

SPECIFICATION

TITLE OF INVENTION: OPTICAL MODULE

[0001] This application claims the priority benefit of China application serial no. 202311611626.1, filed on November 29, 2023, entitled "OPTICAL MODULE". The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

Technical Field

[0002] The present application relates to the technical field of optical communication equipment, and specifically relates to an optical module.

Description of Related Art

[0003] An optical module is an optical communication equipment that performs optical-electrical and electrical-optical conversion. In recent years, the market of global cloud computing data centers has continued to expand, and the construction of 5G telecommunication networks has been fully deployed, so the market demand for high-speed optical modules is also increasing day by day. Various series and types of products have been launched successively, so as to provide optimal optical module solutions for customers in fields such as cloud computing data centers and unrepeatable transmission.

[0004] At present, due to limitations of silicon photonics technology, the output power of coherent optical modules is relatively low. In view of the above, coherent optical modules may improve output power through integrating optical amplifiers. However, protocols such as MSA (multi-source agreement) have strict requirements on the size of coherent optical modules, and it is difficult for the coherent optical modules of the related art to integrate optical amplifiers while meeting the requirements of relevant protocols.

Summary

[0005] The present application provides an optical module that adds an optical amplification assembly inside the optical module to improve the power of optical signals outputted by the optical module while meeting the size requirements of protocols.

5 **[0006]** The present application provides an optical module including a housing having an accommodating cavity therein, a main circuit board accommodated in the accommodating cavity, a light source assembly accommodated in the accommodating cavity and electrically connected to the main circuit board, and an optical amplification assembly accommodated in the accommodating cavity and electrically connected to the main circuit board. The optical
10 amplification assembly is optically connected to the light source assembly, and the optical amplification assembly is used to amplify an optical signal outputted from the light source assembly. The main circuit board, the light source assembly, and the optical amplification assembly are stacked.

[0007] In an embodiment of the present application, the optical amplification assembly includes
15 a pump source device, a wavelength division multiplexer, an amplification fiber, and an isolator. One end of the amplification fiber is connected to the wavelength division multiplexer, and the other end is connected to the isolator. The wavelength division multiplexer is used to couple the optical signal outputted from the light source assembly and pump light outputted by the pump source device into the amplification fiber. The pump source device and the amplification fiber
20 are arranged on one side of the main circuit board, and the wavelength division multiplexer and the isolator are arranged on the other side of the main circuit board.

[0008] In an embodiment of the present application, the main circuit board is disposed opposite to the light source assembly, the pump source device and the amplification fiber are arranged on a side of the main circuit board away from the light source assembly, and the wavelength division
25 multiplexer and the isolator are arranged between the main circuit board and the light source

assembly.

[0009] In an embodiment of the present application, the optical amplification assembly further includes a variable optical attenuator optically connected to the isolator and an optical monitoring detector optically connected to the variable optical attenuator. The variable optical attenuator, the optical monitoring detector, the wavelength division multiplexer, and the isolator are located on a same side of the main circuit board and are arranged side by side.

[0010] In an embodiment of the present application, the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction. The wavelength division multiplexer and the isolator are located on one side of the variable optical attenuator in the second direction, the wavelength division multiplexer is closer to the variable optical attenuator relative to the isolator, and the optical monitoring detector is located on the other side of the variable optical attenuator in the second direction.

[0011] In an embodiment of the present application, the optical amplification assembly further includes a connection fiber optically connected to the pump source device, the wavelength division multiplexer, the isolator, the variable optical attenuator, and the optical monitoring detector. The connection fiber, the wavelength division multiplexer, the isolator, the variable optical attenuator, and the optical monitoring detector are located on the same side of the main circuit board. The connection fiber includes a first coiled fiber portion, a second coiled fiber portion, a third coiled fiber portion, and a fourth coiled fiber portion connected in sequence, the first coiled fiber portion and the third coiled fiber portion are respectively located on opposite sides of the variable optical attenuator in the second direction, the first coiled fiber portion is close to the isolator, while the third coiled fiber portion is close to the optical monitoring detector, and the second coiled fiber portion and the fourth coiled fiber portion are respectively located on opposite sides of the variable

optical attenuator in the third direction.

[0012] In an embodiment of the present application, the amplification fiber is coiled around an outer periphery of the pump source device.

[0013] In an embodiment of the present application, the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction. The pump source device is arranged obliquely with respect to both the second direction and the third direction.

[0014] In an embodiment of the present application, opposite ends of the housing are respectively provided with an optical interface and an electrical interface, the optical interface is configured to be optically connected to an optical fiber outside the optical module, and one end of the main circuit board is electrically connected to equipment outside the optical module through the electrical interface. Both the light source assembly and the optical amplification assembly are arranged close to the optical interface.

[0015] In an embodiment of the present application, the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction. The housing is divided into a first housing portion and a second housing portion in the third direction. An end portion of the second housing portion is provided with the electrical interface used to be matched with an interface of external equipment, an end portion of the first housing portion is provided with the optical interface, and the first housing portion is provided with a heat sink on an outer side of a first cover. The accommodating cavity is divided into a first sub-cavity and a second sub-cavity communicating with each other in the third direction,

the first sub-cavity is located in the first housing portion, and the second sub-cavity is located in the second housing portion. A maximum length of the first sub-cavity in the first direction is greater than a maximum length of the second sub-cavity in the first direction. The light source assembly and the optical amplification assembly are accommodated in the first sub-cavity, and the light source assembly is close to a side of the first cover, to facilitate heat dissipation of the light source assembly through the first cover and the heat sink thereof.

