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Optical Transceivers of Small Form (SFF) For Advanced Applications (High transmission rate, single mode)

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ABSTRACT

Small Form-Factor Pluggable (SFP) is a compact, hot-swappable network interface module format used in telecom and datacom applications. SFP interfaces on network hardware are modular slots for specific media transceivers, such as B. Suitable for fiber optic or copper cables. The advantage of using SFPs over fixed interfaces such as the modular connectors in Ethernet switches is that individual ports can be equipped with different types of transceivers. SFF optical modules require new packaging technology because the optical axis of the optical part is much smaller than traditional optical modules, such as the "1by9" type, two types of optical packages are described, both for transceivers with MT-based sockets for single-mode applications. Optical coupling between optical components and fibers on the V-groove is achieved through passive alignment, reducing assembly time.

Keywords:*Optical Connectors, Optical Coupling, Optical Fiber, Single Mode Fiber and Surface Mount Technology.*

أجهزة الإرسال والاستقبال الضوئية ذات الشكل الصغير (SFF) للتطبيقات المتقدمة (معدل نقل مرتفع، وضع فردي)

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الملخص

قابس التوصيل الصغير (SFP) هو تنسيق وحدة واجهة شبكة مدمج وقابل للتبديل السريع يستخدم في تطبيقات الاتصالات والبيانات .واجهات SFP على أجهزة الشبكة عبارة عن فتحات معيارية لأجهزة إرسال واستقبال وسائط معينة، مناسبة للألياف الضوئية أو الكابلات النحاسية .تتمثل ميزة استخدام SFP على الواجهات الثابتة مثل الموصلات المعيارية في محولات Ethernet في أنه يمكن تجهيز المنافذ الفردية بأنواع مختلفة من أجهزة الإرسال والاستقبال. تتطلب الوحدات البصرية SFF تقنية تغليف جديدة لأن المحور البصري للجزء البصري أصغر بكثير من الوحدات البصرية التقليدية، مثل النوع "1bit 9tybe"، يتم وصف نوعين من الحزم البصرية، لكل من أجهزة الإرسال والاستقبال ذات المقابس القائمة علىMT للوضع الفردي التطبيقات .يتم تحقيق الاقتران البصري بين المكونات والألياف الضوئية على فتحة V من خلال المحاذاة السلبية، مما يقلل من وقت التجميع.

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الكلمات المفتاحية:
الموصلات الضوئية، الاقتران البصري، الألياف الضوئية، الألياف أحادية الوضع وتكنولوجيا التثبيت السطحي.

Introduction

The transmission media used for the communication of signals from one purpose to another are copper wires, coaxial cables, waveguides and radio links. These media have their own benefits and drawbacks. Recently, the foremost trendy medium of transmission for communication has been developed. This contemporary medium of transmission, referred to as optical fiber, has bestowed a new frontier within the field of telecommunication transmission.

Strong demand for higher throughput and forceful deduction of optical elements have created fiber-optic information transmission goods in digital computer systems or in native space networks. Many new optical connectors are projected and introduced into the market to deal with additional demand for additional compact and affordable optical wiring in large-scale systems. Those new SFF connectors, which have virtually identical kind issues as RJ-45 electrical connectors, change the doubling of the optical port density with reduced value. There is a corresponding demand for optical transceivers to be additional compact and to mate to those new connectors. New SFF optical transceivers, whose housing widths square measure 1/2 those of typical 1by9 transceivers, the square measure being developed by several vendors and a few of them have already been showing within the market.

Most optical transceivers for data communication are for multimode fiber networks since most applications in data communication do not need a long-distance transmission, but recently, single-mode fibre networks using 1300 nm Fabry-Perot laser diode are being commonly used in datacom applications because of the need for higher bit-rate of more than one Gbit/s and for higher reliability. Upgradability is another merit of a single-mode fiber network. Transmission of more than 10 Gbit/s in the future would be possible with single-mode fibers. As the cost of optical transceivers is reduced by volume production, the single-mode application would gain more acceptance.

SFF optical transceivers are the standard of the next generation for high-end datacom applications using single-mode fiber networks. In this paper, the design of SFF optical transceiver is discussed focusing on the optical packaging for high bit rate, single mode fiber transmission. Evaluation results of a prototype transceiver for 2.125 Gbit/s Fiber Channel with the MPO connector [1], [2] are also reported.

SFF AND CONVENTIONAL OPTICAL TRANSCEIVER.

