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Ho et al.

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(45) **Date of Patent: Dec. 17, 2019**

(54) **WELDING ASSEMBLY FOR COUPLING A TRANSMITTER OPTICAL SUBASSEMBLY (TOSA) MODULE TO AN OPTICAL TRANSMITTER OR TRANSCEIVER**

(71) Applicant: **Applied Optoelectronics, Inc.**, Sugar Land, TX (US)

(72) Inventors: **I-Lung Ho**, Sugar Land, TX (US); **Hsiu-Che Wang**, Rosenberg, TX (US); **Hao-Hsiang Liao**, Sugar Land, TX (US)

(73) Assignee: **Applied Optoelectronics, Inc.**, Sugar Land, TX (US)

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G02B 6/42 (2006.01)
G02B 6/12 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/4237*** (2013.01); ***G02B 6/4245*** (2013.01); *G02B 6/12009* (2013.01); *G02B 6/423* (2013.01); *G02B 6/4215* (2013.01); *G02B 6/4225* (2013.01); *G02B 6/4234* (2013.01); *G02B 6/4246* (2013.01); *G02B 6/4256* (2013.01); *G02B 6/4266* (2013.01); *G02B 6/4281* (2013.01); *G02B 6/4292* (2013.01)

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CPC .. G02B 6/4237; G02B 6/4245; G02B 6/4225; G02B 6/423; G02B 6/4234; G02B 6/4246
See application file for complete search history.

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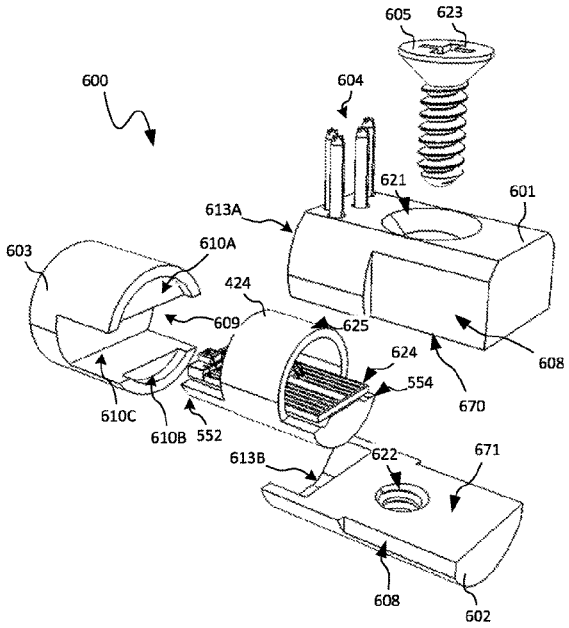
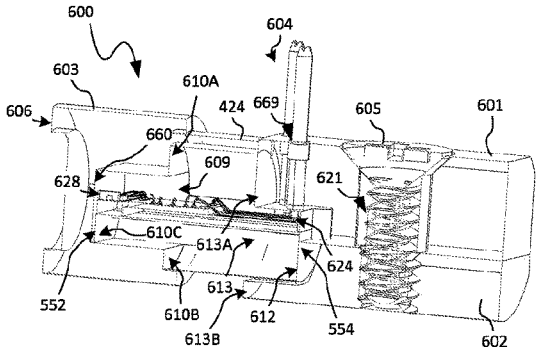
Primary Examiner — Sung H Pak
Assistant Examiner — Hoang Q Tran
(74) *Attorney, Agent, or Firm* — Grossman Tucker Perreault & Pflegar, PLLC; Norman S. Kinsella

(57) **ABSTRACT**

In accordance with an embodiment, a welding assembly is disclosed that allows for a laser assembly to be coupled into a socket of the same and held at a fixed position, e.g., by a mechanical grabber of a welding system. The mechanical grabber may then travel along one or more axis to bring the TOSA module into mechanical alignment with an opening of an associated optical subassembly housing. The welding assembly may further include an alignment member that provides one or more alignment contact surfaces configured to be brought directly into contact with a surface of the associated subassembly housing. When the one or more alignment contact surfaces are "flush" with the surface of the subassembly housing the emission face of the TOSA module is substantially parallel, and by extension, optically aligned with the opening of the associated subassembly housing.

15 Claims, 11 Drawing Sheets





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Eoptolink v. Applied Optoelectronics
IPR2026-00123

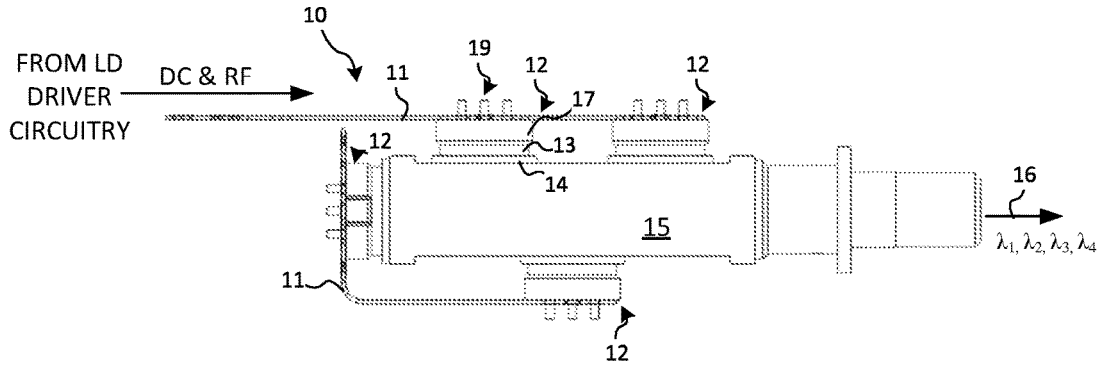

FROM LD DRIVER CIRCUITRY
DC & RF
10
11
19
12
17
13
14
15
16
$\lambda_1, \lambda_2, \lambda_3, \lambda_4$