[0016] In an embodiment of the present application, an inner wall of the first housing portion in the first direction is formed with a groove, and the groove is recessed in the first direction toward a direction away from the first sub-cavity.

[0017] In an embodiment of the present application, the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction. A length of the housing in the third direction ranges from 96.5 mm to 106.5 mm.

[0018] In an embodiment of the present application, the optical module further includes a pull ring including a force application portion and at least two sliding arms. The force application portion is connected to the housing through each of the sliding arms, the force application portion and the housing are spaced apart from each other in the third direction, and an external force is applied to the force application portion to drive the pull ring to move so as to release locking between the optical module and an external optical cage. A length of the housing in the third direction ranges from 3mm to 6mm.

[0019] Correspondingly, the present application further provides an optical module including a housing having an accommodating cavity therein, a main circuit board accommodated in the accommodating cavity, a light source assembly accommodated in the accommodating cavity and

electrically connected to the main circuit board, and an optical amplification assembly accommodated in the accommodating cavity and electrically connected to the main circuit board. The optical amplification assembly is optically connected to the light source assembly, and the optical amplification assembly is used to amplify an optical signal outputted from the light source assembly. The optical amplification assembly includes a pump source device, a wavelength division multiplexer, an isolator, and an amplification fiber. One end of the amplification fiber is connected to the wavelength division multiplexer, and the other end is connected to the isolator. The wavelength division multiplexer is used to couple an optical signal outputted from the light source assembly and pump light outputted by the pump source device into the amplification fiber. The pump source device, the wavelength division multiplexer, the isolator, and the amplification fiber are arranged on opposite sides of the main circuit board.

[0020] The beneficial effects of the present application are that, different from the related art, the present application provides an optical module. The optical module includes a light source assembly and an optical amplification assembly. The optical amplification assembly is optically connected to the light source assembly. The optical amplification assembly is used to optically amplify an optical signal outputted by the light source assembly, so that the optical module has a relatively high output power. Further, in the present application, a main circuit board, the light source assembly, and the optical amplification assembly are stacked, that is, by reasonably arranging the light source assembly and the optical amplification assembly, the size of the optical module may both meet the MSA protocol requirements and accommodate the added optical amplification assembly, so that the optical module can achieve high output power.

Description of the Drawings

[0021] To make the technical solutions provided in the embodiments of the present application more clearly illustrated, several accompanying drawings required by the embodiments for

description are briefly introduced as follows. Obviously, the drawings in the following description are merely some embodiments of the disclosure, and for a person having ordinary skill in the art, other drawings can be obtained based on these drawings without an inventive effort.

[0022] FIG. 1 is a schematic structural side view of a coherent optical module of the related art.

5 **[0023]** FIG. 2 is a schematic structural view of an optical module in an embodiment of the present application.

[0024] FIG. 3 is a schematic structural cross-sectional view of the optical module shown in FIG. 2.

[0025] FIG. 4 is a schematic view of a partial structure of the optical module shown in FIG. 2 in
10 a first embodiment.

[0026] FIG. 5 is a schematic view of a partial structure of the optical module shown in FIG. 2 in a second embodiment.

[0027] FIG. 6 is a schematic diagram of an optical amplification assembly in an embodiment of the present application.

15 **[0028]** Description of Reference Numerals:

[0029] 10: optical module, 11: housing, 111: accommodating cavity, 1111: first sub-cavity, 1112: second sub-cavity, 112: first housing portion, 113: second housing portion, 114: first cover, 115: second cover, 116: optical interface, 117: electrical interface, 118: groove, 12: main circuit board, 13: pull ring, 131: force application portion, 132: sliding arm, 14: heat sink, 15: silicon photonic
20 chip, 20: light source assembly, 30: optical amplification assembly, 31: pump source device, 33: wavelength division multiplexer, 34: isolator, 35: variable optical attenuator, 36 optical monitoring detector, 37 connection fiber, 371: first coiled fiber portion, 372: second coiled fiber portion, 373: third coiled fiber portion, 374: fourth coiled fiber portion, 38: amplification fiber.

25 Specific Embodiments

[0030] The technical solutions in the embodiments of the present application will be clearly and completely described below together with the drawings in the embodiments of the present application. Obviously, the described embodiments are only part of the embodiments of the present application, not all of the embodiments. Based on the embodiments in the present application, all other embodiments obtained by a person having ordinary skill in the art without creative labor are within the scope of protection of the present application. In addition, it should be understood that the specific embodiments described herein serve to illustrate and explain the present application merely and are not used to limit the present application. In the present application, unless otherwise specified, the directional terms used such as "upper", "lower", "left", and "right" usually refer to the upper, lower, left, and right directions when the device is in actual use or working state, specifically referring to the drawing directions in the accompanying drawings.

