FEATURING

Reduced Costs Achieved
with Optical Disc Laser Coupler Technology

Gigabit Optical Communication Transceiver

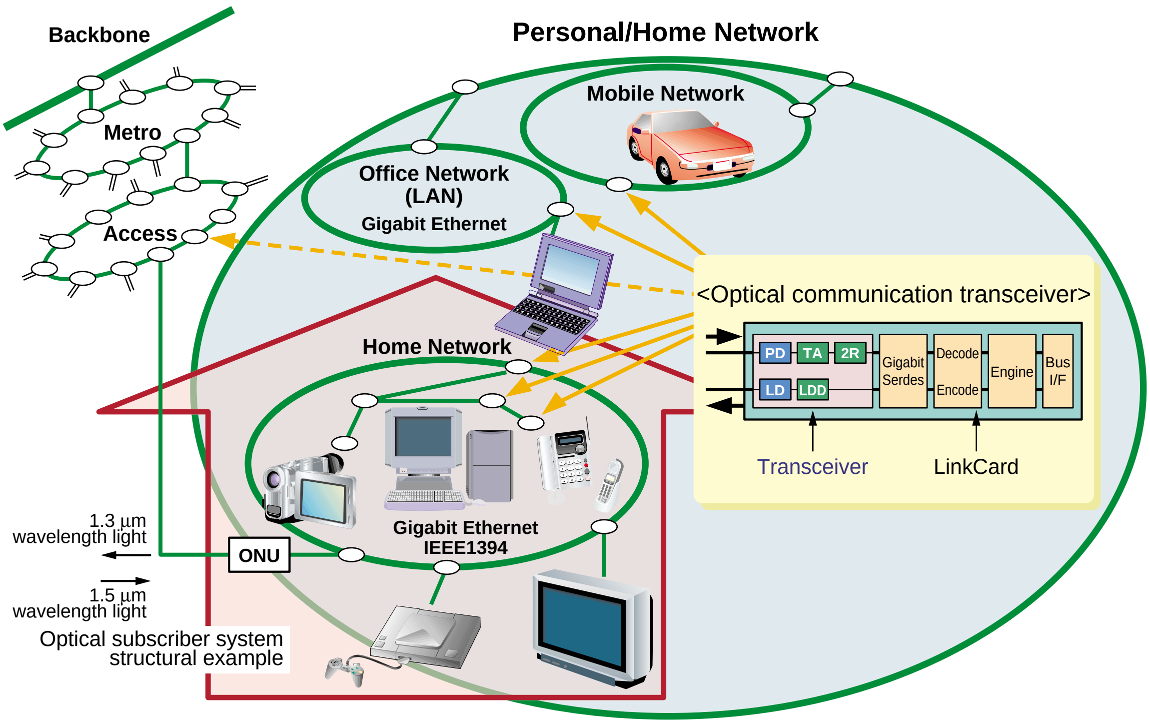
- **Low threshold voltage high-efficiency laser diode**
- **Low-capacitance high-sensitivity photodiode**
- **Unified transmission/reception front end module**
- **Gigabit optical communication transceiver**

The needs for increasing speeds and capacities in modern data communication systems have lead to increasing hopes for the introduction of optical communication in a wide range of communication networks. However, while the optical communication transceiver, which is the key component in such systems, makes high-speed communication possible, it remains an extremely expensive device. Thus the difficulty of reducing costs has become the largest problem hindering the adoption of optical communication technologies in a wider range of applications.
Independently of these issues, Sony has been developing, for many years, laser diodes and laser couplers for use in the miniature thin-form optical pickups used in optical disc players and drives. The application of these proven laser diode process and optical integration technologies should be extremely effective at reducing costs in the transceivers required in optical communication systems.

Sony is now developing optical communication transceivers that can be deployed in a wide range of applications, and that achieve gigabit class high-speed transmission at low cost based on this approach.
In this article, we present photodiodes and laser diodes that are the subject of new development efforts currently in progress, and technologies for optical communication transceivers and front end modules that will use those laser diodes and photodiodes.

