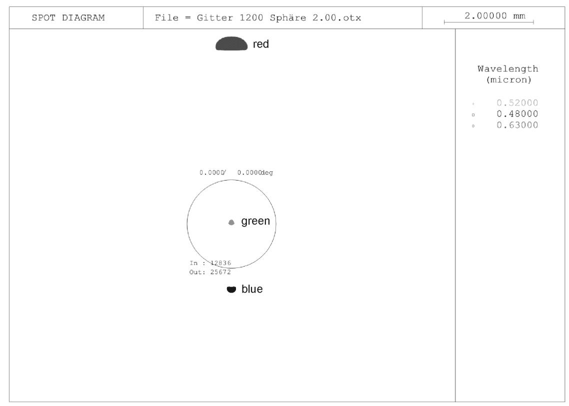

Fig. 4 Spot Diagram (circle diameter 2mm) for the improved demultiplexer

4. Results of the Simulation for different line densities

It is obvious that the grating changes the focal length especially of the sagittal section; therefore the shape of the mirror must be improved. It is necessary to change the radius of curvature notable in the sagittal section. Hence the basic shape of the mirror is not longer a sphere or ellipsoid. To meet the demands a higher order shape, which is nearly cylindrical, is used. The change of the mirror shape improves the imaging quality substantial. The Spot Diagram for the improved demultiplexer is shown in fig. 4.

The Spot Diagram shows three dividable colors. The gap between every color is larger than 2mm. Because of the spectrometric function of the demultiplexer it is not possible to focus all three colors simultaneously. There is always a combination of over and under correction for the different colors. Hence the radius of the mirror in the sagittal section is optimized to focus the colors completely as much as possible.

This improved demultiplexer can separate three colors with enough space between them to regain the information with a POF- or detector-array. The shapes of the foci feature low coupling losses and the shape of the mirror is easy to produce in injection molding.

The experimental results show, that it is possible to build up a demultiplexer by means of a diffraction grating. A special shape of the mirror is needed to suppress most of the aberrations which results of the grating. The improved demultiplexer can separate all three colors with a gap of 2mm and crosstalk lower than 30dB. Even the more complex models show a gap between the different colors, hence it is possible to regain all transmitted information without any channel overlap, expecting a X-talk-suppression of more than 30 dB.

5. References

[1] Daum, W. and Krauser, J. and Zamzow, P. E. and Ziemann, O., in *POF – Polymer Optical Fibers for Data Communication*, (Springer-Verlag, Heidelberg 2002)

[2] Kragl, H., “A product family for simplex POF home net”, (http://www.pofac.de/itg/fg_5_4_1/de/fachgruppentreffen/treffen21.php, 2006)

[3] Chen, R. T. and Lipscomb, G. F., “WDM and Photonic Switching Devices for Network Applications”, Proceedings of SPIE 3949, (2000)

[4] Colachino, J., “Mux/DeMux Optical Specifications and Measurements”, Lightchip Inc. white paper, Lightreading, (2001)

[5] Voges, E. and Petermann, K., in *Optische Kommunikationstechnik*, (Springer-Verlag, Heidelberg 2002) pp. 156 -177

[6] Fraunhofer Institute for Integrated Circuits, “Optical multiplexer for short range communication” (ttp://www.iis.fraunhofer.de/ec/oc/download/demux.pdf, 2008)

[7] Fischer, U. H. P. and Haupt, M., “WDM over POF: the inexpensive way to breakthrough the limitation of bandwidth of standard POF communication”, Proc. SPIE 6478 (2007)