[0031] In the present application, unless otherwise clearly specified and defined, terms such as "connected", "connection", "stacked" and the like should be understood in a broad sense. For instance, it may be a fixed connection, or a detachable connection, or integrated; it may be directly connected, or indirectly connected through an intermediate medium, or it may be the internal communication between two elements or the interaction relationship between two elements. For a person having ordinary skill in the art, the specific meanings of the above terms in the present application may be understood according to specific circumstances.

[0032] The present application provides an optical module, which will be described in detail below. It should be noted that the description order of the following embodiments is not intended to limit the preferred order of the embodiments of the present application. Moreover, in the following embodiments, the description of each embodiment has its own emphasis, and for parts not described in detail in a certain embodiment, reference may be made to the relevant description of other embodiments.

[0033] In QSFP-DD (quad small form factor pluggable-double density) packaged coherent

optical modules, silicon photonic modulation schemes are adopted, and their output power is limited by silicon photonic technology. For scenarios of 100G transmission, the output power of conventional coherent optical modules can only reach around -6.5dBm. For scenarios of 400G transmission, the output power of conventional coherent optical modules can only reach around -9dBm. Further, conventional coherent optical modules have already sacrificed certain OSNR (optical signal noise ratio) performance in order to ensure the output power of -6.5dBm to -9dBm. The above factors lead to limited applications of conventional coherent optical modules in unrepeated point-to-point transmission scenarios.

[0034] Coherent optical modules may improve the output power through integration of EDFAs (erbium doped fiber amplifiers), enabling the output power of coherent optical modules to reach +5dBm. In transmission scenarios of IP over DWDM and point-to-point transmission scenarios, coherent optical modules with integration of EDFAs may optimize network structure and reduce deployment costs. Further, coherent optical modules with integration of EDFAs may also be compatible with the emerging ROADM (reconfigurable optical add-drop multiplexer) line systems, playing a significant role in metro/regional ROADM networks.

[0035] However, the length and width size of conventional EDFA packaging is 35 mm*20 mm. The length and width size of QSFP-DD coherent optical modules specified by MSA protocol is 127.86 mm*18.35 mm. It can be seen that the width of an EDFA is greater than the width of a coherent optical module, which results in the EDFA being unable to be packaged in the QSFP-DD coherent optical module or smaller coherent optical modules. Further, the four sizes of the coherent optical module as shown in FIG. 1 (i.e., A1, A2, A3, and A4) as well as the total length of the optical module including the pull ring need to satisfy MSA protocol requirements. Therefore, how to package EDFAs in coherent optical modules while ensuring that the size of coherent optical modules satisfies MSA protocol requirements is an urgent problem to be solved.

[0036] In view of the above, the embodiments of the present application provide an optical

module with high output power, and the size of the optical module in the embodiments of the present application may satisfy the protocol requirements as well. Detailed elaboration is provided in the following paragraphs.

[0037] Referring to FIG. 2 and FIG. 3, FIG. 2 is a schematic structural view of an optical module in an embodiment of the present application, and FIG. 3 is a schematic structural cross-sectional view of the optical module shown in FIG. 2.

[0038] In an embodiment, an optical module 10 includes a housing 11, and the housing 11 acts as a basic carrier of the optical module 10 for packaging and protecting the remaining components of the optical module 10. Specifically, the housing 11 has an accommodating cavity 111 therein, and the accommodating cavity 111 is used to accommodate the remaining components of the optical module 10. The housing 11 further includes a first cover 114 and a second cover 115. The optical module 10 has a first direction (as shown by arrow Z in FIG. 3, the same below), a second direction (as shown by arrow X in FIG. 2, the same below), and a third direction (as shown by arrow Y in FIG. 2 and FIG. 3, the same below) that are mutually perpendicular in pairs. The first cover 114 and the second cover 115 cover each other in the first direction to form the accommodating cavity 111, that is, the accommodating cavity 111 is located between the first cover 114 and the second cover 115. The length of the optical module 10 in the second direction is less than the length of the optical module 10 in the third direction. The first direction is a height direction of the optical module 10, the second direction is a width direction of the optical module 10, and the third direction is a length direction of the optical module 10.

[0039] The optical module 10 further includes a light source assembly 20, a main circuit board 12, and an optical amplification assembly 30, and the light source assembly 20, the main circuit board 12, and the optical amplification assembly 30 are all accommodated in the accommodating cavity 111. The optical amplification assembly 30 is optically connected to the light source assembly 20, the light source assembly 20 and the optical amplification assembly 30 are both

electrically connected to the main circuit board 12, and the optical amplification assembly 30 is used to optically amplify an optical signal outputted by the light source assembly 20, so that the optical module 10 of this embodiment has improved output power.

[0040] Referring to FIG. 4 and FIG. 5 together, FIG. 4 is a schematic view of a partial structure of the optical module shown in FIG. 2 in a first embodiment, and FIG. 5 is a schematic view of a partial structure of the optical module shown in FIG. 2 in a second embodiment. Herein, FIG. 4 omits the first cover 114 and the light source assembly 20 of the optical module 10, and FIG. 4 shows a top view perspective of the optical module 10 shown in FIG. 2. FIG. 5 omits the second cover 115 of the optical module 10, and FIG. 5 shows a bottom view perspective of the optical module 10 shown in FIG. 2. The optical amplification assembly 30 in the embodiments of the present application is elaborated in the following paragraphs.

