2010

Product Catalog

ROHM SEMICONDUCTOR

Opto Electronics

Laser Diodes

ROHM Co.,Ltd.

Laser Diodes

ROHM produces the largest volume of laser diodes in the industry. Stable production and quality are ensured through a 100% in-house manufacturing process and the use of common assembly lines. A wide lineup is available, from low- to high-power types.

Table of Contents

What is a Laser Diode ?

Overview

What is a laser ?

Laser is actually an acronym for Light Amplification by Stimulated Emission of Radiation. This basically means that the amplitude of light is increased through induced emission.

The difference between laser diodes and light emitting diodes (LEDs)

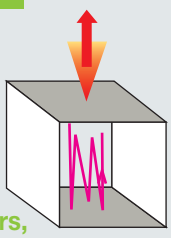
Both laser diodes and LEDs are formed through the creation of a PN semiconductor junction. When an electrical current is supplied, a positive hole, which has a positive charge, bonds with a negatively charged electron, resulting in light emission.

Since an LED produces natural light, the wavelength and phase are not uniform. A laser diode, on the other hand, operates by induced emission, resulting in uniform light wavelength and phase. Its particular characteristics are based on the underlying theory that the amplitude of light increases as it travels back and forth within a resonator, making it possible to obtain a larger optical output.

Therefore, a laser diode, in contrast with an LED, generates coherent or 'arrayed' light using a lens, which can be sent long distances or focused on an extremely small point. In addition, faster operation is possible compared with LEDs, enabling widespread use in more disparate fields.

Structural Diagram of a Laser Diode

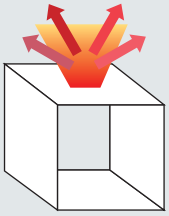
- Linear light emission
- Monochrome light



Travels back and forth between reflecting mirrors, increasing amplitude

Structural Diagram of a Light Emitting Diode

- Light is dispersed
- Mixed colors

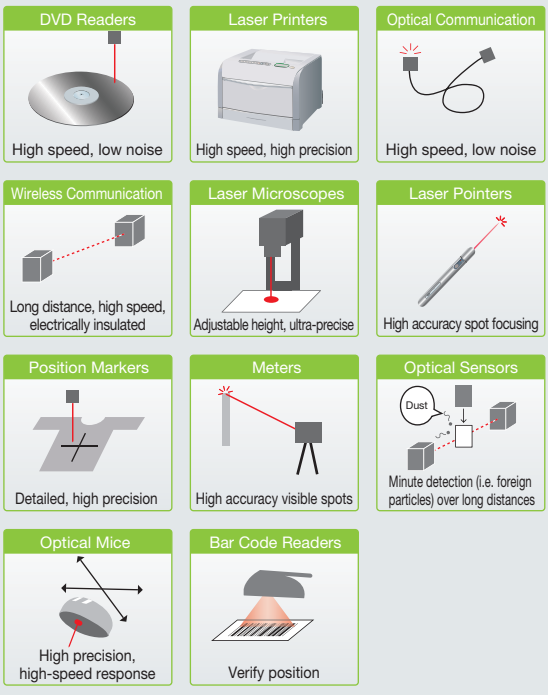


Features and Applications

Sample applications that use lasers are shown at right. Additional uses, such as for projection or minute heating, are also possible.