Optical transceiver. 1by9 pin out package vogue optical transceivers square measure multi-sourced and square measure wide used for varied transmission speed each in single mode and multimode fiber networks. During this package, TO-canned optical parts square measure aligned associate degreed directly mounted to the sleeve of an SC receptacle. Ample area within the transceiver permits these canned devices to be placed at the transmitter and receiver section, High responsibleness, Fig. 1. Compares the difference between SFF and conventional (1by9 type).

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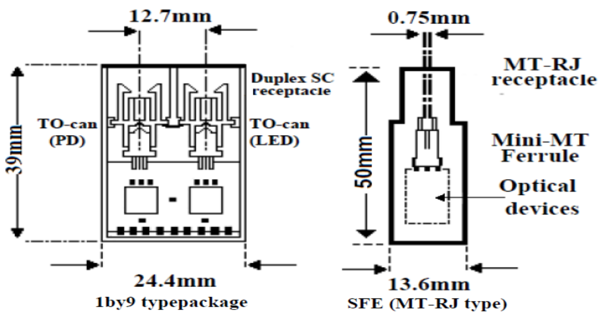

Fig. 1. Basic structure of conventional (1by9) and SFF optical transceiver.

We obtain by hermetically sealed packaging of LD & PD, The cost of airtight packaging for To-canned LD & PD is lower due to mass production.

On the opposite hand, the area between the transmitter and receiver section in the SFF optical transceiver is much narrower. For instance, the space between the optical axes of the transmitter-associated receiver within the transceiver with an MT-RJ receptacle is just zero.75mm. Therefore, constant packaging techniques as utilized in 1by9-sort optical transceivers are not applicable. It is clearly insufferable to position 2 TO-cans in parallel if they're hooked up directly to receptacle components like associate MT cap. Therefore, the packaging technique of the optical portion may be a key issue in developing SFF optical transceivers.

I will discuss two types of packing techniques for SFF transceivers for single-mode applications. The first is the fibre block structure, which uses traditional TO-can-packed LD and PD, and the fiber connections inside the jacket. Emphasis is placed on obtaining high reliability using a sealed package for LD and PD. Another technology is the surface mounting structure that uses a Si seat with V grooves, and exposed LD and PD foils with a waveguide structure. This aims to significantly reduce the cost of mass production.

FIBER-BULK STRUCTURE

High responsibility is further as high bit rate is strictly needed for high-end optical transceivers used in extremely reliable systems like digital computer systems or trunk lines of native space networks. Hermetically sealed packages are ideal for devices used in those transceivers. Utilizing normal TO-canned optical de- vices for SFF optical transceivers is desirable from the view- of the purpose of responsibility and cost.

As an answer to adopting standard TO-canned optical devices to SFF optical transceivers, a fibre-bulk structure has been developed. Fig. 2 shows the development of the transceiver that has the optical portion of the fibre-bulk structure. An MQW Fabry–Perot LD is sealed in an exceedingly TO-can. A PIN-PD and a pre-amplifier are sealed in another TO-can. Each TO-can has ball lenses on the prime of the caps. One finish of short optical fibers area unit fastened to those TO-cans by compound components (fiber retainer) and therefore the alternative finish of the fibers area unit connected to associate MT cap. The lead pins of the TO-cans are soldered to rigid/flexible hybrid circuit board at the rear end of the housing. Slightly bent, loose

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fiber wiring pre-vents excess stresses on the fibers due to the thermal expansion of parts or due to some external force.

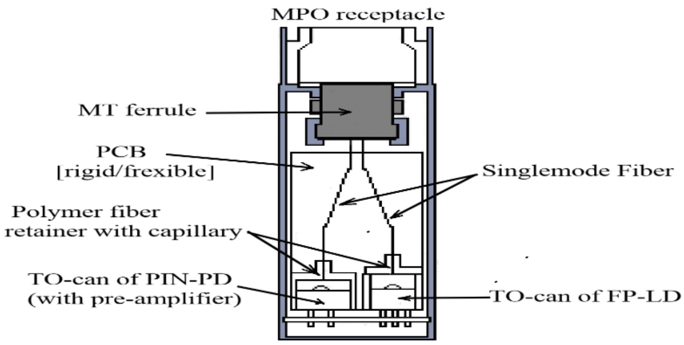

Fig. 2. Construction of the optical transceiver, which has fiber-bulk structure optical portion