[0041] In an embodiment, the main circuit board 12 is integrated with a signal circuit and a power supply circuit, and the main circuit board 12 connects the electronic devices in the optical module 10 according to circuit design through circuit traces, so that electrical functions such as power supply, electrical signal transmission, and grounding can be implemented. The housing 11 has an optical interface 116 and an electrical interface 117 at opposite ends in the third direction, the optical interface 116 is used to be optically connected to an optical fiber outside the optical module 10, and one end of the main circuit board 12 is electrically connected to an equipment outside the optical module 10 through the electrical interface 117. One end of the main circuit board 12 is designed with golden fingers, and the golden fingers are used to be connected to an electrical connector of an optical cage on customer equipment through the electrical interface 117. The main circuit board 12 is also integrated with an electrical chip (not shown), which is used to control and/or process electrical signals, such as a DSP (digital signal processor), etc.

[0042] In an embodiment of the present application, the devices of the optical amplification assembly 30 are connected through optical fibers, a packaging shell of the optical amplification

assembly 30 is omitted, and the devices of the optical amplification assembly 30 are directly arranged in the accommodating cavity 111 of the housing 11 of the optical module 10. In this embodiment, the main circuit board 12, the light source assembly 20, and the devices of the optical amplification assembly 30 are stacked within the housing 11. In this way, with reasonable
5 arrangement of the light source assembly 20 and the optical amplification assembly 30 in this embodiment, the stacked structure composed of the light source assembly 20 and the optical amplification assembly 30 is relatively compact, so that the utilization of an internal space of the optical module 10 is improved, a size of the optical module 10 may both satisfy the MSA protocol requirements and accommodate the added optical amplification assembly 30, thereby achieving
10 high output power for the optical module 10.

[0043] Specifically, in an embodiment, the optical amplification assembly 30 includes a pump source device 31, a wavelength division multiplexer 33, an isolator 34, and an amplification fiber 38, wherein the amplification fiber 38 is preferably an erbium doped fiber, to form an erbium doped fiber amplifier (EDFA). The wavelength division multiplexer 33 is optically connected to
15 the light source assembly 20 and the pump source device 31. The isolator 34 is optically connected to the wavelength division multiplexer 33 through the amplification fiber 38. One end of the amplification fiber 38 is connected to the wavelength division multiplexer 33, and the other end is connected to the isolator 34. One end of the wavelength division multiplexer 33 is connected to the amplification fiber 38, and the other end is optically connected to the light source
20 assembly 20 and the pump source device 31. The wavelength division multiplexer 33 is used to couple the optical signal outputted from the light source assembly 20 and pump light outputted by the pump source device 31 into the amplification fiber 38. The wavelength division multiplexer 33 may specifically be an IWDM (isolated wavelength division multiplexer 33), etc.

[0044] In an embodiment, referring to FIG. 6 together, FIG. 6 shows a system block diagram of
25 the optical amplification assembly 30 in an embodiment of the present application. In this

embodiment, the optical amplification assembly 30 further includes a variable optical attenuator 35 and an optical monitoring detector 36, the variable optical attenuator 35 is optically connected to the isolator 34, and the optical monitoring detector 36 is optically connected to the variable optical attenuator 35. A modulator is integrated on the main circuit board 12, the light source assembly 20 is optically connected to the wavelength division multiplexer 33 through the modulator, and the optical signal outputted by the light source assembly 20 is modulated by the modulator and then inputted to the wavelength division multiplexer 33. The wavelength division multiplexer 33 combines the optical signal outputted by the light source assembly 20 and the pump light outputted by the pump source device 31 into one path and inputs it to the amplification fiber 38, and the pump light outputted by the pump source device 31 excites the amplification fiber 38 to amplify the optical signal outputted by the light source assembly 20 and then outputs sequentially through the isolator 34, the variable optical attenuator 35, and the optical monitoring detector 36, so that the optical module 10 has relatively high output power. The output power of the optical module 10 in the embodiments of the present application may reach +5dBm.

[0045] In the embodiments of the present application, the optical amplification assembly 30 does not adopt an independent packaging box, but arranges its various devices at different positions on the main circuit board 12. Specifically, in this embodiment, the pump source device 31, the wavelength division multiplexer 33, the isolator 34, and the amplification fiber 38 are arranged on opposite sides of the main circuit board 12. Specifically, the pump source device 31 and the amplification fiber 38 are arranged on one side of the main circuit board 12, and the wavelength division multiplexer 33 and the isolator 34 are arranged on the other side of the main circuit board 12. The pump source device 31 and the amplification fiber 38 are located on one side of the main circuit board 12 in the first direction, and the wavelength division multiplexer 33 and the isolator 34 are located on the other side of the main circuit board 12 in the first direction. In this way, in the optical amplification assembly 30 of this embodiment, the packaging box is not needed

compared to a conventional EDFA. Further, through reasonable arrangement of various functional devices of the optical amplification assembly 30, integration of the optical amplification assembly 30 into the optical module 10 is implemented, so that the output power of the optical module 10 is improved through the optical amplification assembly 30, and the size of the optical module 10 is also ensured to satisfy protocol requirements. Further, it is considered in this embodiment that since a volume of the pump source device 31 is greater than that of other devices of the optical amplification assembly 30, the pump source device 31 is arranged separately from the wavelength division multiplexer 33 and the isolator 34 on both sides of the main circuit board 12, so as to improve the utilization of the internal space of the optical module 10, and it may also be further ensured that the size of the optical module 10 satisfies protocol requirements.