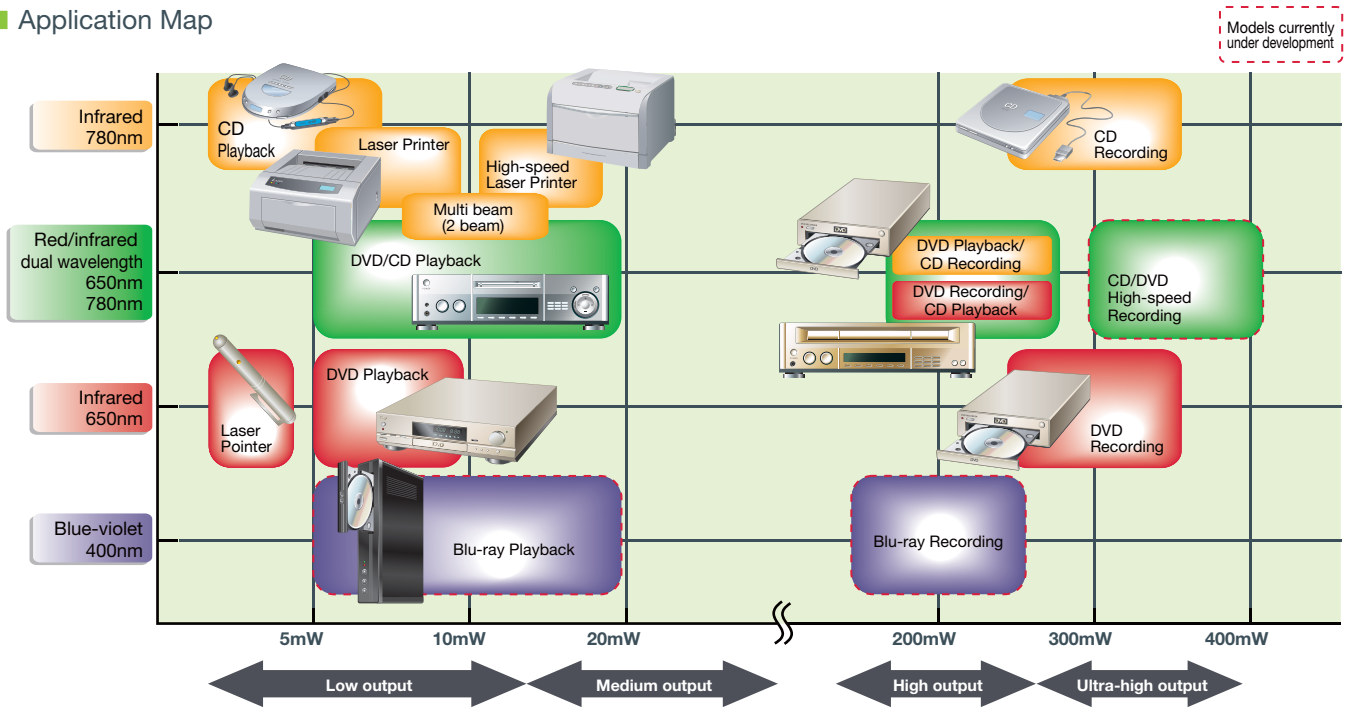
Function List

Function	Characteristics	Application Examples
① Reading	Enables high-speed reading of minute signals	Optical disk reading / writing (CDs, DVDs, Blu-ray)
② Recording	Image signals are written by changing the color of an organic membrane based on high output	Optical disk recording (CD-R, DVD-R, Blu-ray)
③ Photoexposure	Signals are drawn by irradiating a photosensitive drum	Laser printers
④ Communications	High-speed modulation is possible, making it possible to transmit large amounts of information	Optical communications in PCs, mobile phones, and other equipment.
⑤ Illumination	Allows accurate pointing via pin spot illumination	Laser microscopes, laser scalpels, pointing markers, and the like
⑥ Measurement	Attenuation over distance is low, making long-distance transmission possible	Road distance/building height measurements
⑦ Sensing	Interference fringes are easily created, enabling detection of minute changes	Sensing devices such as fire alarms, dust control, and laser mice.



Lineup by Application

Application Map



Lineup by Application

Type	Part No.	Features	Optical Disc					Laser Printer			Other		
			BD-P	DVD-P /ROM	COMBO	DVD-R	CD-P /ROM	High Speed	Middle Speed	Low Speed	General Purpose	Bar Code Reader	Sensor
660nm/780nm Dual Wavelength Laser													
Low/Low	**RLD2WMUV2**	Standard product / CAN	●	●									
	RLD2WMFV2	Standard product / Frame	●	●									
	New **RLD2WMFL1**	High ESD resistance / Frame	●	●									
	New **RLD2WMNL2**	Automotive-grade (85°C) / Glass-sealed CAN	●	●									
	★ **RLD2WMFL3**	80°C-class / Frame	●	●									
	★ **RLD2WMUL3**	80°C-class / CAN	●	●									
	New **RLD2WMFR1**	Self pulsation / Frame	●	●									
	★ **RLD2WMDR1**	Self pulsation / Covered frame	●	●									
Medium/Medium	★ **RLD2WMFL4**	10mW / Frame	●	●									
	New **RLD2WMUS3**	20mW / CAN	●	●									
Low/High	**RLD2WMGZ4**	DVD=10mW / CD=240mW			●								
High/Low	**RLD2WMZS1**	DVD=240mW / CD=20mW				●							
High/High	★ **RLD2WMGU1**	DVD=300mW / CD=350mW			●	●							
Multi-beam Laser													
High Speed	★ **RLD2BPNK2**	Twin infrared / 90µm pitch						●	●				
	★ **RLD2BPNK3**	Twin infrared / 28µm pitch						●	●				
660nm Laser													
Low Power	**RLD65MPT7**	DVD Single beam / CAN			●						●	●	●
	RLD65MPT3-13A	DVD Single beam / Glass-sealed									●	●	●
780nm Laser													
High Speed	**RLD78NZH1**	Infrared single / 5mW							●	●			
	RLD78NZM1	Infrared single / 10mW						●	●				
	New **RLD78NZM2**	Infrared single / 15mW						●					
	★ **RLD78NZM3**	Infrared single / 15mW						●					
Low Power	**RLD78MPA1**	CD / I CUT CAN Package					●				●		●
	RLD78MRA1	CD / Resin package					●				●		●
	RLD78MZGM	Infrared single / 5mW									●		●
High Power	**RLD78PPY5**	CD=240mW			●								●

★ : Under Development

Low Output 2-Wavelength Laser Diode for DVD/CD Playback

RLD2WMNL2

Low operating current and guaranteed operation up to 85°C - ideal for car navigation and DVD systems

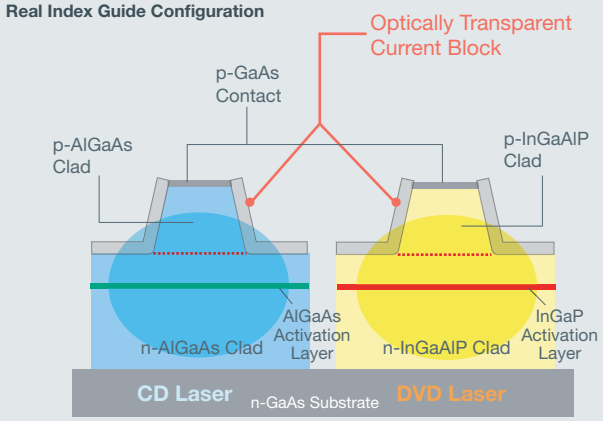
Product Outline

ROHM's dual-wavelength laser diode was designed for DVD and navigation systems exposed to harsh environments, such as in cars. An original structure is utilized for low current operation and stable operation up to 85°C. The package features a CAN-type structure with a sealed glass window, providing a high degree of reliability under virtually any environment.

New waveguide enables low current operation

An optically transparent real index guide is utilized to minimize loss due to light absorption, allowing operation with minimal current.