The fiber retainer has an exactly shaped capillary (through hole) with a diameter of 0.126 mm to fit the fiber, and therefore the sleeve area unit is manufactured from the clear chemical compound, PES (Polyethersulfone). Injection moulding is employed for manufacturing these chemical compound components to scale back prices. The LD is actively aligned by the optical power and stuck exploitation actinic radiation cur-ready rosin. (axial) alignment is completed between the sleeve and therefore the TO-can. Alignment is completed between the sleeve and therefore the fiber retainer. Fiber edge sharpening isn't needed since the sting of glass fiber directly contacts the chemical compound surface of the sleeve and therefore the gap is full of actinic radiation curable rosin. The chemical compound and therefore the actinic radiation curable rosin have a relative index of refraction of one.5, an area unit like that of the oxide glass fiber. Because the coupling loss from the LD to the fiber is comparatively

high by utilizing the affordable spherical lens, the slight wholeness of the optical index matching is suitable. Also, the mirrored LD output lightweight at the optical input surface of the chemical compound half is prevented from going back to the LD by the angular surface. The air holes area unit is fashioned to let the actinic radiation curable rosin get into the capillary and therefore the gap simply. The structure of the receiver facet is comparable to it of the transmitter. The planned fiber-bulk structure ends up in price effectiveness of optical parts, with high reliableness maintained; Fig. 3 shows the elaborated structure round the TO-can of the LD (transmitter) side.

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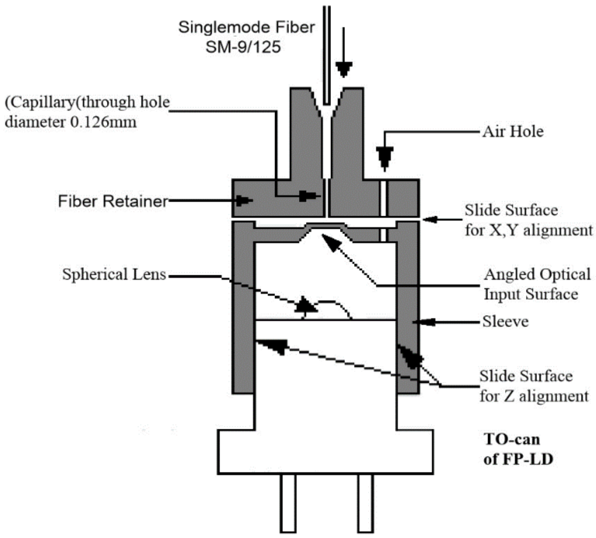
Fig. 3. Detail of the structure around TO-can of LD side.



PROTOTYPE USING FIBER-BULK STRUCTURE

A prototype transceiver with MPO receptacle has been developed using the fiber-bulk structure optical portion. It is good performance, which complies with the 2.125 Gbit/s Fiber Channel standard [3].

Fig. 4 shows the circuit diagram of the example. The functions and physical dimensions of the transceiver absolutely adjust to the trade commonplace Pin-Through Hole SFF module. The LD drive circuit consists of a high-speed current switch IC created by a GaAs method. The LD output may be turned off by a disabled management input. The receiver circuit consists of a post-amplifier that contains proof of sight perform. The IC is formed by a high-speed Si method. One necessary style issue of the circuit in a little optical transceiver is to cut back the interference from the transmitter to the receiver circuit. Differential, impedance-matched LD

drivelines area unit adopted to cut back EMI radiation from the LD package. The preamplifier is mounted at the highest place to the metal during a TO-can package to avoid increase of stray capacitance and noise around the input. Also, differential, impedance-matched lines connect the pre-amplifier output to the post-amplifier input so as to extend the immunity to each internal and external noise.

The MPO connective, a typical optical connective that is widely used and has been proven to own high reliability in single-mode fibre affiliation, is employed within the example. Since the bottom technology of MPO is analogous to alternative MT-based mostly connectors, it's straightforward to adopt the packaging technology to MT-RJ SFF optical transceivers.