[0046] Further, the main circuit board 12 and the light source assembly 20 are arranged opposite to each other, the pump source device 31 and the amplification fiber 38 are stacked on the side of the main circuit board 12 away from the light source assembly 20, and the wavelength division multiplexer 33 and the isolator 34 are stacked between the main circuit board 12 and the light source assembly 20. The main circuit board 12, the light source assembly 20, and the optical amplification assembly 30 form a four-layer stacked structure.

[0047] In an embodiment, a heat sink 14 is provided outside the housing 11 for heat dissipation of the optical module 10. In this embodiment, the housing 11 is divided into a first shell portion 112 and a second shell portion 113 in the third direction, the first shell portion 112 and the second shell portion 113 are connected to each other, and the first shell portion 112 is provided with the heat sink 14 outside the first cover 114. The accommodating cavity 111 is divided into a first sub-cavity 1111 and a second sub-cavity 1112 in the third direction, and the first sub-cavity 1111 and the second sub-cavity 1112 communicate with each other. The first sub-cavity 1111 is located in the first shell portion 112, and the second sub-cavity 1112 is located in the second shell portion 113. It is considered in this embodiment that the first shell portion 112 has a larger space

and is provided with the heat sink 14, so a maximum length H1 of the first sub-cavity 1111 in the first direction may be set to be greater than a maximum length H2 of the second sub-cavity 1112 in the first direction, so that the first sub-cavity 1111 in the first shell portion 112 has sufficient space to accommodate the light source assembly 20 and the optical amplification assembly 30.

5 Therefore, the light source assembly 20 and the optical amplification assembly 30 are accommodated in the first sub-cavity 1111, which is beneficial for arranging the light source assembly 20 and the optical amplification assembly 30 together within the optical module 10. In addition, the light source assembly 20 and the optical amplification assembly 30 are arranged in the first shell portion 112 in this embodiment, so that the light source assembly 20 and the optical
10 amplification assembly 30 are close to the heat sink 14, particularly making the light source assembly 20 close to the side of the first cover 114, to facilitate heat dissipation of the light source assembly 20 through the first cover 114 and the heat sink 14 thereon, so that the heat dissipation effect of the light source assembly 20 and the optical amplification assembly 30 is thereby improved.

15 **[0048]** Further, an inner wall of the first shell portion 112 in the first direction is formed with a groove 118, the groove 118 is recessed in the first direction toward a direction away from the first sub-cavity 1111, so that the maximum length H1 of the first sub-cavity 1111 in the first direction is greater than the maximum length H2 of the second sub-cavity 1112 in the first direction. FIG. 3 exemplarily shows that both a lower surface of the first cover 114 in the first direction and an
20 upper surface of the second cover 115 in the first direction are formed with grooves 118.

[0049] It should be noted that the second shell portion 113 is used to be matched with an interface of an external equipment, the length (i.e., thickness) of the second shell portion 113 in the first direction is limited by standards, while the first shell portion 112 does not need to be inserted into the interface of the external equipment. Therefore, the length of the first shell
25 portion 112 in the first direction may be greater than the length of the second shell portion 113 in

the first direction, so that the inner wall of the first shell portion 112 in the first direction may be formed with the groove 118.

[0050] In an embodiment, the heat sink 14 includes a plurality of heat dissipation columns arranged in an array, so that a heat dissipation area of the optical module 10 is increased through the plurality of heat dissipation columns, and that heat dissipation efficiency of the optical module 10 is improved. Certainly, in other embodiments of the present application, the heat sink 14 may also include heat dissipation structures such as heat dissipation fins, which is not limited herein.

[0051] It is considered in this embodiment that the pump source device 31 has a relatively large volume, and the side of the main circuit board 12 away from the heat sink 14 has sufficient space.

Therefore, the pump source device 31 and the amplification fiber 38 are arranged on the side of the main circuit board 12 away from the heat sink 14. In addition, this also facilitates the thermally connection between the pump source device 31 and the second cover 115, allowing for heat dissipation through the second cover 115. The wavelength division multiplexer 33 and the isolator 34 are located on the side of the main circuit board 12 facing the heat sink 14 and are arranged between the main circuit board 12 and the light source assembly 20. Such reasonable arrangement of each device of the optical amplification assembly 30 improves the utilization of the internal space of the optical module 10, and further ensures that the size of the optical module 10 satisfies protocol requirements.

[0052] In an embodiment, both the light source assembly 20 and the optical amplification assembly 30 are arranged close to the optical interface 116. In this way, the utilization of the internal space of the optical module 10 may be improved in this embodiment by reasonably designing the arrangement positions of the light source assembly 20 and the optical amplification assembly 30 in the third direction, and further ensure that the size of the optical module 10 satisfies protocol requirements.