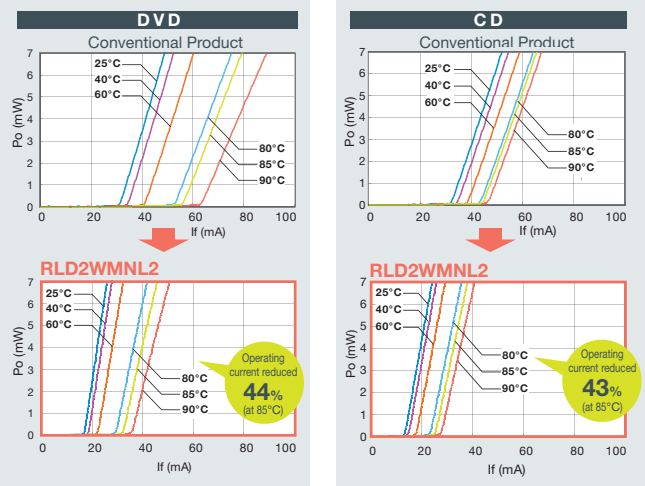
Real Index Guide Configuration



High temperature operation (85°C)

The proprietary structure ensures stable operation up to 85°C, reducing operating current by 44% and 43% over conventional DVD and CD laser diodes, respectively.

<Temperature Characteristics Comparison>

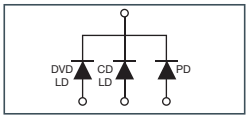


Specifications

Absolute Maximum Ratings

Part No.	Light Output Po(mW)	Reverse Voltage VR(V)	Operating Temp. Topr(℃)	Storage Temp. Tstg(℃)
RLD2WMNL2	7/7	2	-30 to +85	-40 to +85

Equivalent Circuit



Electrical・Optical Characteristics(Tc=25°C, Po=5mW)

Part No.	Oscillation Wavelength lp(nm)	Threshold Current Ith(mA)	Operating Current Iop(mA)	Operating Voltage Vop(V)	Monitor Current Im(mA)	Horizontal Divergence q//(deg)	Vertical Divergence q⊥(deg)
RLD2WMNL2	663/785	18/15	24/20	2.3/1.8	0.25/0.25	10/10	28/32

Low Output 2-Wavelength Laser Diodes for DVD/CD Playback

RLD2WMUL3 / RLD2WMFL3 Series

Supports high temperarure operation for gaming consoles and portable equipment

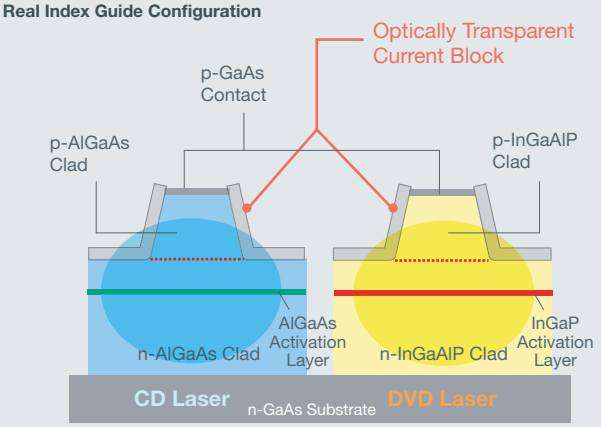
Product Outline

ROHM's dual-wavelength laser diode was designed for DVD and navigation systems exposed to harsh environments, such as in cars. An original structure is utilized for low current operation and stable operation up to 85°C. The package features a CAN-type structure with a sealed glass window, providing a high degree of reliability under virtually any environment.

New waveguide enables low current operation

An optically transparent real index guide is utilized to minimize loss due to light absorption, allowing operation with minimal current.

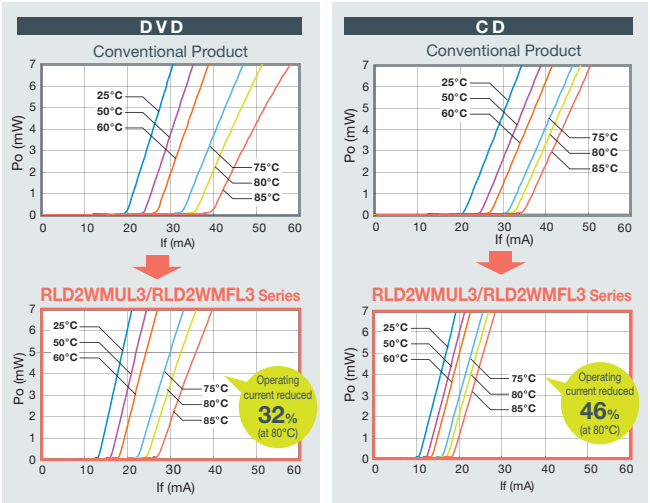
Real Index Guide Configuration



High temperature operation (80°C)

Operating current is reduced by 32% and 46% for DVD and CD playback, respectively, compared with conventional products (RLD2WMUV2 / RLD2WMFV2). Stable operation is guaranteed up to 80°C , 5°C more than standard models.

<Temperature Characteristics Comparison>

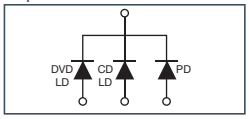


Specifications

Absolute Maximum Ratings

Part No.	Light Output Po(mW)	Reverse Voltage VR(V)	Operating Temp. Topr(℃)	Storage Temp. Tstg(℃)
RLD2WMUL3	7/7	2/2	-10 to +80	-40 to +85
RLD2WMFL3	7/7	2/2	-10 to +80	-40 to +85

Equivalent Circuit



Electrical・Optical Characteristics(Tc=25°C, Po=5mW)

Part No.	Oscillation Wavelength lp(nm)	Threshold Current Ith(mA)	Operating Current Iop(mA)	Operating Voltage Vop(V)	Monitor Current Im(mA)	Horizontal Divergence q//(deg)	Vertical Divergence q⊥(deg)
RLD2WMUL3	658/782	13/12	18/17	2.2/1.8	0.25/0.25	8.5/10	27/32
RLD2WMFL3	658/782	13/12	18/17	2.2/1.8	0.15/0.17	8.5/10	27/32

Self-pulsation Dual Wavelength Laser Diodes for DVD/CD Playback

RLD2WM□R1 Series

Original configuration utilized for low 70mA operating current

Product Outline

ROHM dual wavelength self-pulsation laser diodes for DVD/CD players were designed to provide low operating current and low noise operation under high temperatures. The unique self-pulsation method eliminates the need for a superposition IC and radiation countermeasures. Separate containment control structures are utilized for light (pulsation) and current (affects temperature and operating current characteristics), resulting in an operating current of only 70mA.