FIG. 1

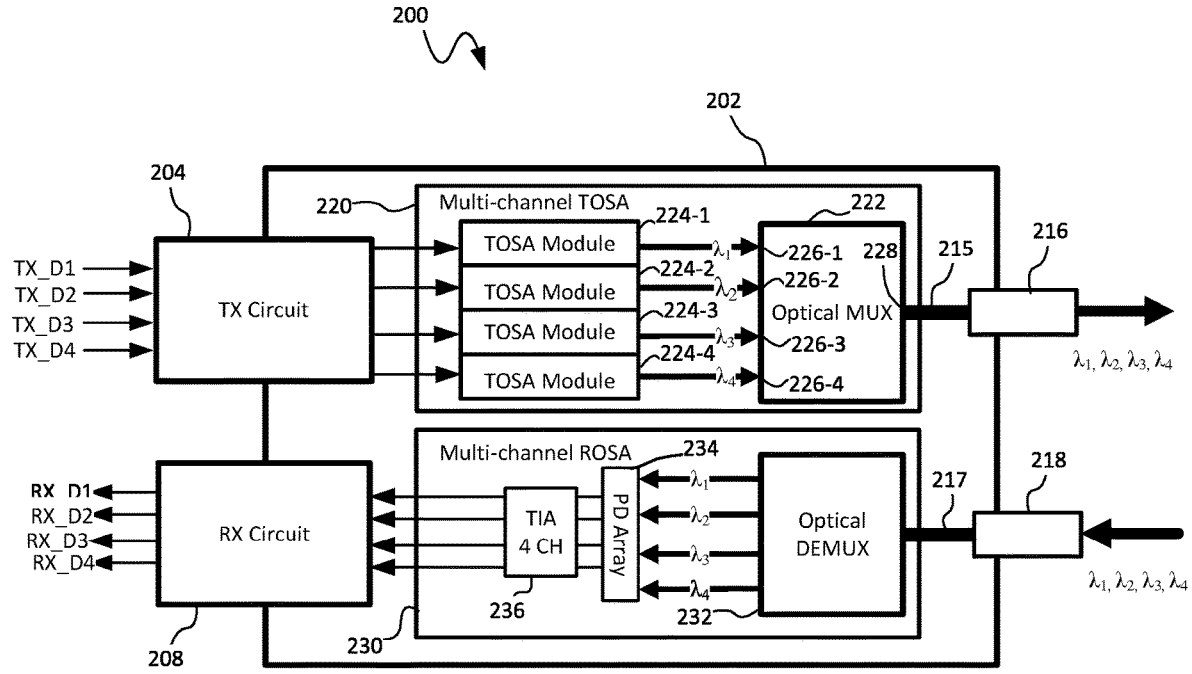

200
202
204
220
Multi-channel TOSA
224-1
222
TOSA Module
TOSA Module
TOSA Module
TOSA Module
224-2
224-3
224-4
226-1
226-2
226-3
226-4
Optical MUX
228
215
216
TX_D1
TX_D2
TX_D3
TX_D4
TX Circuit
$\lambda_1, \lambda_2, \lambda_3, \lambda_4$
Multi-channel ROSA
234
RX_D1
RX_D2
RX_D3
RX_D4
RX Circuit
TIA
4 CH
PD Array
Optical
DEMUX
217
218
236
232
230
208