Low Threshold Voltage High-Efficiency Laser Diode

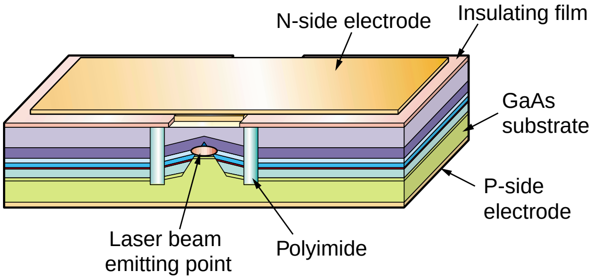
Sony has developed an 850 nm band laser for use as the light source in the transmission side of an optical communication transceiver. Figure 2 shows the structure of this device. This device uses Sony's unique separated double



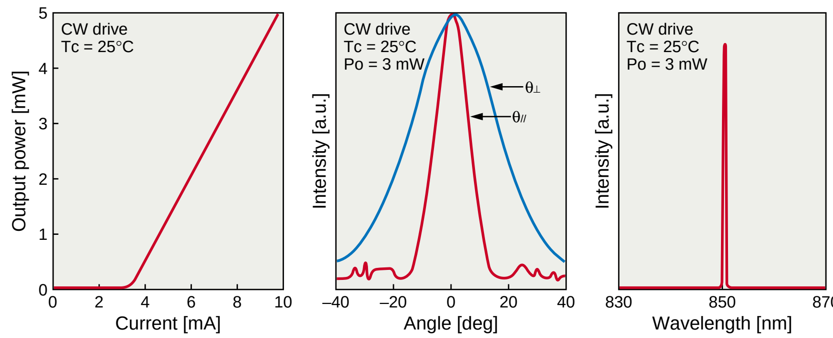
■ **Figure 1 Optical Communication Network** heterostructure (SDH) technology. With the SDH structure, an embedded heterostructure, which normally requires two or more crystal growth process steps, can be formed with a single crystal growth process step by forming a mesa-stripe before the growth step. This device has a short resonator length of 200 µm to achieve high-speed modulation, and furthermore aims at reduced device capacitance by forming separation grooves on both sides of the laser beam emitting point. To make electrode formation easier, the separation grooves are embedded evenly with polyimide. As a result, the laser developed in this project achieves the low device capacitance of 12 pF. Another feature of the laser developed in this project is the adoption of a window structure that prevents optical loss at the optical emission surface through modifications to the mesa-stripe geometry. Figures 3 and 4, and table 1, present representative characteristics of this device. The low threshold current and high differential efficiency are obtained. The temperature characteristics have also been improved, and increases in the threshold current and degradation of the differential efficiency are held to a minimum, even at high temperatures. This means that modules using this device will achieve reduced power consumption and high operating stability regardless of the operating conditions.

Low-Capacitance High-Sensitivity Photodiode

Sony has developed an 850 nm band photodiode as the signal reception device in an optical communication transceiver. Figure 5 shows the structure of this device. A PIN structure is formed on a GaAs substrate. The optical reception surface is a disc 100 µm in diameter. An anti-reflection film is formed on the optical reception surface and an insulating film is formed under the P-side electrode to reduce the device capacitance. Table 2 lists the characteristics of the device. Like the laser diode, the device capacitance is held to an absolute minimum to achieve high-speed transmission.



■ **Figure 2 Laser Diode Chip Structure**



(1) I-L (2) FFP (3) Spectrum

■ **Figure 3 Laser Diode Representative Characteristics**

■ **Table 1 Laser Diode Main Characteristics**

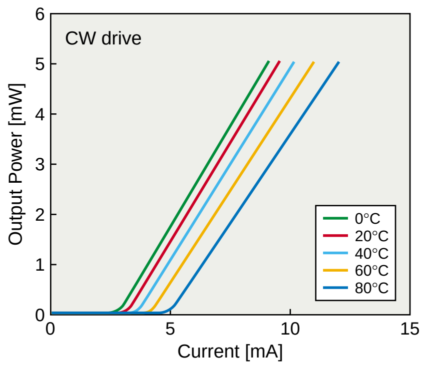
Item		Symbol	Typical value	Unit
Threshold current		Ith	3.1	mA
Operating current		Iop	7.2	
Operating voltage		Vop	1.6	V
Oscillation wavelength		λp	850	nm
Radiation angle	Parallel to junction	θ//	14	deg
	Perpendicular to junction	θ⊥	34	
Differential efficiency		ηD	0.7	mW/mA

