Green light for MOST

GaN high-speed LEDs and their application in a POF-based communication module

Toyoda Gosei has developed green Gallium Nitride LEDs for data links using POFs. Their frequency response characteristics and eye diagram measurements show that green LEDs have the capability of high-speed data transmission with up to 500 Mbit/s. Temperature dependencies of the dominant wavelength, emission intensity and forward voltage are small enough for usage in high-speed POF based data links.

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As an application Toyoda Gosei developed a bidirectional single POF communication module, whose optical circuit consists of a WDM polymer which was fabricated using light-induced self-written waveguide techniques, using green and a conventional red LEDs.

In POF data link, the red 650 nm LED has been used as a general light source. **Figure 1** shows that the standard step-index (SI) PMMA POF has some minimum loss windows in the visible wavelength region. Temperature measurements of the red and green LEDs during operation show, that the green LED has fewer dependencies of the dominant wavelength; operating between 0 and 85 °C the wavelength fluctuates than 3 nm (**figure 2**).

The red light source has a minimum attenuation near 650 nm, yet in a very narrow range. Therefore, the optical power loss will be increased over temperature due to shifts of the peak wavelength. As a countermeasure a resonant cavity structure LED designed for high-speed operation at 650 nm must be chosen.

On the other hand, because there is a largely low attenuation in the area from 480 to 530 nm, green LEDs have an advantage in terms of temperature stabilization. Therefore, the green LED is able to enhance the power budget and communicate over long distances.

The GaN LED has previously been developed for applications as indicators or displays. The green GaN LED can become the new light source in the field of optical communication. Therefore Toyoda Gosei started to develop a green high-speed LED which can be used at data transmission rates of up to 500 Mbit/s.

Toyoda Gosei possesses a light-induced self-written optical waveguide technique that has been developed in cooperation with Toyota Central R&D Labs. Inc. Resin is photo-polymerized using blue light radiation from a fiber. A straight waveguide can be produced due to a self-trapping mechanism. Using this process a bidirectional transceiver using a single POF and two wavelengths (green and red LED) was produced, which means that there is no need for the alignment of optical waveguides and elements such as a light source or photo diode.

High-speed GaN LED

The green high-speed GaN LED has been developed by aligning LED tip structure and fabrication. For evaluating the transmission characteristics of the developed green LED, a high frequency driver circuit was developed. The random pattern (1.0 V_{pp}) from the pulse pattern generator (MP1632C Anritsu) was fed into the transceiver at a data rate of 150/400/500 Mbit/s.

The optical power through the POF (V078789-L51501 G&G, 1 m length) was detected by a avalanche photo diode and converted to a electrical

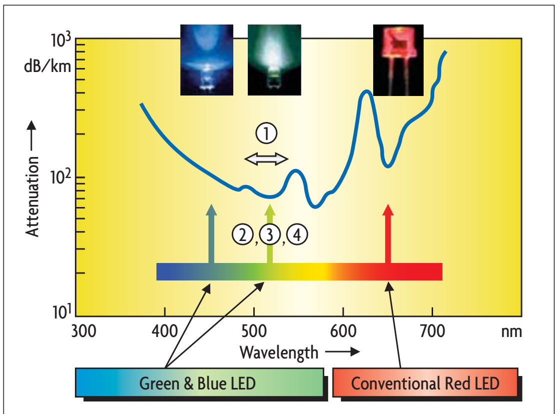


Figure 1. Attenuation of a step-index PMMA POF.

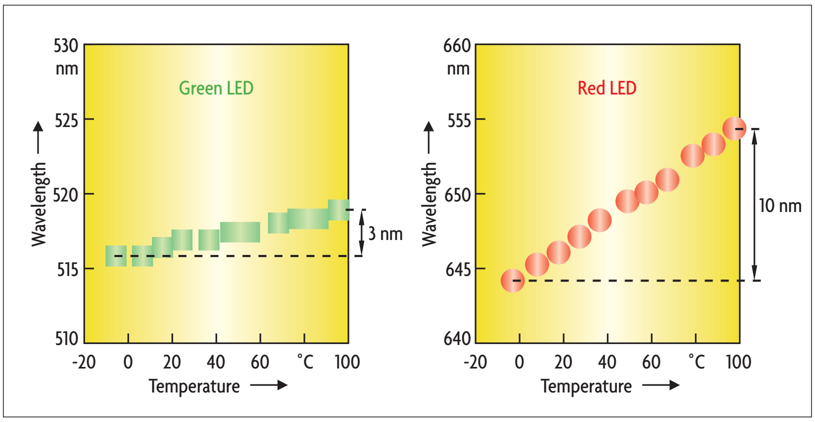


Figure 2. Temperature dependencies of green and red LEDs.

signal. The waveform obtained by an oscilloscope measurement (SDA 5000A LeCroy) under operation at 500 Mbit/s is shown in **figure 3**. The signal contains a slight jitter, but the large aperture suggests that this transceiver can transmit successfully at data rates of up to 500 Mbit/s.