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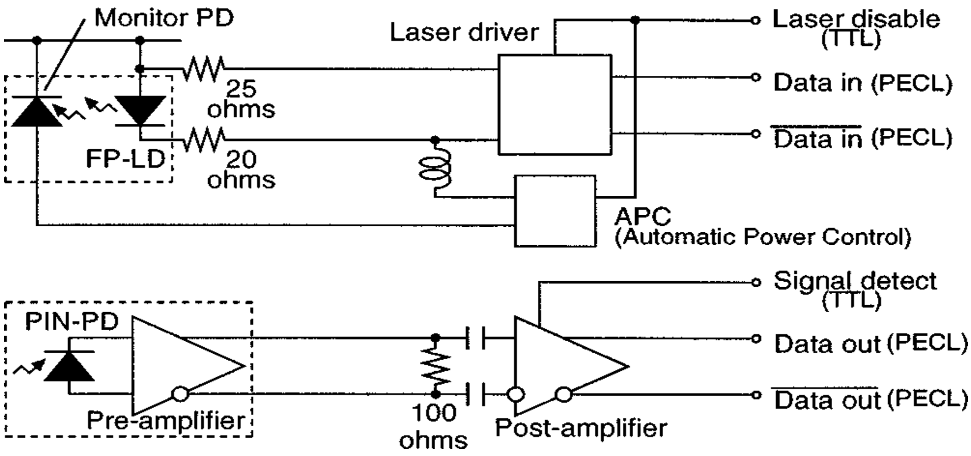

Fig. 4. Circuit block The transceiver is assembled as follows:

1. Fix the fibers to the MT ferrule with epoxy adhesive and polish the sting of the collet, (MT collet subassembly).
2. Align the LD and the PD and fix them to the fiber retainer's exploitation ultraviolet curable organic compound. Throughout the alignment, fibers (provided for alignment, not the same as those of MT collet subassembly) are inserted into the capillaries. When checking the optical coupling between the fibers and LD, PD, remove the fibers. (Optical subassemblies).
3. Solder the electronic elements (IC's, capacitors, etc.) on the rigid/flexible hybrid printed circuit board.
4. Solder the optical subassemblies to the circuit boards.
5. Put every subassembly into the housing, then insert the fibres into the capillaries, and fix them with ultraviolet-curable organic compounds.
6. Place the metal cowl once adding ultraviolet rays to the capillaries. One of the mandatory features of this assembly technique is that the last procedure contains entirely inserting the fibers into the capillary of the fiber retainer and fixing them by ultraviolet radiation compound.

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Fig. 5 shows the procedure of assembling the fiber-bulk optical portion of the prototype

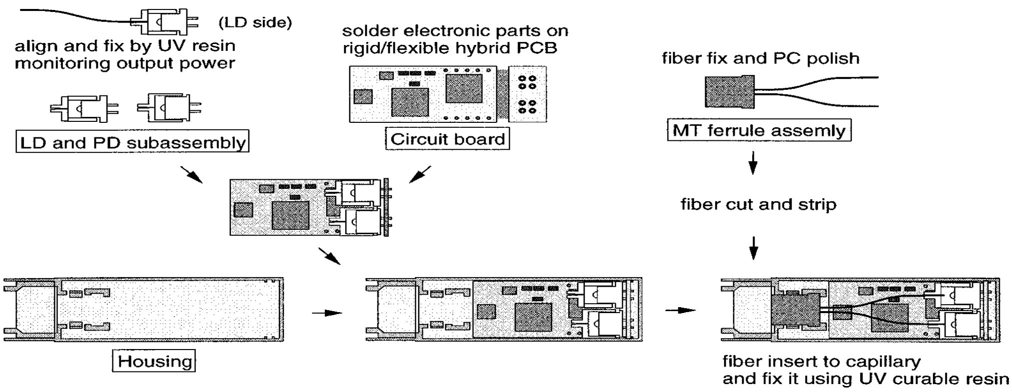

Fig. 5. Procedure of assembling the proto type which utilize the optical portion of fiber bulk structure.

Since the capillary is exactly formed by injection molding, optical affiliation is maintained when pulling off and inserting the fiber. The fiber retainer with capillary works as a sort of optical connector. This feature simplifies the total collection procedure. As for the repeatability of the optical coupling within the fiber retainer, the output power of LD changes about 3 dB in the worst case by reinsertion and gluing. To urge higher repeatability and yield, adopting transfer-shaped fiber retainers is additionally considered.

Fig. 6 shows the external appearance of the prototype transceiver. The physical dimensions fully comply with the industry standard for SFF transceivers. The housing is made of metal for heat radiation.

Fig. 6. External appearance of prototype with MPO receptacle.