[0053] In an embodiment, as shown in FIG. 4, the wavelength division multiplexer 33 and the

isolator 34 are located on one side of the variable optical attenuator 35 in the second direction, the wavelength division multiplexer 33 is closer to the variable optical attenuator 35 relative to the isolator 34, and the optical monitoring detector 36 is located on the other side of the variable optical attenuator 35 in the second direction. The positions of the variable optical attenuator 35 and the optical monitoring detector 36 on the main circuit board 12 are relatively fixed, the variable optical attenuator 35 is located in a middle region of the main circuit board 12 in the second direction, and the optical monitoring detector 36 is located at one side edge of the main circuit board 12 in the second direction. The wavelength division multiplexer 33 and the isolator 34 are located on the side of the variable optical attenuator 35 away from the optical monitoring detector 36. Further, since the volume of the wavelength division multiplexer 33 is greater than the volume of the isolator 34, the isolator 34 is arranged at the edge position of the main circuit board 12 in the second direction, while the wavelength division multiplexer 33 is arranged between the isolator 34 and the variable optical attenuator 35, so that the isolator 34 may avoid a connection fiber 37 described in the following paragraphs. The space between the variable optical attenuator 35 and the optical monitoring detector 36 is insufficient to accommodate the wavelength division multiplexer 33. In this way, the utilization of the internal space of the optical module 10 is improved in this embodiment by reasonably arranging each functional device of the optical amplification assembly 30, and further ensures that the size of the optical module 10 satisfies protocol requirements.

[0054] Further, the optical amplification assembly 30 further includes the connection fiber 37, and the connection fiber 37 is optically connected to the pump source device 31, the wavelength division multiplexer 33, the isolator 34, the variable optical attenuator 35, and the optical monitoring detector 36. A silicon photonic chip 15 is also integrated on the main circuit board 12, the light source assembly 20 is optically connected to the silicon photonic chip 15 through the connection fiber 37, and the silicon photonic chip 15 is also optically connected to the wavelength

division multiplexer 33 through the connection fiber 37. The isolator 34 and the variable optical attenuator 35, as well as the variable optical attenuator 35 and the optical monitoring detector 36, are both optically connected through the connection fiber 37.

[0055] The connection fiber 37, the wavelength division multiplexer 33, the isolator 34, the variable optical attenuator 35, and the optical monitoring detector 36 are located on the same side of the main circuit board 12. The connection fiber 37 has a relatively long length, so the connection fiber 37 is arranged in coils around a circumference of the housing 11. Therefore, the connection fiber 37 includes a first coiled fiber portion 371, a second coiled fiber portion 372, a third coiled fiber portion 373, and a fourth coiled fiber portion 374 connected in sequence. The first coiled fiber portion 371 and the third coiled fiber portion 373 are located on both sides of the variable optical attenuator 35 in the second direction, the first coiled fiber portion 371 is close to the isolator 34, and the third coiled fiber portion 373 is close to the optical monitoring detector 36. The second coiled fiber portion 372 and the fourth coiled fiber portion 374 are located on both sides of the variable optical attenuator 35 in the third direction. In this embodiment, since the volume of the isolator 34 and the volume of the optical monitoring detector 36 are relatively small, the isolator 34 and the optical monitoring detector 36 are arranged at the edge positions of the main circuit board 12 in the second direction, so as to avoid the first coiled fiber portion 371 and the third coiled fiber portion 373 of the connection fiber 37. As such, the size of the optical amplification assembly 30 in the first direction is reduced, the utilization of the internal space of the optical module 10 is improved, and that the size of the optical module 10 is ensured to satisfy protocol requirements.

[0056] In an embodiment, as shown in FIG. 5, the pump source device 31 is arranged obliquely with respect to both the second direction and the third direction. In this way, it is ensured that the pump source device 31 does not significantly affect the size of the optical module 10 in the second direction in this embodiment, while the space occupied by the pump source device 31 in

the third direction is minimized as much as possible. As such, a region of the main circuit board 12 where the pump source device 31 is not arranged in the third direction is sufficient for accommodating other electronic devices, so the utilization of the internal space of the optical module 10 is improved, and that the size of the optical module 10 is ensured to satisfy protocol requirements. Further, the amplification fiber 38 is coiled around an outer periphery of the pump source device 31.

[0057] It should be noted that the optical amplification assembly 30 in the embodiment of the present application may be an EDFA (erbium doped fiber amplifier) or the like, where the amplification fiber 38 is an erbium doped fiber. The working principle of the above optical amplification assembly 30 falls within the understanding scope of a person having ordinary skill in the art, and description thereof is not elaborated herein.

[0058] In the embodiments of the present application, the light source assembly 20 includes a light-emitting device 21 and a light source circuit board 22, and the light-emitting device 21 is electrically connected to the light source circuit board 22. The light source circuit board 22 is integrated with a logic control circuit, the light source circuit board 22 is used to control the light-emitting device 21 to output an optical signal, and the light source circuit board 22 may be electrically connected to the main circuit board 12 through a flexible circuit board or a plug-in electrical connector. The light-emitting device 21 includes a hermetic box, and the hermetic box has a packaging cavity inside. The light-emitting device 21 further includes a tunable laser module, the tunable laser module is packaged in the packaging cavity, and the tunable laser module is used to generate a wavelength-tunable optical signal. In this embodiment, the tunable laser module adopts a semiconductor gain chip combined with a tunable external cavity, so as to generate wavelength-tunable laser with a narrow line width. The light-emitting device 21 further includes an output head, and the output head is used to output the optical signal generated by the tunable laser module.

