

# Technical study of visible light wavelength division multiplexing using polymer optical fiber

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Visible light wavelength division multiplexing (VWDM) experiment was performed using polymer optical fiber (POF). Lights of two different wavelengths (650 and 530 nm) were sent to a single POF. Red light (650 nm) was used for 100-Mb/s full duplex IP data transmission and green light (530 nm) was used for voice signal transmission. Light sources are light-emitting diodes (LEDs). A POF coupler (splitter) and the prisms were employed as multiplexer and demultiplexer, respectively. The channel isolation and insert loss were measured, which are 20.5 and 17.65 dB for 650-nm channel respectively, and 19.16 and 20.55 dB for 530 nm one respectively.

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Recently there has been considerable interest in the development of polymer optical fibers (POF). The ductility of polymers is an important advantage and confers on POF easy processing, easy handling, low costs, and large core diameter<sup>[1]</sup>. POF has an extended applicability, such as in computer networks, local area networks, data links, automobile, optical sensors, lighting, etc.. The large core diameter, up to 1 mm or more, enables high efficiencies of fiber coupling.

We have demonstrated 100-Mb/s POF data link<sup>[2]</sup> and POF networks<sup>[3]</sup>, and we have performed visible wave divisional multiplexing (VWDM) over POF. Wavelength division multiplexing (WDM) is sending light of different wavelengths on a single fiber. Each light is a separate, signal-carrying channel. Thus, the information transmission capacity of a single fiber is fold increased. There are two kinds of WDM: dense wave division multiplexing (DWDM) and course wave division multiplexing (CWDM). The spacing between the individual wavelengths transmitted through the same fiber serves as the basis for defining DWDM and CWDM. Spacing in CWDM systems is typically 20 nm, while most DWDM systems today offer 0.8-nm (100-GHz) wavelength separation. The technologies have been used in glass optical fiber communication for years and substantially enhanced the communication capability of the network. The wavelengths used in above-mentioned WDMs typically locate at infrared area. Now, along with the development of POF network, it is necessary to apply WDM

to it. There are three low loss transmission windows in visible band for POF<sup>[4]</sup>, which are 520 nm (80 dB/km), 580 nm (50 dB/km), and 650 nm (160 dB/km), respectively (see Fig. 1). So we can use visible light to carry out WDM. It is a candidate for three-channel communications (community antenna television (CATV), telephone, and Internet) over a single fiber. In this article 650 and 530 nm light-emitting diodes (LEDs) were used for signal transmission.

The block diagram of the POF VWDM system is shown in Fig. 2. Green LED (530 nm) was used for voice signal carrying and red LED (650 nm) was used for IP data transmission. A drive circuit was designed for 523-nm LED signal modulation. A POF Hub with work wavelength of 650 nm was used for IP data transmission,

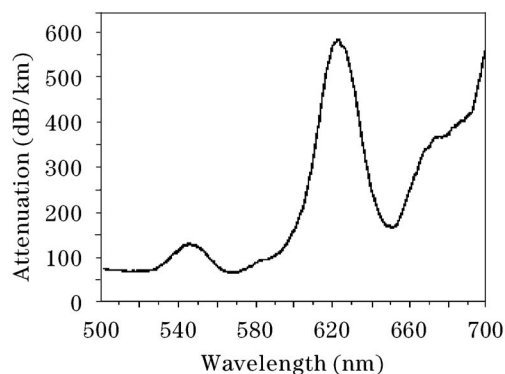


Fig. 1. Loss spectrum of POF.

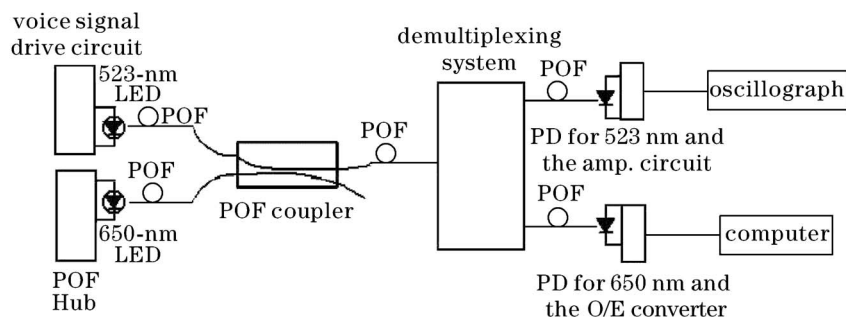


Fig. 2. POF CWDM System.

which was developed by University of science and technology of China. The used POF was Mitsubishi GH4001 1000- $\mu\text{m}$  core jacketed step-index polymer optical fiber.