Reflected light noise countermeasures unnecessary

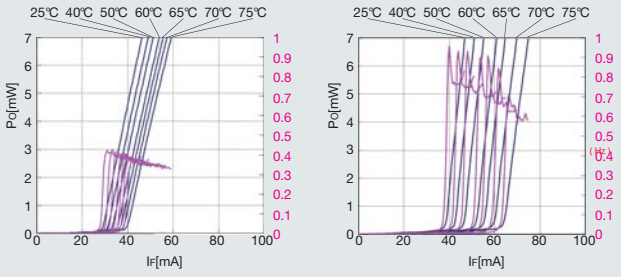
Conventional single mode laser diodes are weak against reflected light noise, making a superposition IC necessary. ROHM's self-pulsation laser diodes, however, operate by turning the oscillation ON/OFF at high frequency (in the hundreds of MHz), eliminating the need for noise countermeasures.

<Light Spectrum>

Stable at high temperatures

A unique structure is utilized for both current and light containment, resulting in low current operation and low noise, even under high temperatures.

<Temperature Characteristics>



Specifications

Absolute Maximum Ratings

Part No.	Light Output Po (mW)	Reverse Voltage VR (V)	Operating Temp. Topr (°C)	Storage Temp. Tstg (°C)
RLD2WMUR1 RLD2WMFR1 RLD2WMDR1	7/6	2	-10 to +70	-40 to +85

Electrical and Optical Characteristics (Tc=25°C, Po=5mW)

Part No.	Oscillation Wavelengths λp (nm)	Initial Oscillation Current Ith (mA)	Operating Current Iop(mA)	Operating Voltage Vop (V)	Monitor Current Im (mA)	Horizontal Spread Angle θ// (deg)	Vertical Spread Angle θ⊥(deg)
RLD2WMFR1 RLD2WMDR1	658/790	35/30	45/45	2.3/1.9	0.13/0.26	9/10	35/39
RLD2WMUR1	658/790	35/30	45/45	2.3/1.9	0.15/0.18	9/10	35/39

Narrow Pitch Twin Beam Infrared Laser Diodes for Laser Printers

RLD2BPNK3 Series

New materials utilized for narrow (28μm) pitch and superior temperature characteristics

Product Outline

Conventional laser diodes with a narrow luminous point interval are susceptible to the thermal effects of neighboring components during operation, resulting in reduced performance. In answer to this ROHM has developed a dual-beam infrared laser diode that utilizes novel materials for excellent temperature characteristics, even with a narrow pitch (28μm).

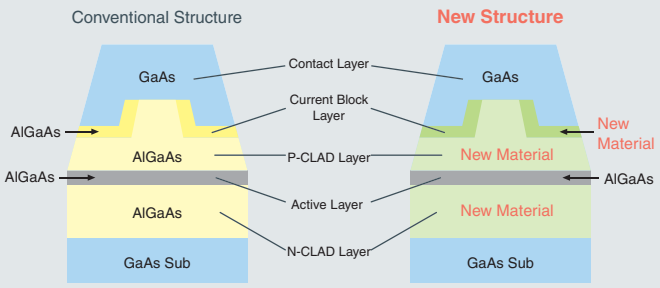
Original material technology

Proprietary construction prevents carrier overflow from the active layer (AlGaAs) during high temperature operation.

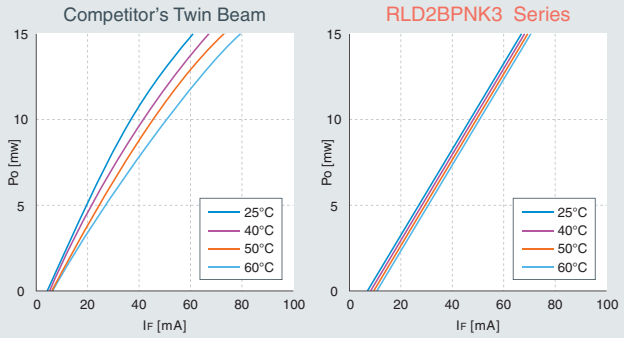
Twin beam type with excellent temperature characteristics

The utilization of new materials results in a change in current of only 6% (at 6mW) when Tc increases from 25°C to 60°C. Lower droop characteristics are also ensured.

ROHM's New Narrow Pitch Infrared Twin Beam Laser Diode Element Structure



Temperature Characteristics Comparison

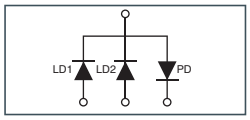


Specifications

Absolute Maximum Ratings (TC=25°C)

Symbol	Po	VR	Top Max.
Unit	mW	V	°C
Limits	10	2	-10 to +60

Equivalent Circuit



Electrical • Optical Characteristics (TC=25°C)

Symbol	Ith	Iop	Vop	η	Im	θ//	θ⊥	λ	Beam Pitch
Unit	mA	mA	V	mW/mA	mA	deg	deg	nm	μm
Typical	10	30	2.3	0.3	3.5	9	24	792	28