FIG. 2

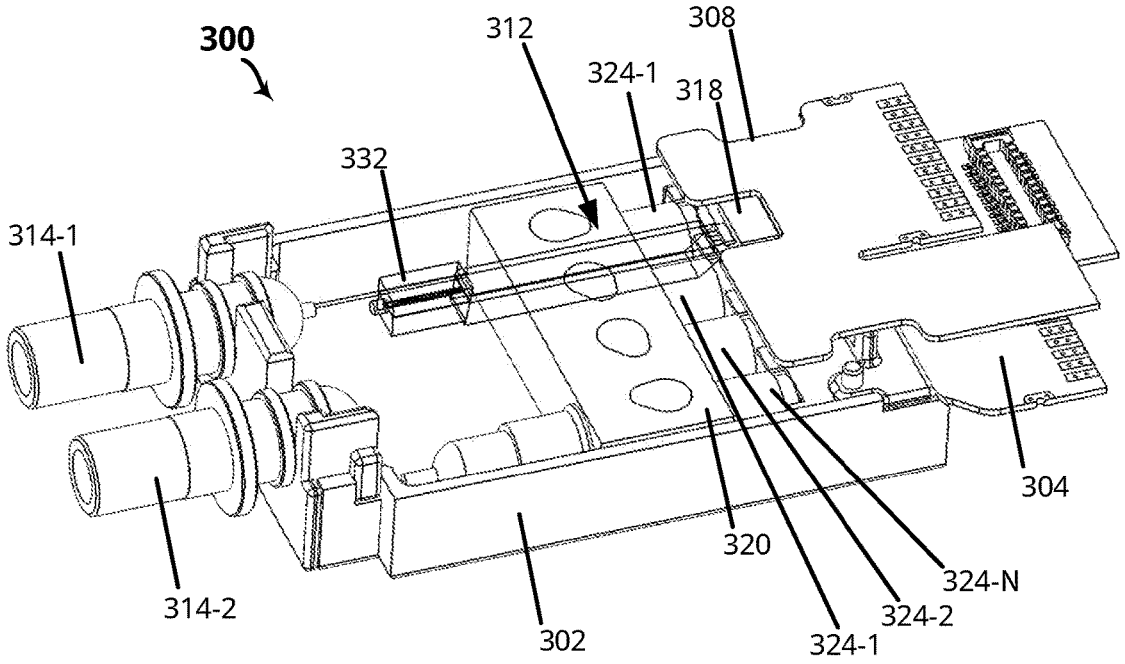
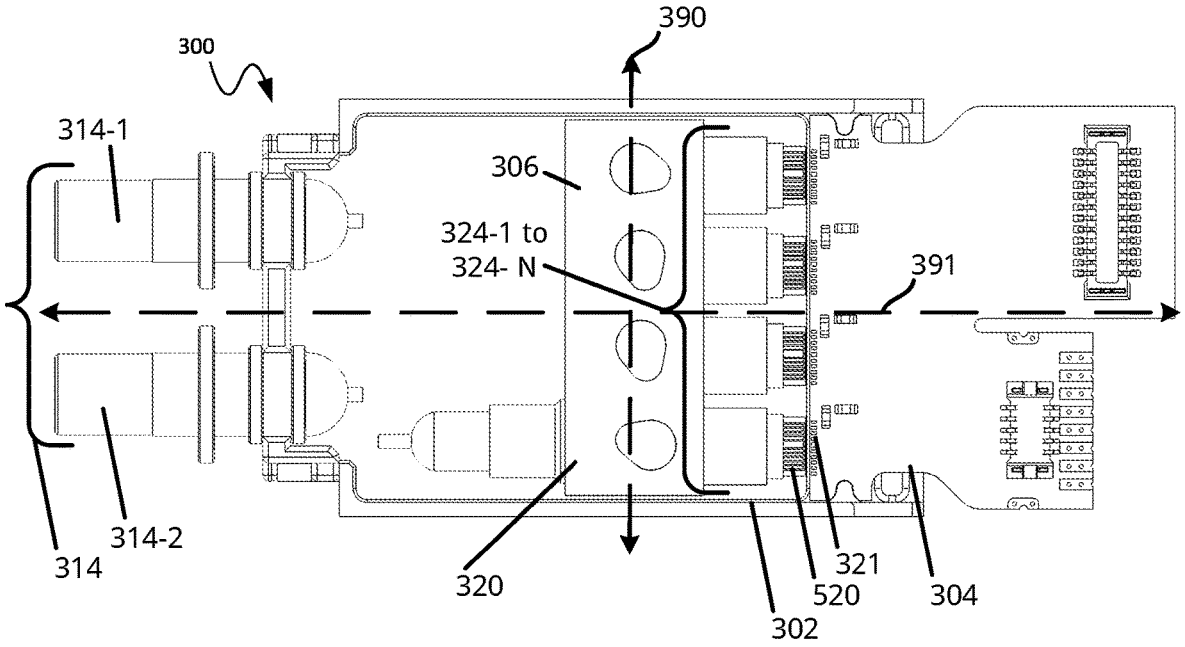

300
312
308
324-1
318
332
314-1
304
320
324-N
324-2
314-2
302
324-1

FIG. 3A


390
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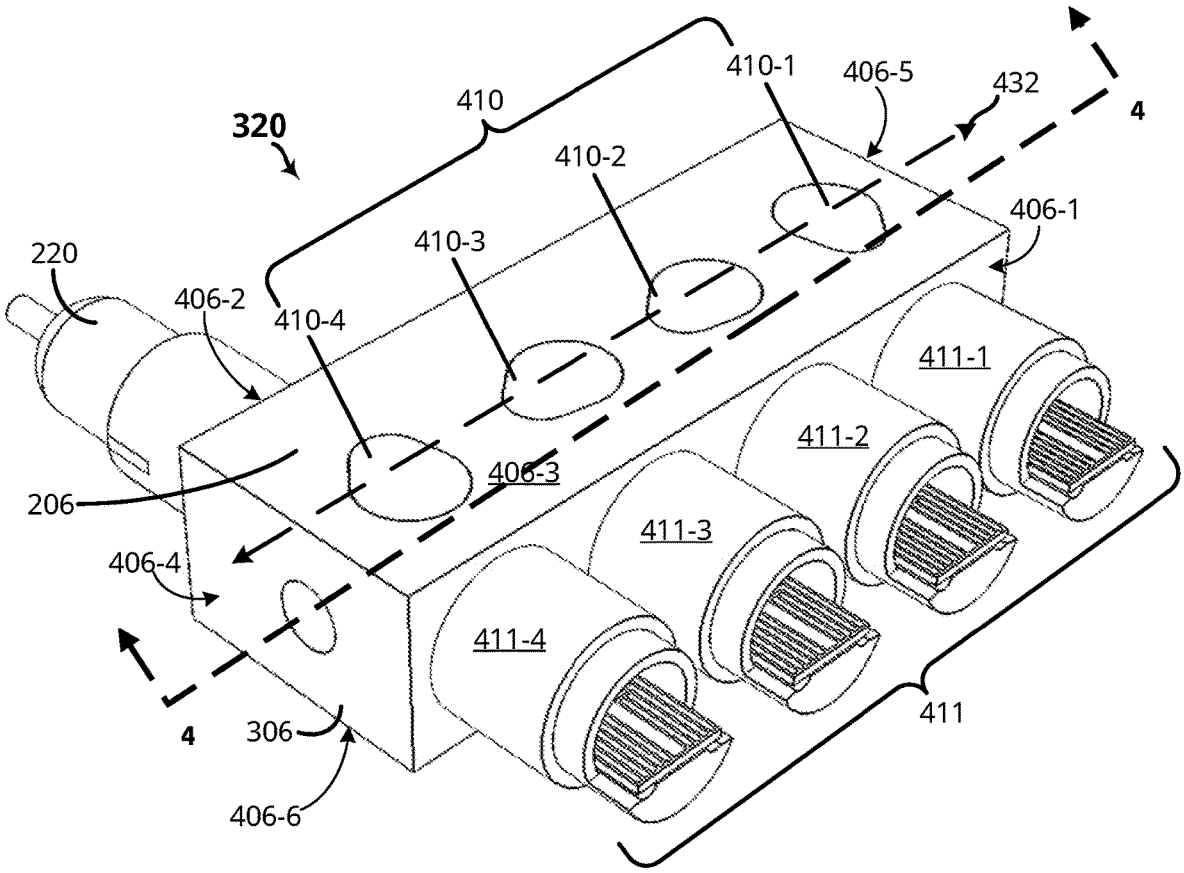
314-1
306
324-1 to
324- N
391
314-2
314
320
321
520
304
302