Conditions: Tc = 25°C, Po = 3 mW @CW

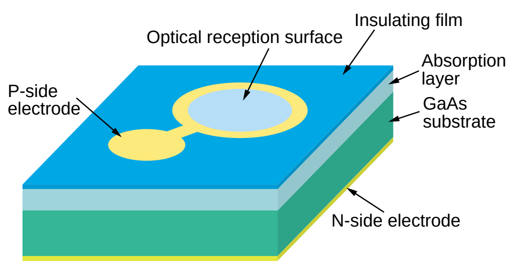
■ **Table 2 Photodiode Main Characteristics**

Item	Symbol	Typical value	Unit
Optical sensitivity	R	0.62	A/W
Dark current	Id	<1	nA
Breakdown voltage	Vbd	>40	V
Capacitance	C	1.2	pF

λ = 850 nm, Optical receptor size: ϕ100 µm



■ **Figure 4 Characteristics Temperature Dependency**



■ **Figure 5 Photodiode Chip Structure**

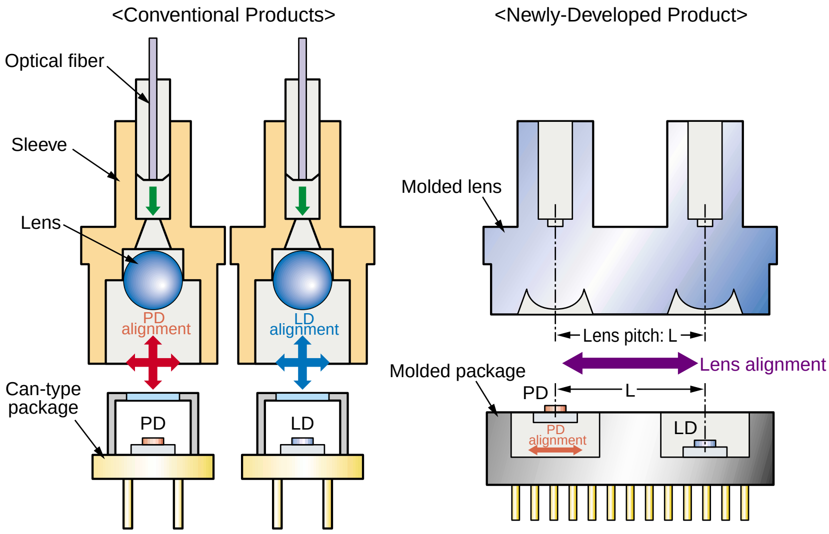
Unified Transmission/ Reception Front End Module

■ Component Structure of the Unified Transmission/Reception Type Device

One major feature of the optical communication transceiver developed in this project is the front end module structure that unifies the transmission and reception blocks. Figure 6 shows the structures of conventional front end modules and the front end module developed in this project. Since conventional modules use laser and photodiodes that are mounted in individual can packages and are constructed from discrete components including lenses and sleeves, the number of components is large and assembly is difficult, leading to higher costs. In contrast, the module developed in this project achieves a significant reduction in the parts count and simplified assembly by mounting the laser and photodiode in the same package and by forming the lens and sleeve assemblies as a completely unified single molded structure. Also, for the laser system, the 45° mirror, which brings the laser optical path up to the vertical direction, and the output monitor photodiode are mounted on a submount which is formed as a single unified structure. The reception photodiode is mounted in the same package as the preamplifier IC to achieve increased sensitivity. (See figure 7.)