Table (I) summarizes the analysis results of the image measured at prototype condition, and while not flowing. All the characteristics satisfied the specification of the short-reach reach a pair of.125 Gbit/s Fiber Channel standard. The ability consumption is reduced to one-third after adopting new ASICs for a 3.3 V power supply, which is below development

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No	unit	Specification	Result
1	Optical Output Level	-3 to -12 dB m	-7.2dBm
2	Extinction Ratio	9 min	12.7 min
3	Centre Wavelength	1270 to 1355 nm	1331.6 nm
4	RMS Spectral Width	6 max nm	2.4 nm
5	Minimum Received Power*	-20 max dB m	-21.4 dB m
6	Power Dissipation	-	1.28 w

TABLE 1. EVALUATION RESULTS OF PROTOTYPE.

Fig. 7. Shows the optical output waveform from the transmitter. It shows the rolled-off waveform using a Bessel low-pass filter with a cutoff frequency of 1600 MHz. The waveform satisfies the eye mask of the 2.125 Gbit/s Fiber Channel standard.

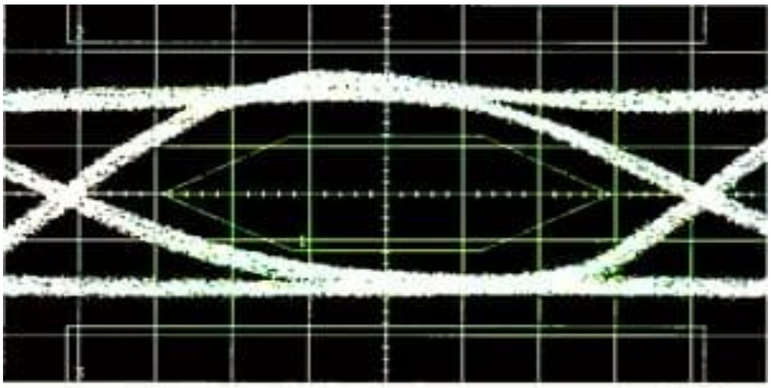

Fig. 7. Optical output waveform of transmitter (2.125 Gbit/s, PRBS 21)

Fig. 8. shows the output undulation from the receiver, When looking at the bit error rate (BER) characteristic of the receiver, we find that two traces within the graph show the characteristics with the transmitter section active or inactive. In each cases, the sensitivities were below the required value of−20 dBm. The sensitivity difference between the two cases is regarding1.5 dB. This difference is caused by interference from the transmitter to the receiver. Some shielding applied between the section could additional reduce the degradation

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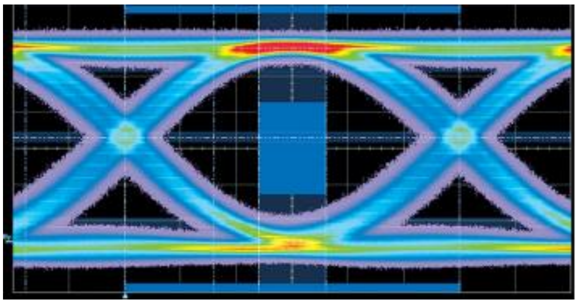

due to the interference as shown in Fig. 9.

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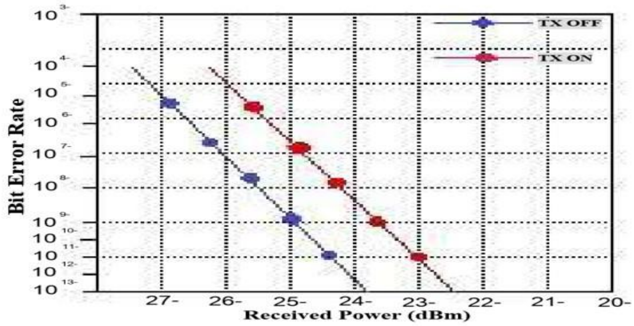
Fig. 8. Optical output waveform of transmitter (2.125 Gbit/s, PRBS 21).

Fig. 9. Bit error rate (BER) characteristics of receiver.

The stability of the optical subassembly was conjointly confirmed by temperature testing. Fig. 10 shows the optical output power of the LD optical subassembly against ambient temperature. the ability deviation over the temperature from to C was regarding two.0dB with the polymer fiber retainer, which indicates enough stability of the polymer opt ical subassembly even in singlemode use.