Condition : Po=6mW

Product Lineup

660nm / 780nm Dual Wavelength Lasers

Type	Part No.	Wavelength λP (nm)	Absolute Maximum Ratings (TC=25°C) PO (mW)	VR (V)	Topr Max. (V)	Electrical and Optical Characteristics (TC=25°C) Ith (mA)	IOP (mA)	η (W/A)	VOP (V)	Im (mA)	θ⊥ (deg)	θ// (deg)	PO (mW)	Package	Equivalent Circuit	RoHS
Low/Low	RLD2WMUV2	658	7	2	75	20	27	0.72	2.3	0.22	27	8	5	φ5.6mm (4PIN Open Package)	PD (4), 780nm (2), (3), 660nm (1)	Yes
		782	7	2	75	18	27	0.55	1.8	0.25	32	9	5			
	RLD2WMFV2	658	7	2	75	20	27	0.72	2.3	0.13	27	8	5	High radiation 4PIN frame		Yes
		782	7	2	75	18	27	0.55	1.8	0.16	32	9	5			
	New RLD2WMFL1 (Higher ESD)	660	7	2	75	13	19	0.85	2.3	0.15	27.5	8.5	5	High radiation 4PIN frame		Yes
		782	7	2	75	12	18	0.75	1.8	0.20	29.5	9.3	5			
	New RLD2WMNL2 (For Car)	663	7	2	85	18	24	0.7	2.3	0.25	28	10	5	φ5.6mm (4PIN)		Yes
		785	7	2	85	15	20	0.7	1.8	0.25	32	10	5			
	★ RLD2WMFL3 ★ RLD2WMUL3 (高温対応)	658	7	2	80	13	18	0.9	2.2	0.15	27	8.5	5	High radiation 4PIN frame		Yes
		782	7	2	80	12	17	0.85	1.8	0.17	32	10	5			
	New RLD2WMFR1 ★ RLD2WMDR1 (Self pulsation)	658	6	2	70	35	45	0.75	2.3	0.13	37	9	5	High radiation 4PIN frame / ★ Covered high radiation 4PIN frame		Yes
		790	7	2	70	30	45	0.5	1.9	0.26	39	11	5			
Medium/Middle	★ RLD2WMFL4	660	10	2	75	15	23	0.95	2.3	0.24	27	8.5	8	High radiation 4PIN frame		Yes
		782	10	2	75	12	22	0.8	1.8	0.32	29	9	8			
	New RLD2WMUS3	662	20	2	75	22	40	0.8	2.3	0.6	20	10	15	φ5.6mm (4PIN Open Package)		Yes
		785	20	2	75	22	45	0.8	1.8	0.75	17	10	15			
Low/High	RLD2WMGZ4	658	10	2	75	25	30	0.8	2.3	–	24	10.5	5	High radiation 3PIN frame		Yes
		782	240 (Pulse)	2	75	35	130	0.95	1.9	–	16	8	90			
High/Low	RLD2WMZS1	662	240 (Pulse)	2	75	60	150	0.9	2.7	–	17	9.5	80	φ5.6mm (②)	780nm (2), (3), 660nm (1)	Yes
		782	20	2	75	65	70	0.8	1.9	–	15.5	7.5	6			
High/High	RLD2WMGU1	662	300 (Pulse)	2	85	60	160	0.9	2.8	–	17.5	9.5	90	High radiation 3PIN frame		Yes
		785	350 (Pulse)	2	90	55	250	0.85	2.5	–	16	8.5	160			

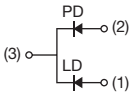
★ : Under development Note : Unless otherwise specified, the electrical and optical characteristics are typical values.

Multi-beam Lasers

Type	Part No.	Number of Beams	Pitch (μm)	Wavelength λP (nm)	Absolute Maximum Ratings (TC=25°C) PO (mW)	VR (V)	Topr Max. (V)	Electrical and Optical Characteristics (TC=25°C) Ith (mA)	IOP (mA)	η (W/A)	VOP (V)	Im (mA)	θ⊥ (deg)	θ// (deg)	PO (mW)	Package	Equivalent Circuit	RoHS
High Speed	★ RLD2BPNK2	2	90	785	10	2	60	10	30	0.3	1.8	3.0	29	9.5	6	φ5.6mm (4PIN)	PD (4), LD2 (2), (3), LD1 (1)	Yes
	★ RLD2BPNK3	2	28	790	10	2	60	10	30	0.3	2.4	3.4	21	9.5	6	φ5.6mm (4PIN)		Yes

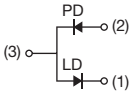
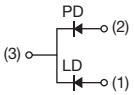
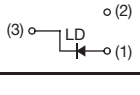
★ : Under development Note : Unless otherwise specified, the electrical and optical characteristics are typical values.

660nm Lasers

Type	Part No.	Wavelength λ_P (nm)	Absolute Maximum Ratings (T_C=25°C)			Electrical and Optical Characteristics (T_C=25°C)							P_O (mW)	Package	Equivalent Circuit	RoHS
			P_O (mW)	V_R (V)	T_{opr} Max. (V)	I_{th} (mA)	I_{OP} (mA)	η (W/A)	V_{OP} (V)	I_m (mA)	$\theta_\perp$ (deg)	$\theta_{//}$ (deg)				
Low Power	**RLD65MPT7**	655	7	2	70	20	30	0.7	2.3	0.2	27	8	5	 ϕ5.6mm (Open Package②)		Yes
	RLD65MPT3-13A	655	5	2	40	30	40	0.4	2.3	0.2	27	8	5	 ϕ5.6mm		Yes

Note : Unless otherwise specified, the electrical and optical characteristics are typical values.