The lights of two wavelengths were multiplexed into a transmission fiber by a POF coupler. Through the transmission fiber the signals were sent to the demultiplexing system. How to efficiently split the two lights is a key factor in this experiment. We used three prisms as core demultiplexer device for splitting the lights to an adequate distance. The prisms are equilateral triangle prism with side length of 60 mm. The spectrum of the light sources is shown in Fig. 3(a) and the demultiplexing result is shown in Fig. 3(b).

The demultiplexed lights were sent to photo-detectors respectively through receive POFs; here an avalanche diode was used as photo-detector for its high sensitivity. The voice signal carried by 530-nm light was exported oscillograph, while the IP signal carried by 650 nm one was carried to a polarization controller (PC) by an O/E converter. IP data signal and 200-Hz sine wave signal (substitute to voice signal) were transmitted through this VWDM system.

For IP data transmission channel, the emission signal power and the received signal power of the 650-nm LED are  $-12.95$  and  $-30.6$  dBm, respectively, so the insertion loss is 17.65 dB. The emission and received waveforms were shown in Figs. 4(a) and (b), respectively.

Furthermore we investigated the communication quality of the channel by using LCping software. It was found

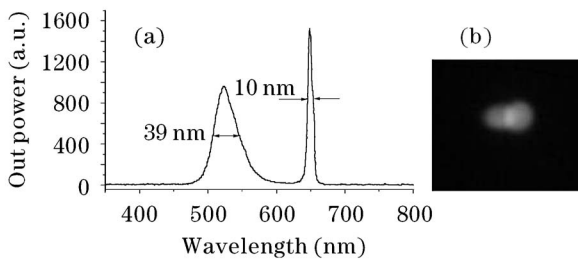


Fig. 3. The spectrum of the light sources (a) and the demultiplexing result (b).

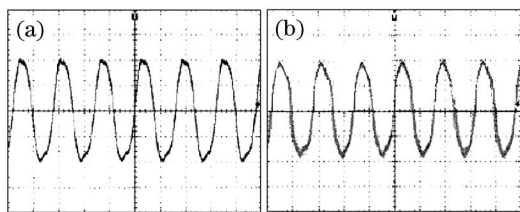


Fig. 4. IP data emission signals (a) and received signals (b).

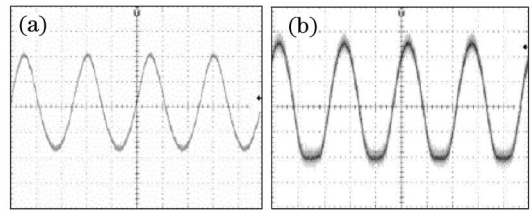


Fig. 5. Emission signal waveform (a) and received signal waveform (b).

that the packets loss less than 10 through transmitting 10,000 packets of 65500 bytes, which means that the communication between computers can be realized.

For voice signal transmission channel, the signal emission power and received signal power of 523-nm LED are  $-12.19$  and  $-32.74$  dBm, respectively. The insertion loss is 20.55 dB. From Fig. 5 we can see that the signal waveform was well recovered after transmission.

We also measured the isolation of both channels. For 650-nm channel the isolation is 20.5 dB, and the isolation of 523-nm channel is 19.16 dB.

In summary, VWDM was performed with commercially available polymer optical fiber, the IP data channel and voice signal channel well worked within a single fiber. The insertion loss and the channel isolation were measured, which indicated the feasibility of the system. POF VWDM systems can significantly reduce the cost of achieving multi-channel communication and further enhance transmission capacity via POF. This experiment is a preparation for three-channel communication over a single fiber.

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