FIG. 3B


320
410
410-1
406-5
432
4
410-2
406-1
220
410-3
406-2
410-4
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411-2
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206
411-3
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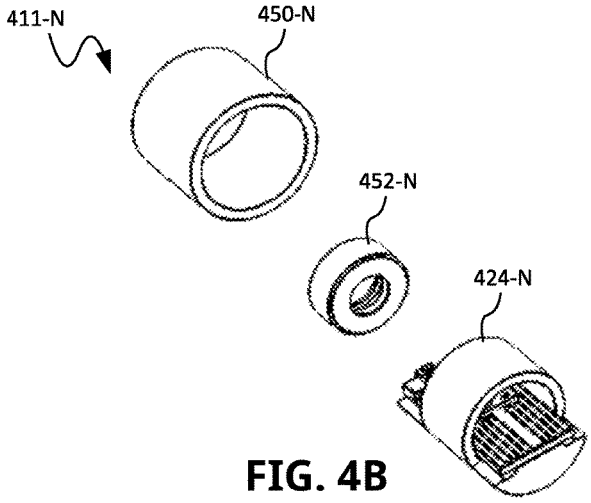
4
306
411
406-6

FIG. 4A


411-N
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452-N
424-N

FIG. 4B

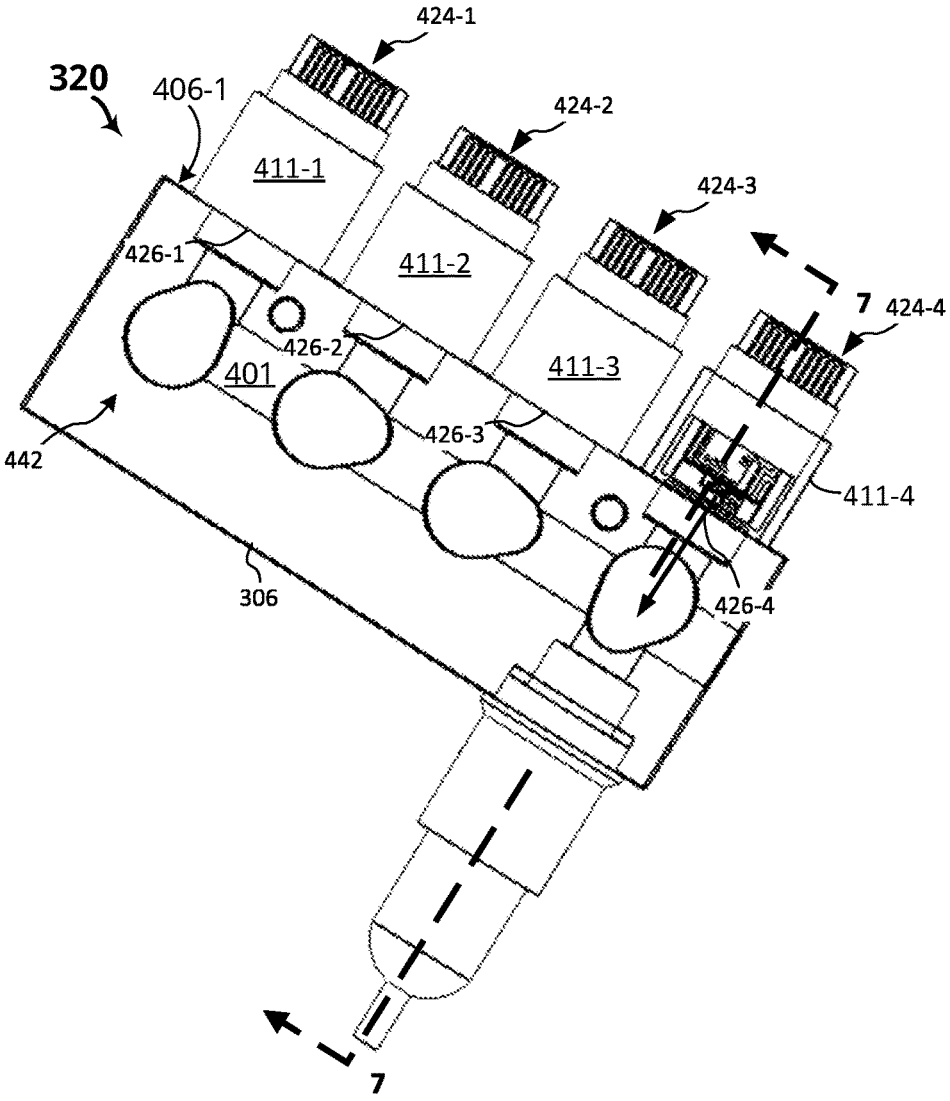

424-1
320
406-1
424-2
411-1
424-3
426-1
411-2
7
424-4
426-2
401
411-3
426-3
442
411-4
306
426-4
7