[0059] The optical monitoring detector 36 of the above optical amplification assembly 30 has a small size and may be placed between the light-emitting device 21 and the main circuit board 12. The wavelength division multiplexer 33, the isolator 34, and the variable optical attenuator 35 have relatively large sizes and may be placed between the light source circuit board 22 and the main circuit board 12, while the pump source device 31 and the amplification fiber 38 are arranged on the other side of the main circuit board 12, thereby making the stacked structure of the light source assembly 20, the main circuit board 12, and the optical amplification assembly 30 more compact.

[0060] Referring to FIG. 2 again, in an embodiment, in order to arrange the light source assembly 20 and optical amplification assembly 30 inside the optical module 10, while ensuring that an overall length of the optical module 10 remains unchanged and satisfies the specific size requirements of protocol standards, a length of a portion with the heat sink 14 of the housing 11 of the optical module 10 is extended. Therefore, in this embodiment, a length L1 of the housing 11 in the third direction is 96.5 mm to 106.5 mm, for example, 96.5 mm, 96.12 mm, 97.35 mm, 98.16 mm, 99.68 mm, 101.66 mm, 102.41 mm, 103.72 mm, 104.69 mm, 106.5 mm, etc. In this way, the accommodating cavity 111 inside the housing 11 has sufficient space, so that a length of the main circuit board 12 in the third direction may also be appropriately extended to accommodate the light source assembly 20 and the optical amplification assembly 30, ensuring that the optical module 10 has high output power.

[0061] In an embodiment, the optical module 10 further includes a pull ring 13, and the pull ring 13 is connected to the housing 11. The pull ring 13 is used to release locking between the optical module 10 and the optical cage. Specifically, when the optical module 10 is inserted in the optical cage, the pull ring 13 can be pulled from outside to release the locking between the optical module 10 and the optical cage, thereby allowing the optical module 10 to be pulled out from the optical cage. Specifically, the pull ring 13 includes a force application portion 131 and at least two sliding arms 132. The force application portion 131 is connected to the housing 11 through each

sliding arm 132. An external force is applied to the force application portion 131 to drive the pull ring 13 to move to release the locking between the optical module 10 and the optical cage. The force application portion 131 and the housing 11 are spaced apart from each other in the third direction, and the user applies a force to the force application portion 131 through a gap between the force application portion 131 and the housing 11.

[0062] Considering that the length of the housing 11 of the optical module 10 is extended, in order to ensure that the overall length of the optical module 10 and a length L2 of the gap between the force application portion 131 on the pull ring 13 and the housing 11 satisfy the requirements, a length L3 of the force application portion 131 in the third direction is reduced in this embodiment.

Specifically, the length L3 of the force application portion 131 in the third direction is 3 mm to 6 mm, for example, 3 mm, 3.5 mm, 4 mm, 4.5 mm, 5 mm, 5.5 mm, 6 mm, etc., so that there is a sufficiently large gap between the force application portion 131 and the housing 11, which may facilitate the pluggable connection between an external optical fiber and the optical interface 116 of the optical module 10. Meanwhile, the length L3 of the force application portion 131 in the third direction in this embodiment is not excessively small, which may ensure that the force application portion 131 has sufficient structural strength and sufficient space for marking.

[0063] The optical module provided by the present application has been described in detail above. Specific examples have been applied in this document to illustrate the principles and implementation methods of the present application. The description of the above embodiments is only used to help understand the method and core idea of the present application. Meanwhile, for a person having ordinary skill in the art, based on the idea of the present application, there will be changes in specific implementation methods and application scope. In summary, the content of this specification should not be understood as a limitation on the present application.

CLAIMS

[Claim 1] An optical module, characterized in comprising:

a housing, having an accommodating cavity therein;

a main circuit board, accommodated in the accommodating cavity;

5 a light source assembly, accommodated in the accommodating cavity and electrically connected to the main circuit board; and

an optical amplification assembly, accommodated in the accommodating cavity and electrically connected to the main circuit board, wherein the optical amplification assembly is optically connected to the light source assembly, and the optical amplification assembly is
10 configured to amplify an optical signal outputted from the light source assembly;

wherein the main circuit board, the light source assembly, and the optical amplification assembly are stacked.

[Claim 2] The optical module according to claim 1, characterized in that

the optical amplification assembly comprises a pump source device, a wavelength division
15 multiplexer, an amplification fiber, and an isolator;

one end of the amplification fiber is connected to the wavelength division multiplexer, and the other end is connected to the isolator;

the wavelength division multiplexer is configured to couple the optical signal outputted from the light source assembly and pump light outputted by the pump source device into the
20 amplification fiber;

wherein the pump source device and the amplification fiber are arranged on one side of the main circuit board, and the wavelength division multiplexer and the isolator are arranged on the other side of the main circuit board.