LISW optical waveguide

Using the LISW technique a LISW optical waveguide is produced out of resin, which is photo-polymerized by blue laser light coming out of a optical fiber. The resin begins curing from the core tip where the light is most intense. Because the refractive index of the hardened portion is getting higher than of uncured resin, the core is formed by a self-trapping mechanism.

The core grows straight along the optical axis while keeping a uniform diameter. Furthermore, if in advance a half mirror is inserted into the optical axis a branching waveguide can be obtained by a simple process. Applying this fabrication method, it low cost optical communication devices can be produced which do not require a costly alignment.

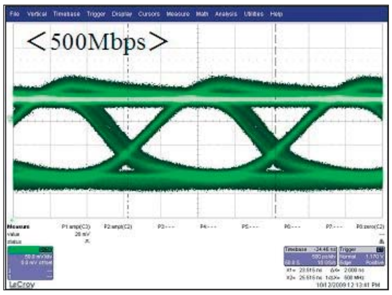


Figure 3. Eye diagram of a transmitter using a green LED at a data rate of 500 Mbit/s.

Proposal for a module using a green GaN LED

Figure 4 shows the prototype of an optical communication module using a green LED instead of red one; so high-speed communication performance can be achieved at a minimal cost. For example, when some perimeter surveillance cameras are installed on a vehicle, the amount of data that has to be transmitted will be higher than 440 Mbit/s (picture resolution 320 × 240, color 16 bit RGB, 30 fps, 4 channels, uncompressed). Using a green LED it will be possible to transmit this amount of data.

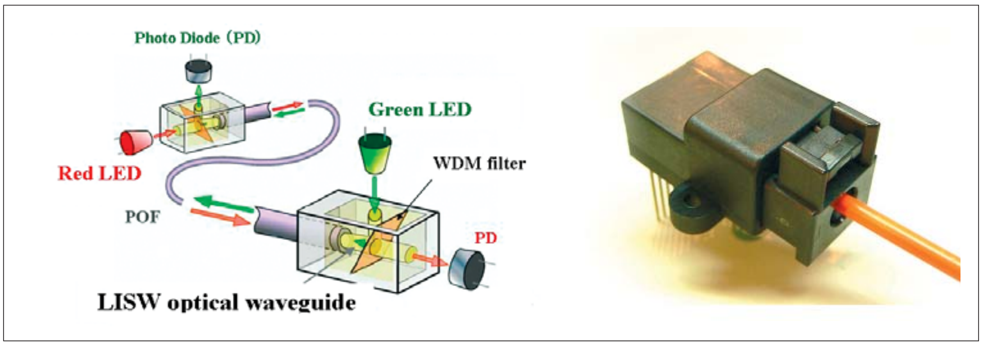
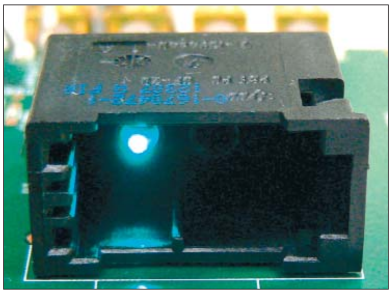


Figure 5. Schematic view of a bidirectional optical module and picture of a prototype of the transceiver.

Figure 5 shows a schematic diagram of a bidirectional optical module and a prototype of transceiver. The transceiver consists of the LISW waveguide, a WDM filter, LEDs with two wavelengths (500 and 650 nm) and a photo diode. The optical LISW circuit is mounted in a transparent plastic case. Using a branching LISW waveguide and a WDM filter, bidirectional communication using a single POF can be achieved.The process of bidirectional data communication using this module works like this: The light signals emitted by a green LED are launched into the waveguide.

The green signals are reflected by the filter and arrive at the other module through an optical fiber connected by in-line connectors. Then the signals are reflected by the filter again, so that the beams reach a photo diode mounted on the other module. The WDM filter is designed to reflect green light and to transmit red light.

The MOST is currently based on a ring topology. Therefore, when a camera is used in a car for perimeter surveillance, it can receive the data but it can not loop back a control signal to the camera without an additional connection. As a technical solution, the modules developed by Toyoda Gosei enable a bidirectional transmission using a single POF. *sj*


Fiugure 4. Prototype of an optical communication module using a green LED.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