FIG. 4C

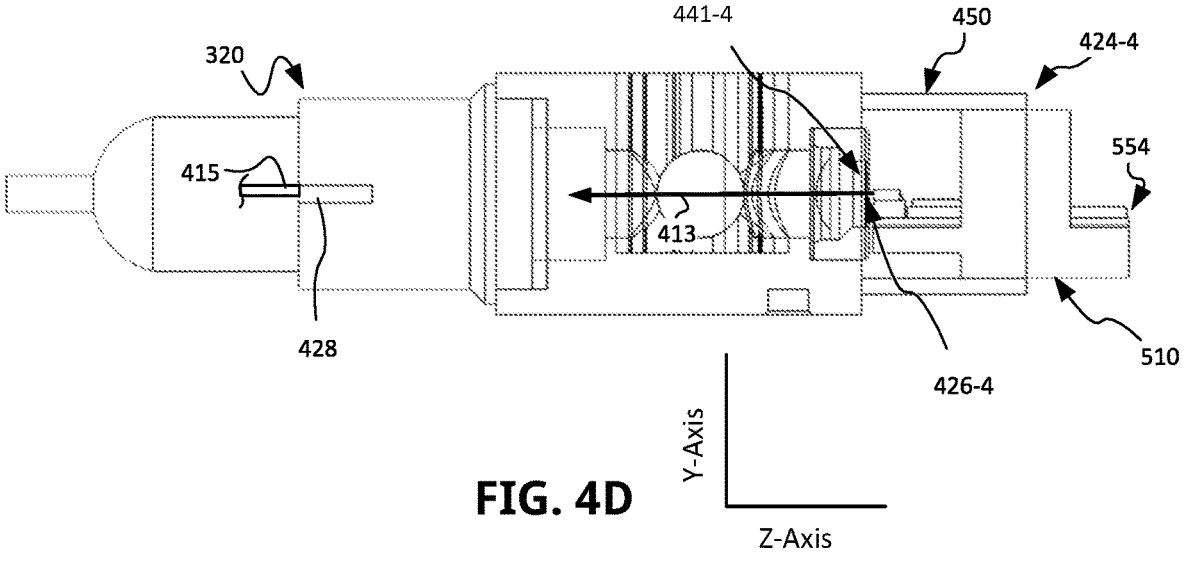

441-4
450
424-4
320
554
415
413
428
510
426-4
Y-Axis
Z-Axis

FIG. 4D

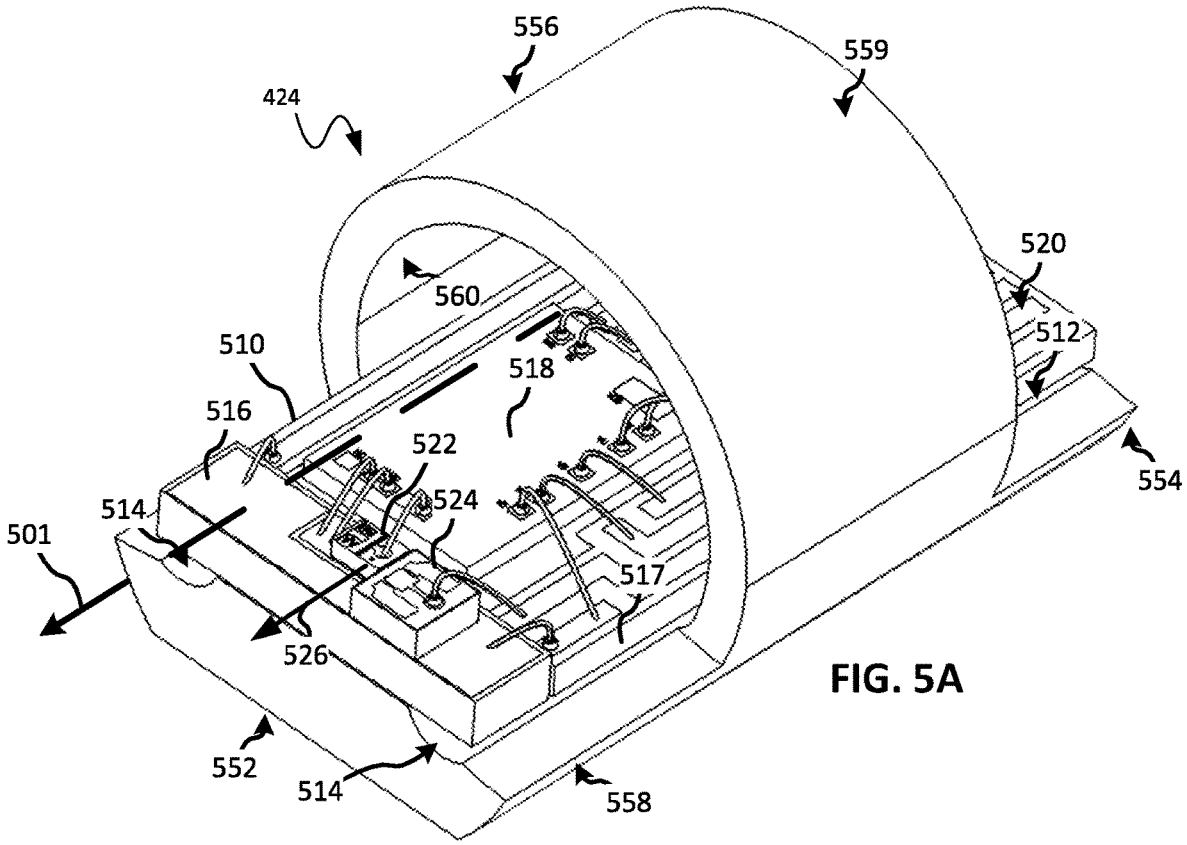

556