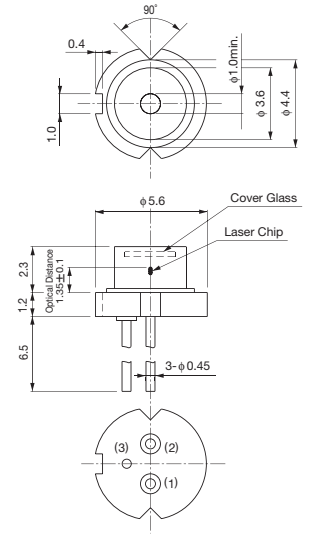
780nm Lasers

Type	Part No.	Wavelength λ_P (nm)	Absolute Maximum Ratings (T_C=25°C)			Electrical and Optical Characteristics (T_C=25°C)							P_O (mW)	Package	Equivalent Circuit	RoHS
			P_O (mW)	V_R (V)	T_{opr} Max. (V)	I_{th} (mA)	I_{OP} (mA)	η (W/A)	V_{OP} (V)	I_m (mA)	$\theta_\perp$ (deg)	$\theta_{//}$ (deg)				
High Speed	**RLD78NZH1**	785	5	2	60	20	27	0.3	1.9	0.45	28	11	3	 ϕ5.6mm		Yes
	RLD78NZH2	785	10	2	60	20	35	0.4	1.9	0.45	28	11	6	 ϕ5.6mm		Yes
	RLD78NZM1	790	10	2	60	10	20	0.6	1.9	1.0	28	9	6	 ϕ5.6mm		Yes
	New **RLD78NZM2**	790	15	2	60	10	20	0.6	1.9	1.0	28	9	6	 ϕ5.6mm		Yes
	★ **RLD78NZM3**	784	11	2	60	10	20	0.6	1.9	1.0	28	9	6	 ϕ5.6mm		Yes
Low Power	**RLD78MPA1**	785	5	2	70	35	45	0.25	1.9	0.15	37	11	3	 ϕ5.6mm (Open Package①)		Yes
	RLD78MRA1	785	4.5	2	70	35	45	0.25	1.9	0.15	37	11	3	 ϕ5.6mm (Compatible frame)		Yes
	RLD78MZGM	785	5	2	60	35	45	0.25	1.9	0.2	37	11	3	 ϕ5.6mm		Yes
High Power	**RLD78PPY5**	784	240 (Pulse)	2	75	35	130	0.9	2.0	–	16.5	9	90	 ϕ5.6mm (Open Package②)		Yes

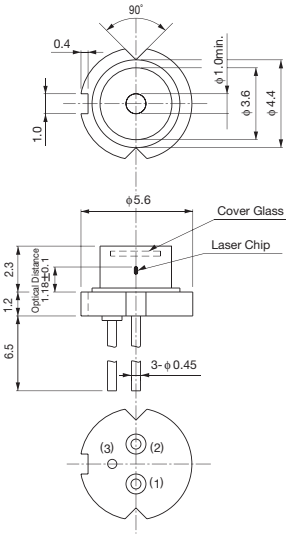
★ : Under development Note : Unless otherwise specified, the electrical and optical characteristics are typical values.

Dimensions (Unit : mm)

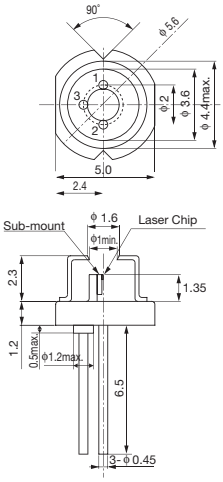
ϕ5.6mm



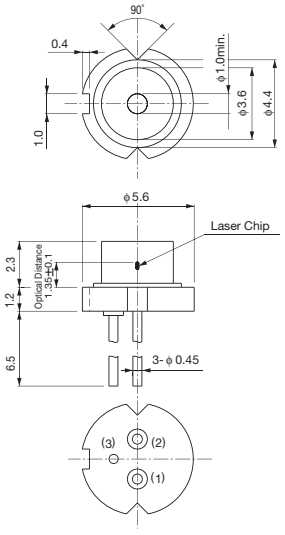
ϕ5.6mm(②)



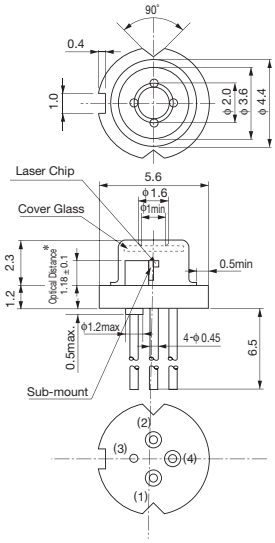
ϕ5.6mm(Open Package①)



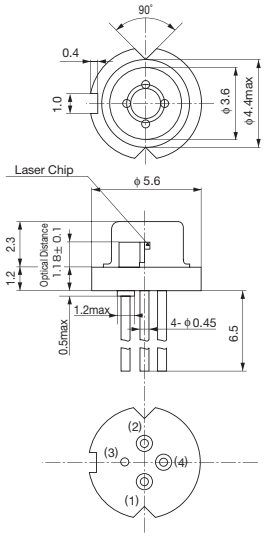
ϕ5.6mm(Open Package②)



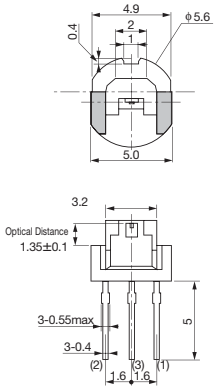
ϕ5.6mm (4PIN)



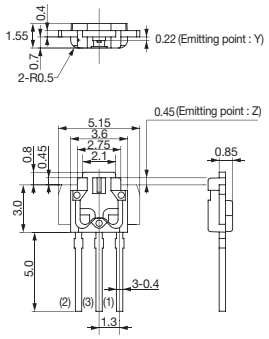
ϕ5.6mm 4PIN (Open Package)



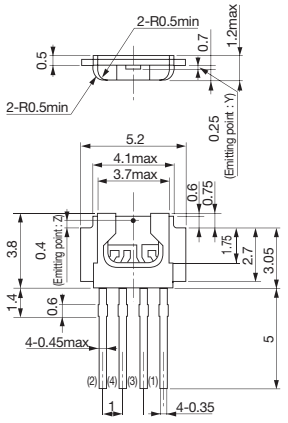
ϕ5.6mm (Compatible frame)