[Claim 3] The optical module according to claim 2, characterized in that

25 the main circuit board is disposed opposite to the light source assembly, the pump source

device and the amplification fiber are arranged on the side of the main circuit board away from the light source assembly, and the wavelength division multiplexer and the isolator are arranged between the main circuit board and the light source assembly.

[Claim 4] The optical module according to claim 2 or 3, characterized in that

the optical amplification assembly further comprises:

a variable optical attenuator, optically connected to the isolator; and

an optical monitoring detector, optically connected to the variable optical attenuator;

wherein the variable optical attenuator, the optical monitoring detector, the wavelength division multiplexer, and the isolator are located on a same side of the main circuit board and are arranged side by side.

[Claim 5] The optical module according to claim 4, characterized in that

the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction,

wherein the wavelength division multiplexer and the isolator are located on one side of the variable optical attenuator in the second direction, the wavelength division multiplexer is closer to the variable optical attenuator relative to the isolator, and the optical monitoring detector is located on the other side of the variable optical attenuator in the second direction.

[Claim 6] The optical module according to claim 5, characterized in that

the optical amplification assembly further comprises:

a connection fiber, optically connected to the pump source device, the wavelength division multiplexer, the isolator, the variable optical attenuator, and the optical monitoring detector, wherein the connection fiber, the wavelength division multiplexer, the isolator, the variable optical attenuator, and the optical monitoring detector are located on the same side of the main circuit

board;

wherein the connection fiber comprises a first coiled fiber portion, a second coiled fiber portion, a third coiled fiber portion, and a fourth coiled fiber portion connected in sequence, the first coiled fiber portion and the third coiled fiber portion are respectively located on opposite sides of the variable optical attenuator in the second direction, the first coiled fiber portion is close to the isolator, while the third coiled fiber portion is close to the optical monitoring detector, and the second coiled fiber portion and the fourth coiled fiber portion are respectively located on opposite sides of the variable optical attenuator in the third direction.

[Claim 7] The optical module according to claim 2 or 3, characterized in that

the amplification fiber is coiled around an outer periphery of the pump source device.

[Claim 8] The optical module according to claim 2 or 3, characterized in that

the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction;

wherein the pump source device is arranged obliquely with respect to both the second direction and the third direction.

[Claim 9] The optical module according to claim 1, characterized in that

opposite ends of the housing are respectively provided with an optical interface and an electrical interface, the optical interface is configured to be optically connected to an optical fiber outside the optical module, and one end of the main circuit board is configured to be electrically connected to an equipment outside the optical module through the electrical interface;

wherein both the light source assembly and the optical amplification assembly are arranged close to the optical interface.

[Claim 10] The optical module according to claim 1, characterized in that

the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction;

5 wherein the housing is divided into a first housing portion and a second housing portion in the third direction, the accommodating cavity is divided into a first sub-cavity and a second sub-cavity communicating with each other in the third direction, the first sub-cavity is located in the first housing portion, the second sub-cavity is located in the second housing portion; a maximum length of the first sub-cavity in the first direction is greater than a maximum length of the second
10 sub-cavity in the first direction, the second housing portion is configured to be matched with an interface of an external equipment, the first housing portion is provided with a heat sink, and the light source assembly and the optical amplification assembly are accommodated in the first sub-cavity.

[Claim 11] The optical module according to claim 10, characterized in that
15 an inner wall of the first housing portion in the first direction is formed with a groove, and the groove is recessed in the first direction toward a direction away from the first sub-cavity.

[Claim 12] The optical module according to claim 1, characterized in that
the optical module has a first direction, a second direction, and a third direction that are mutually perpendicular in pairs, the light source assembly and the optical amplification assembly
20 are stacked with each other in the first direction, and a length of the optical module in the second direction is less than a length of the optical module in the third direction;

wherein a length of the housing in the third direction ranges from 96.5 mm to 106.5 mm.

[Claim 13] The optical module according to claim 12, characterized in that
the optical module further comprises:
25 a pull ring, comprising a force application portion and at least two sliding arms, wherein the

force application portion is connected to the housing by each of the sliding arms, the force application portion and the housing are spaced apart from each other in the third direction, and an external force is applied to the force application portion to drive the pull ring to move so as to release locking between the optical module and an external optical cage;

5 wherein a length of the force application portion in the third direction ranges from 3 mm to 6 mm.

[Claim 14] An optical module, characterized in comprising:

a housing, having an accommodating cavity therein;

a main circuit board, accommodated in the accommodating cavity;

10 a light source assembly, accommodated in the accommodating cavity and electrically connected to the main circuit board; and

an optical amplification assembly, accommodated in the accommodating cavity and electrically connected to the main circuit board, wherein the optical amplification assembly is optically connected to the light source assembly, and the optical amplification assembly is
15 configured to amplify an optical signal outputted from the light source assembly;

wherein the optical amplification assembly comprises a pump source device, a wavelength division multiplexer, an isolator, and an amplification fiber, one end of the amplification fiber is connected to the wavelength division multiplexer, and the other end is connected to the isolator, the wavelength division multiplexer is configured to couple an optical signal outputted from the
20 light source assembly and pump light outputted by the pump source device into the amplification fiber, and the pump source device, the wavelength division multiplexer, the isolator, and the amplification fiber are respectively arranged on opposite sides of the main circuit board.