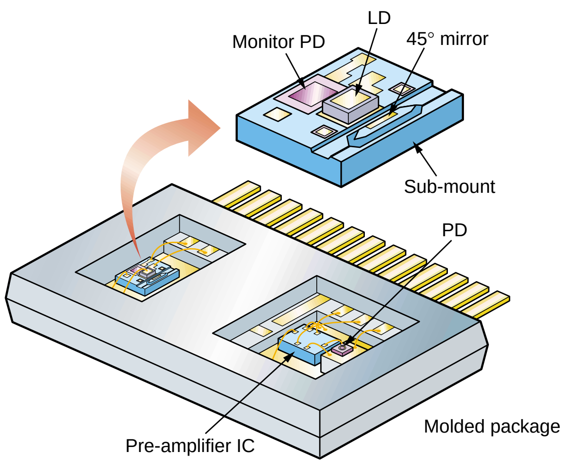
■ Transmission and Reception Batch Alignment Mounting

A significant feature of the front end module developed in this project is that it uses a unique Sony-developed mounting method that takes best advantage of Sony's laser coupler technology. Although structures that use lenses to couple the laser and photodiode to the optical fiber are the most common in the optical systems in these modules, this requires micron-level high-precision alignment of each device in the module. When aligning conventional modules, a technique called active alignment is used. In this technique, an optical fiber is attached and the laser and photodiode are aligned while actually being operated. Then they are fixed in place at the positions where the optical coupling is at the maximum. While this technique is reliable, connecting the optical fiber and driving the laser and photodiode are time consuming. Furthermore, since the transmission and reception systems in conventional modules are separate structures, the number of alignment operations is doubled, and this contributes to higher total costs for these products. In contrast, in the module developed in this project, the photodiode and laser are mounted in advance to match the lens pitch, and the lenses are mounted referenced to the actually mounted laser and photodiode devices. By referencing to the positions of the actually mounted devices themselves in this manner, the influence of the dimensional precision of the package and lens molds is held to a minimum. Also, since the whole alignment operation is performed using passive alignment, which uses image processing, the number of manufacturing steps in the mounting process can be reduced significantly. (See figure 6.)



	Conventional product	Newly-developed product
Component structure	• Two can-type packages used • The lens and sleeve have a separate structure (transmission and reception are separate systems)	• Unified package for transmission and reception systems • The lens and sleeve have a unified structure (transmission and reception are a unified system)
Alignment method	• Active alignment (3 axes) • Separate alignment for the transmission and reception systems	• Passive alignment using image processing (2 axes) • Alignment of transmission and reception systems at the same time

■ **Figure 6 Front End Module Structural Comparison**



■ **Figure 7 Package Mounting**

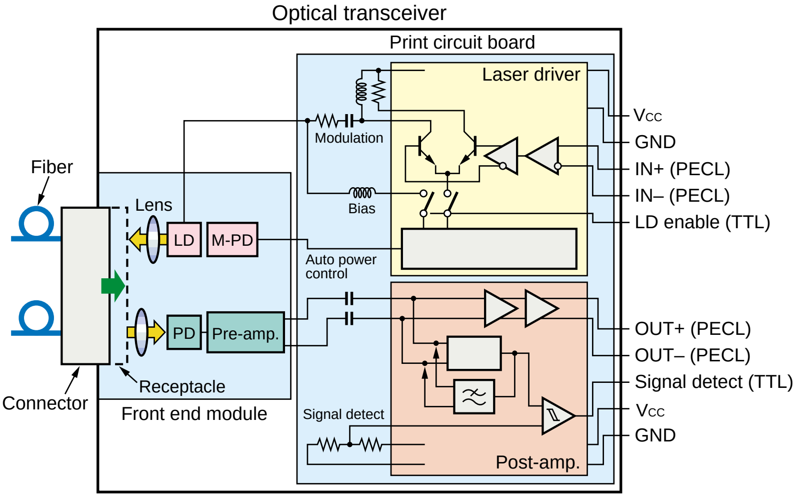
Gigabit Optical Communication Transceiver

Figure 8 shows the functional block diagram of the optical communication transceiver developed in this project. This optical communication transceiver consists of a front end module and a driver circuit board. The front end module has a receptacle structure, and an existing optical connectors can be attached.