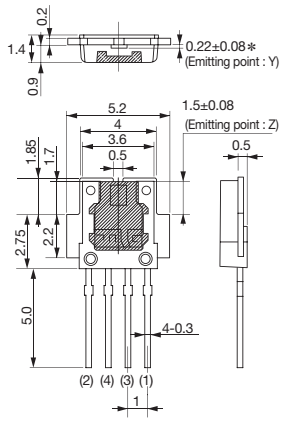
High radiation 3PIN frame



High radiation 4PIN frame



Covered High radiation 4PIN frame (Under development)

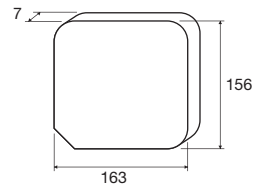


* : Please note that differences may exist depending on the part number. Therefore, it is strongly recommended that the customer verify the actual specifications before usage.

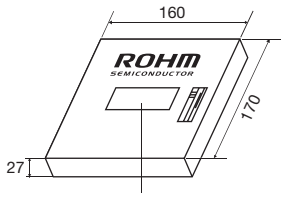
Packing Specifications (Unit : mm)

High Radiation Frame

Tray



Box

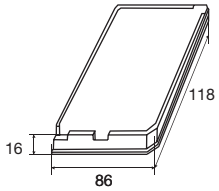


Explanation label Safety standard (JIS C6802)

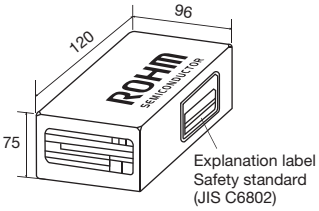
Packaging Style		Quantity per unit (pcs/tray)	Basic Ordering unit (pcs)	Weight (g)
Packaging Type	Case			
Tray	Vacuum Pack	200	1000	240

Other

Tray



Box



Explanation label Safety standard (JIS C6802)

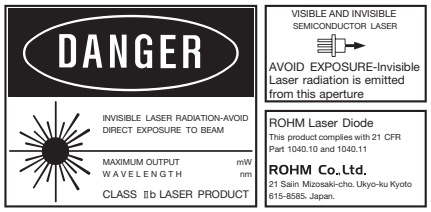
Antistatic laminate vacuum bag

Packaging Style		Quantity per unit (pcs/tray)	Basic Ordering unit (pcs)	Weight (g)
Packaging Type	Case			
Tray	Vacuum Pack	100	500	250

Safety

The light emitted from laser diodes, while almost invisible to the human eye, can cause retinal damage if viewed directly. Never look directly into the laser beam or through any lenses or fibers when the system is operating.

For optical axis alignment or other operations, we recommend the use of an infrared-sensitive camera (ITV) or wearing protective goggles.



The products described in this specification are designed to be used with ordinary electronic equipment or devices (such as audio-visual equipment, office-automation equipment, communication device, electrical appliances, and electronic toys). If you intend to use these products or devices which require an extremely high level of reliability and the malfunction of which would directly endanger human life (such as medical instruments. transportation equipment, aerospace machinery, nuclear-reactor controllers, fuel controllers and other safety devices), please be sure to consult with our sales representative in advance.

Symbols and Definitions

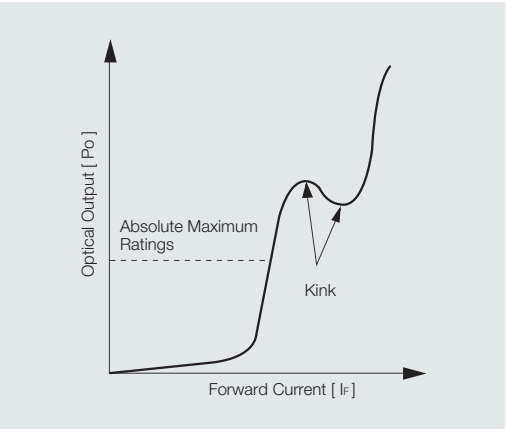
Absolute maximum ratings

Absolute maximum ratings are values which must not be exceeded even momentarily regardless of external conditions.

These values are specified for a case temperature TC of 25°C.

Parameter	Symbol	Definition
Optical Output	P_O	Maximum allowable optical output during continuous or pulse operation. No kinks will appear in the output vs. forward current curve up to this output value. (Fig. 1)
Reverse Voltage	V_R	The maximum allowable voltage when a reverse bias is applied to the device. Lasers and photo diodes are rated separately.
Operating Temperature	Topr	Allowed ambient temperature range when the device is in operation. Delined to be the case temperature of the device.
Storage Temperature	Tstg	Allowed temperature range when the device is being stored.