559
424
520
560
512
510
518
516
522
524
514
554
501
517
526
552
514
558

FIG. 5A

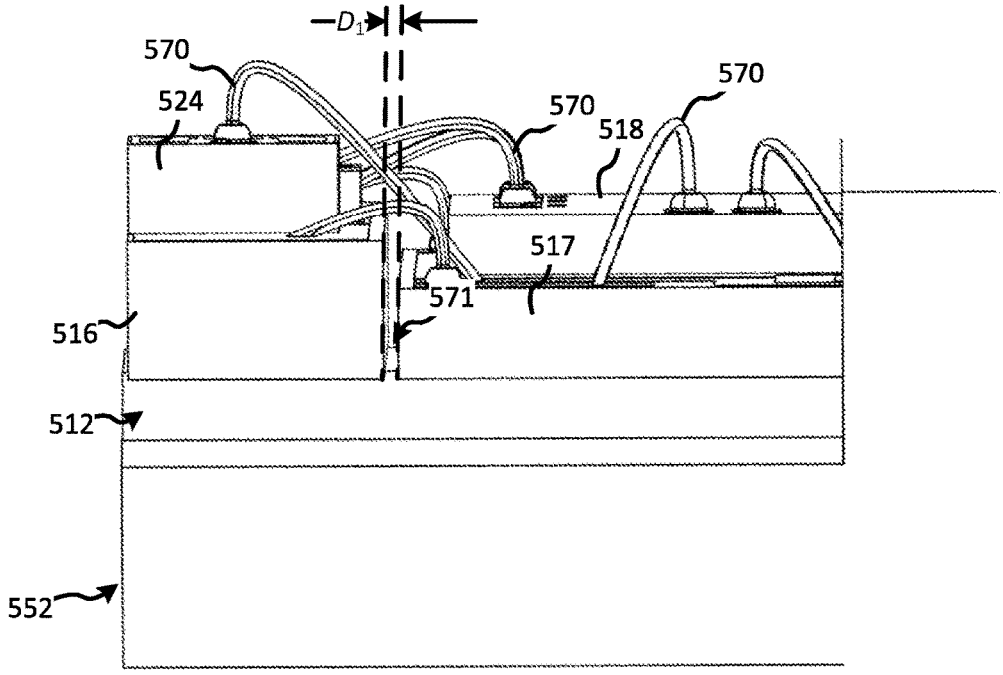
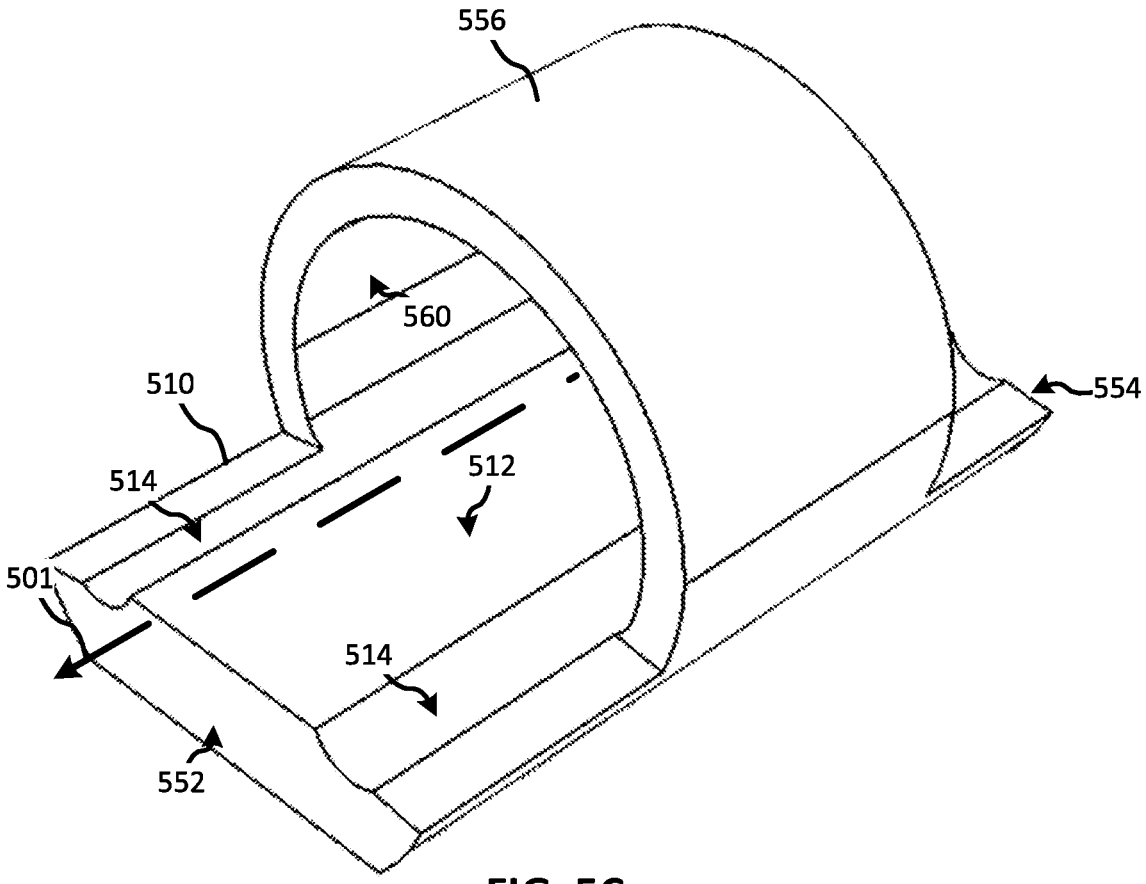