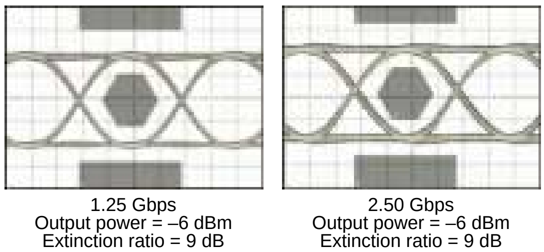
The driver circuit operates from a single 3.3 V power supply, and signal input and output operate at PECL levels. Laser enable and signal detect control signals (TTL outputs) can be set up. The package has a compact form with external dimensions of 14 × 50 ×10 mm, and power consumption is approximately 0.56 W with both transmission and reception driven. Also, other specifications and characteristics were designed assuming use with the 1000BASE-SX (Gigabit Ethernet) standard. (See table 3.) Figure 9 shows the optical transmission characteristics (eye pattern). An excellent eye aperture can be acquired at transmission speeds of either 1.25 Gbps or 2.5 Gbps, and it provides adequate margin for the standard mask. It also achieves a fully adequate slew rate with rise and fall times of under 200 ps. Figure 10 shows the optical reception characteristics. The minimum reception sensitivity is under -20 dBm (@BER = 1×10^{-12}) for transmission rates of both 1.25 Gbps and 2.5 Gbps, and it provides adequate sensitivity for the standard mask. It achieves excellent waveform quality with ringing suppressed in the reception waveform, and can provide an adequate eye aperture.

Future Developments

Sony is now proceeding with optical communication transceiver development projects to achieve even further miniaturization, even lower power consumption, and even lower costs by applying Sony's laser diode and laser coupler technologies developed for use in optical disc systems. Sony is also putting effort into the development of Sony's unique optical communication transceivers, which supports not only existing networks, but also a wide range of applications such as home networks and mobile networks. Keep your eye on Sony for future gigabit optical communication transceivers.



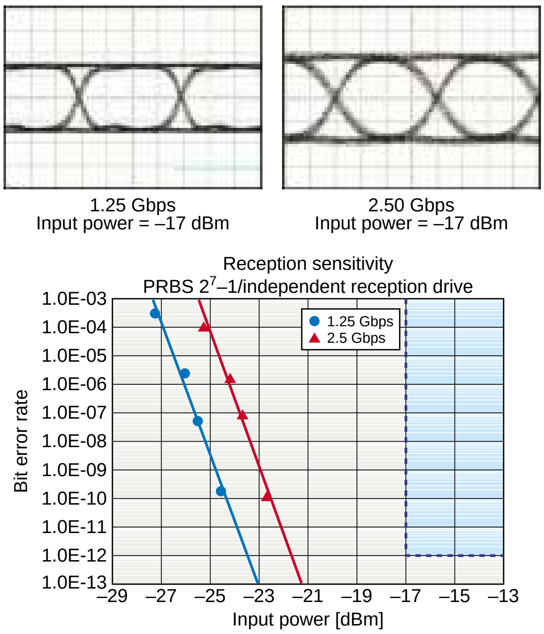
■ **Figure 8 Optical Communication Transceiver Function Block Diagram**



■ **Figure 9 Optical Transmission Characteristics**

■ **Table 3 Optical Communication Transceiver Setting Characteristics**

Item		Typical value	Unit	Remarks (*1000 BASE-SX standard values)
Transmission rate		Up to 2.50	Gbps	1.25 Gbps*
Package dimensions		14 × 50 × 10	mm	Small form factor Multi Source Agreement compatible
Fiber used		50/125 GI-MMF		Duplex LC connector conformed
Transmission distance		Up to 500	m	Fiber frequency band: 400 MHz · km
Supply voltage		+3.3	V	
Power consumption		0.56	W	When both transmission and reception systems driven
Transmission characteristics	Center wavelength	850	nm	770 to 860 nm*
	Average optical output	–6	dBm	–9.5 to –5.0 dBm*
	Optical absorption ratio	10	dB	> 9 dB*
Reception characteristics	Coding error rate	1×10^{-12}		PRBS: 2^7–1/mark ratio: 1/2
	Minimum reception sensitivity	–20	dBm	< –17 dBm*



■ **Figure 10 Optical Reception Characteristics**