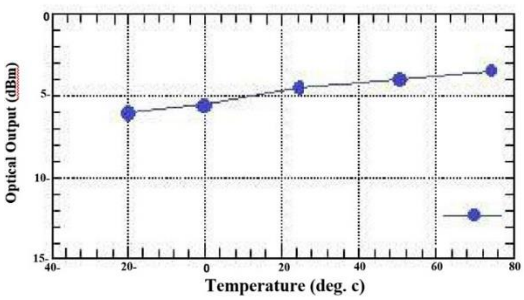


Fig. 10. Optical output power versus temperature characteristics of LD pigtail portion.

SURFACE MOUNT STRUCTURE.

The cost of assembling optical transceiver devices and parts has become a large part of the total cost as the cost decreases due to the increase in production volume and thus the cost of assembly decreases .Fig.11. and shows an example of the transceiver within the MT-RJ receptacle. V-grooves on a Si-bench are shaped by directional etching using KOH solution. Fibers are placedplace within the V-grooves and fixed by ultraviolet radiation curable rosin. The LD has an integrated waveguide and spot-size device within the chip [4].

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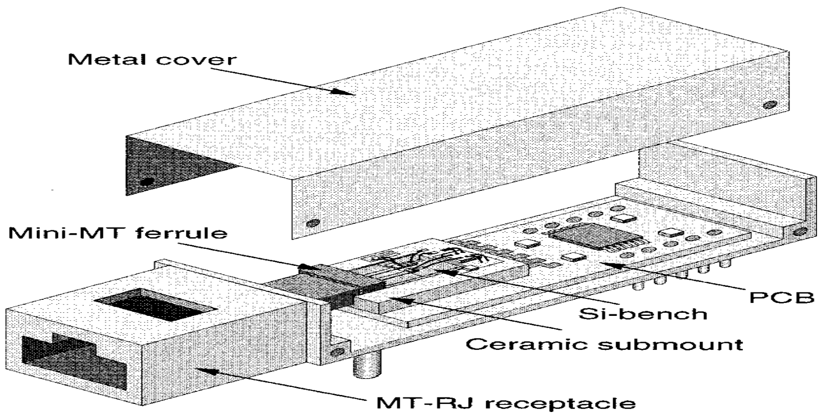

Fig. 11. Construction of the transceiver with optical subassembly by surface mounted structure.

Two PD chips, one for receiving the optical signal and another one for monitoring the LD output, also have waveguide structures and are illuminated at the side edge of the chips [5]. They are all passively aligned automatically on the Si-bench. Image processing of the alignment marks on the Si-bench and the LD or PD chip realizes passive automatic alignment. High accuracy of relative position between the V-groove and the marks are obtained by forming them from an identical mask. The alignment accuracy is about m , which is enough to realize low-loss optical coupling between the single-mode fiber and the LD. The typical coupling loss is 4 dB. The vertical alignment is achieved by dominant the thickness of electrodes and solder of the chips exactly and by utilizing a custom-designed die bonder. No lenses are required during this optical subassembly. The gaps between fiber edges and LD or PD chips are full of transparent silicon resin to keep up dependableness and to reduce the influence of reflection on the LD performance. Therefore, the surfaces of the fiber and therefore the LD are not needed to be angled. The Si-bench is placed on a ceramic submount with a pre-amplifier IC chip and a mini-MT ferrule. PC sharpening of the mini-MT ferrule is finished when inserting the fibers that are fixed on the V-grooves of the Si-bench. The length of every fibers is 8 millimetres within the mini-MT ferrule, and three millimetres within the V-grooves. The LD, PD, and IC chips area unit is sealed with silicon resin. This sealing method shows no problems under the temperature-humidity test (75°C,95%,1000 h). The ceramic sub mount has interface pins for electrical affiliation to a printed circuit board (PCB). As all of the optical components area units gathered into one subassembly, the remainder of the assembly procedure of the transceiver is simplified.

The technique utilizing the surface mount structure will reduce the cost of optical transceivers by:

1. Reduction of the quantity of precise components.
2. Using negative alignment technology to increase assembly speed

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3. Simplifying the procedure of ultimate aggregation. The overall price of the transceiver is anticipated to be remittent drastically by this technology in massive volume production.

CONCLUSIONS

Two encapsulation techniques, namely the block fiber structure and the surface mount structure, are demonstrated for the application of the high-speed single-mode optical part of the SFF optical transmitters. The model with MPO connector using the larger cross-sectional fiber structure achieved the specified performance of a 1.25 Gbit/s fiber channel. SFF optical transceivers with these technologies also increase optical port density as well as depreciate high-end systems at a bit rate of two Gbit/s or higher per port.

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