D_1
570
524
570
570
518
517
571
516
512
552

FIG. 5B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560
510
554
514
512
501
514
552

FIG. 5C

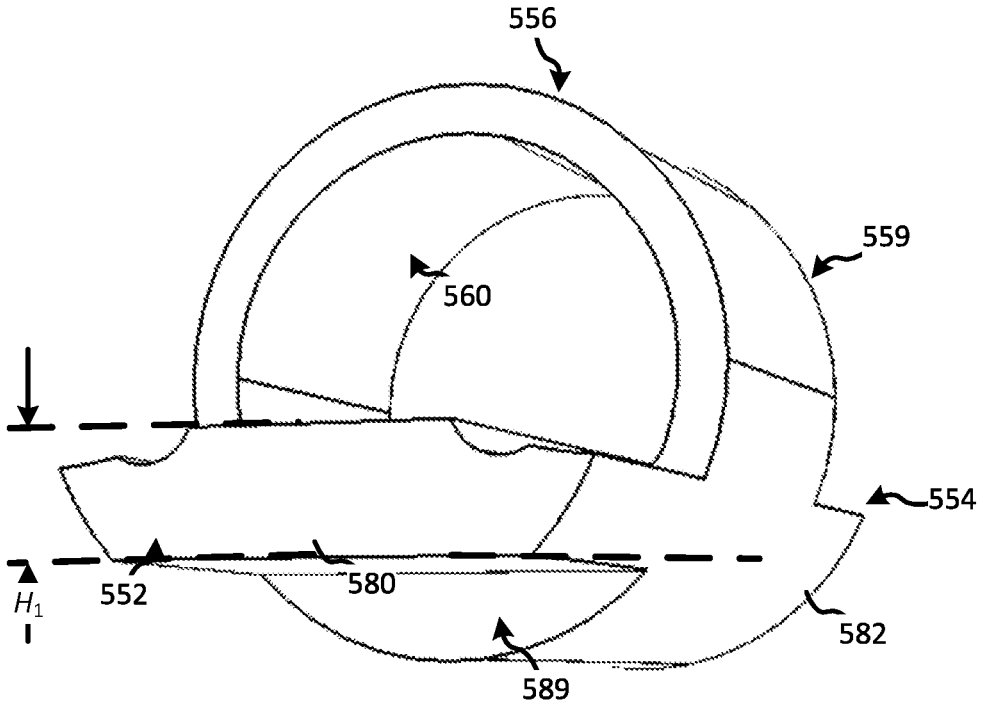
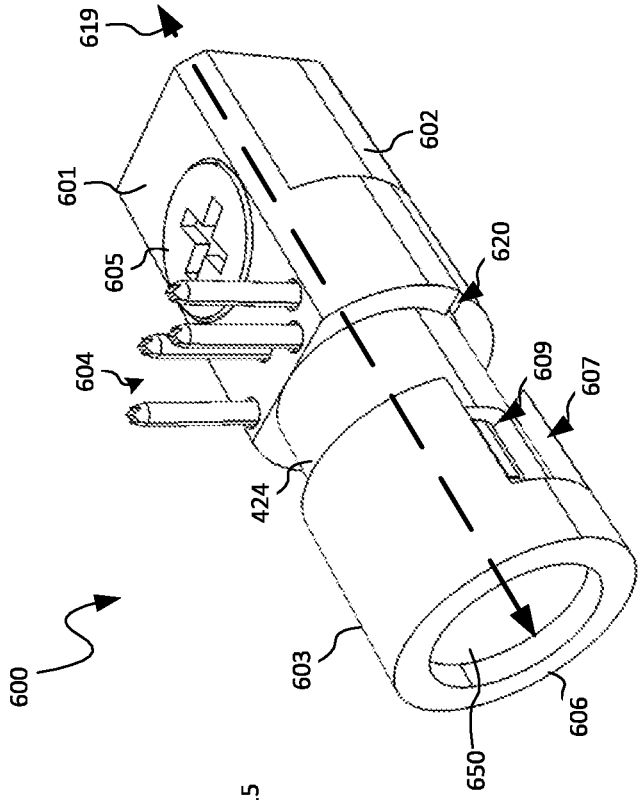

556
559
560
554
552
580
582
589
H_1

FIG. 5D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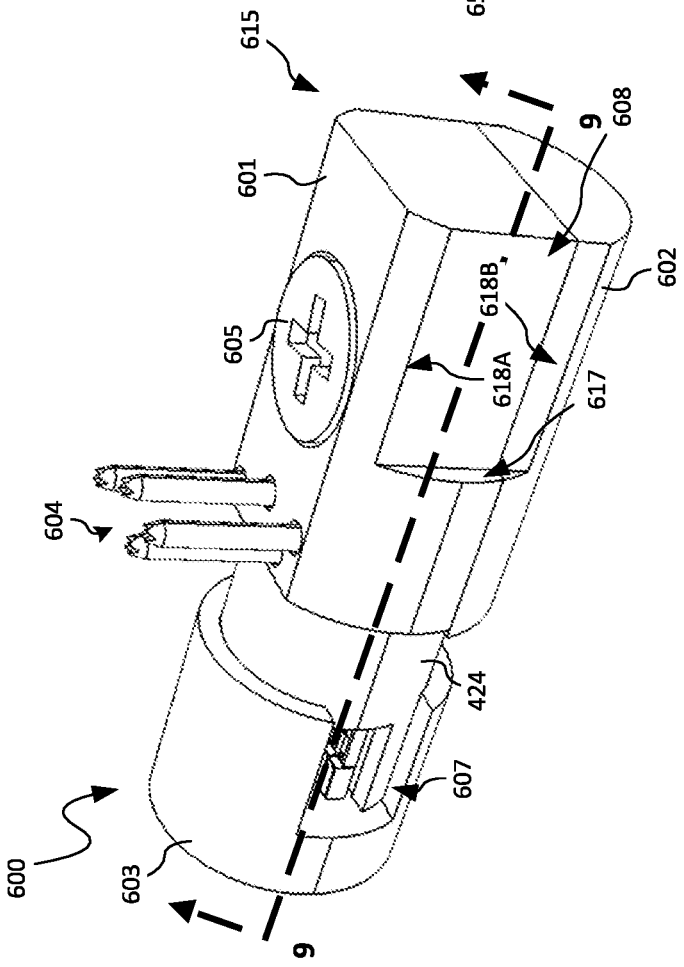
602
601
605
620
604
609
607
424
600
603
606
650