Fig.1 Optical Output vs. Forward Current



Electrical and Optical Characteristics

Item	Symbol	Definition
Threshold current	I_{th}	In Fig. 2, A is the spontaneous emission range and B is the stimulated emission range. The threshold current is the current at which laser emission begins.
Operating current	I_{OP}	The forward current required to generate the specified optical output.
Operating voltage	V_{OP}	The forward voltage required to generate the specified optical output.
Differential efficiency	η	The average increase in the output per unit of drive current. In the laser emission range, this is the slope of the linear optical output vs. forward current curve. (Fig. 2)
Monitor current	I_m	When the specified optical output is generated, this is the output current of the photodiode when a specified reverse voltage is applied to the monitor photodiode.
Parallel divergence angle Perpendicular divergence angle	$\theta_{//}$ $\theta_{\perp}$	Light emitted from the laser spreads as shown in Fig. 3. The result of measurements of this spread in the parallel (x) and perpendicular (y) directions with respect to the junction surface is shown in Fig. 3. The widths of the spread at the points where the strength drops to 1 / 2 the peak strength (half value full angles) are defined as angles and called $\theta_{//}$ and $\theta_{\perp}$. (Fig. 4)
Parallel deviation angle Perpendicular deviation angle	$\Delta\phi_{//}$ $\Delta\phi_{\perp}$	These values express the deviation of the optical axis with respect to the reference plane, and are defined for the parallel and perpendicular spread angles (Fig. 4) to be (a - b) / 2 (Fig. 5).
Emission point accuracy	ΔX, ΔY, ΔZ	This indicates the amount of deviation of the emission point. ΔX and ΔY indicate deviation from the center of the package, and ΔZ indicates deviation from the reference plane. (Fig. 6)
Peak emission Wavelength	λ	Peak emission wavelength when generating the specified output. As shown in Fig. 17, the emission spectrum has both a single mode and a multimode. In the multimode, the wavelength is delined as the wavelength with the highest intensity.
Coherency	γ	This parameter indicates the coherence of a laser beam. When the laser beam forms interference fringes, this parameter indicates the amount of attenuation of the clarity of the fringes.
Astigmatism (Wave Iron aberration)	A_S	Astigmatism refers to an apparent difference between the parallel and perpendicular (with respect to the junction plane) focal points (Fig. 8).
Droop	ΔP	Attenuation of output when the laser is driven by pulse. This is delined as (P1−P4) / P4 ×100% as shown in Fig. 9.

Fig.2 Optical Output vs. Forward Current

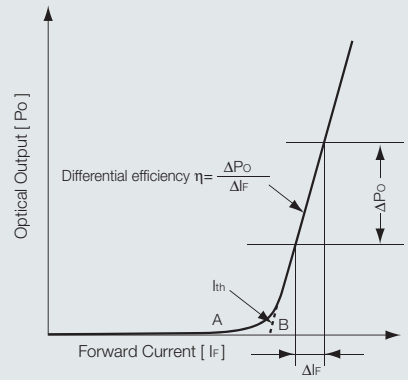


Fig.3 Radiation Characteristics

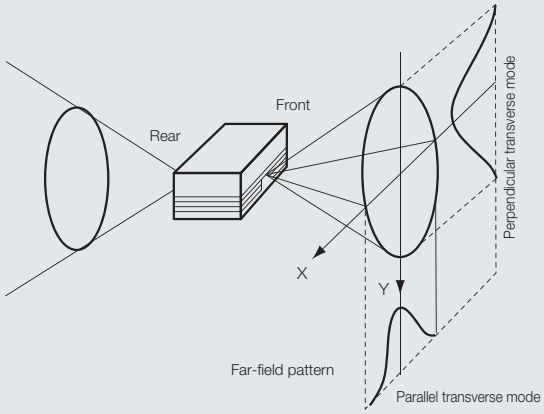


Fig.4 Radiation Characteristics

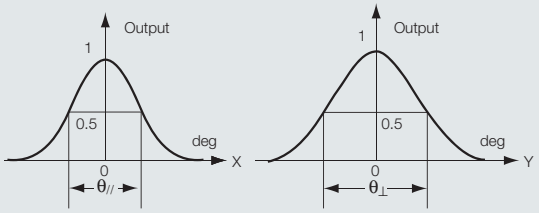


Fig.5 Deviation Angle

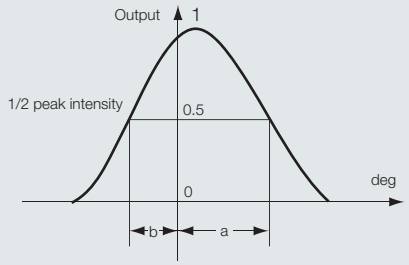


Fig.6 Emission Point Accuracy

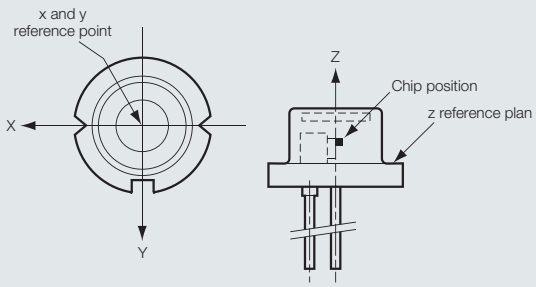


Fig.7 Emission Spectrum

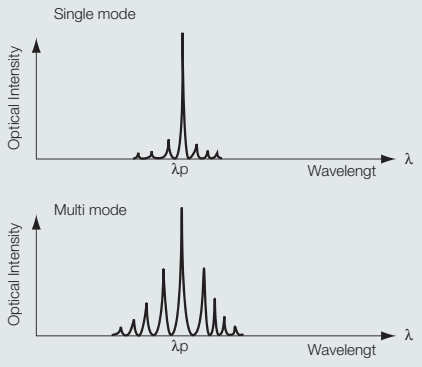


Fig.8 Astigmatism

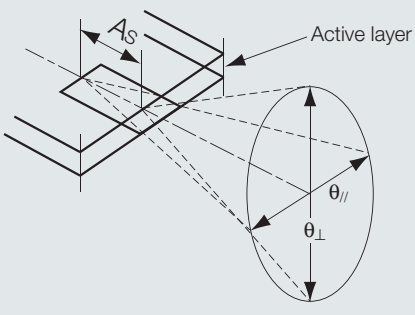
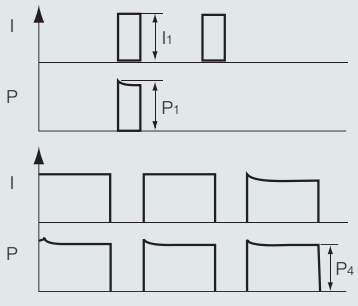


Fig.9 Droop



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