FIG. 7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601
608
9
602
605
618B
618A
617
604
424
607
600
603
9

FIG. 6

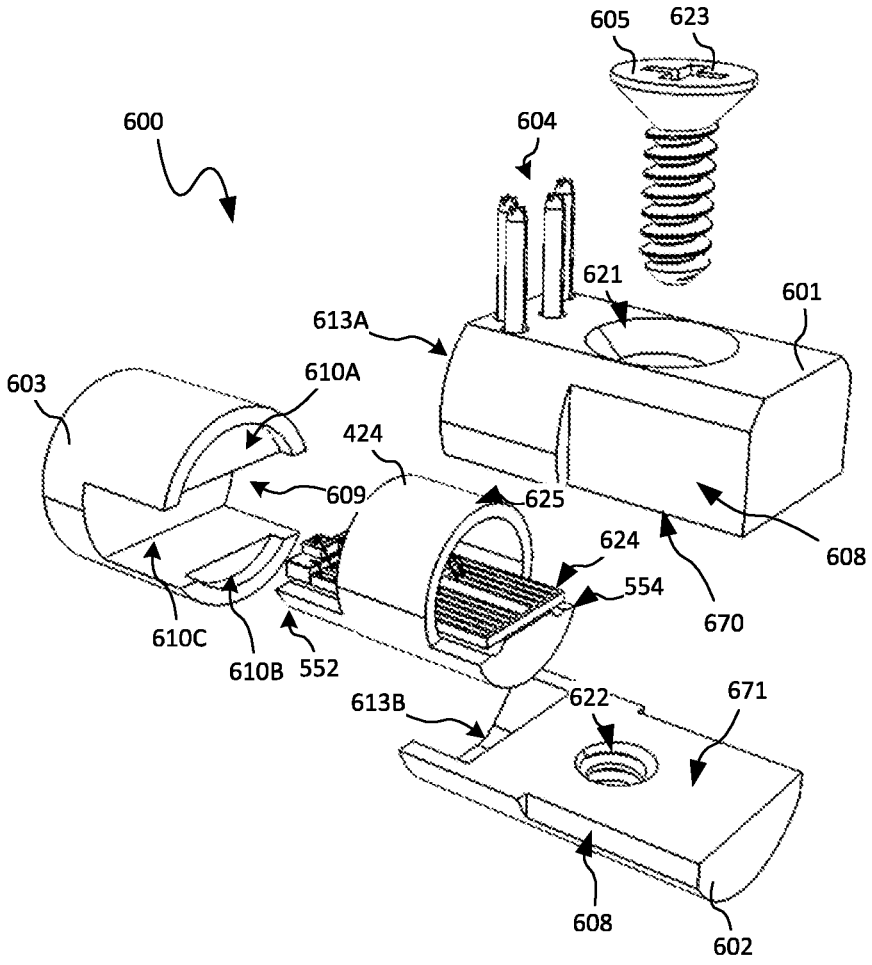
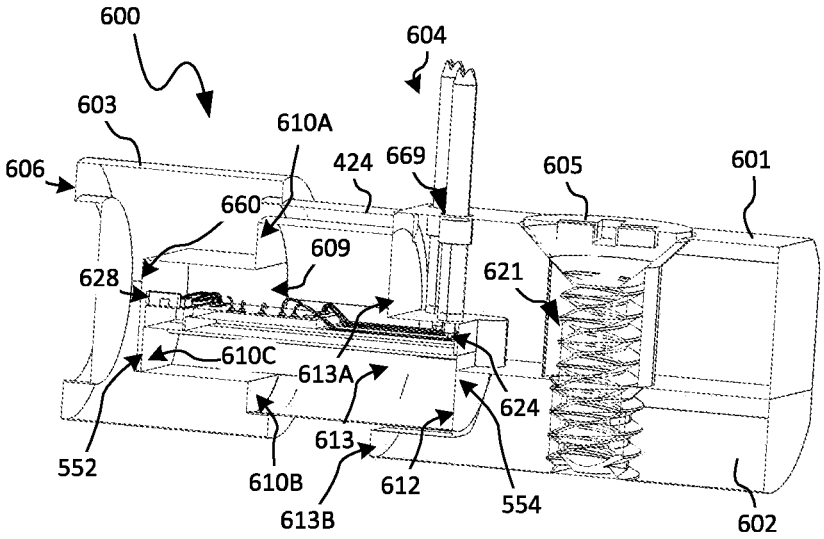

605
623
600
604
621
601
613A
603
610A
424
609
625
624
608
554
670
610C
610B
552
613B
622
671
608
602

FIG. 8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604
603
610A
606
424
669
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601
660
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628
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610C
613A
624
613
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610B
612
554
613B
602

FIG. 9

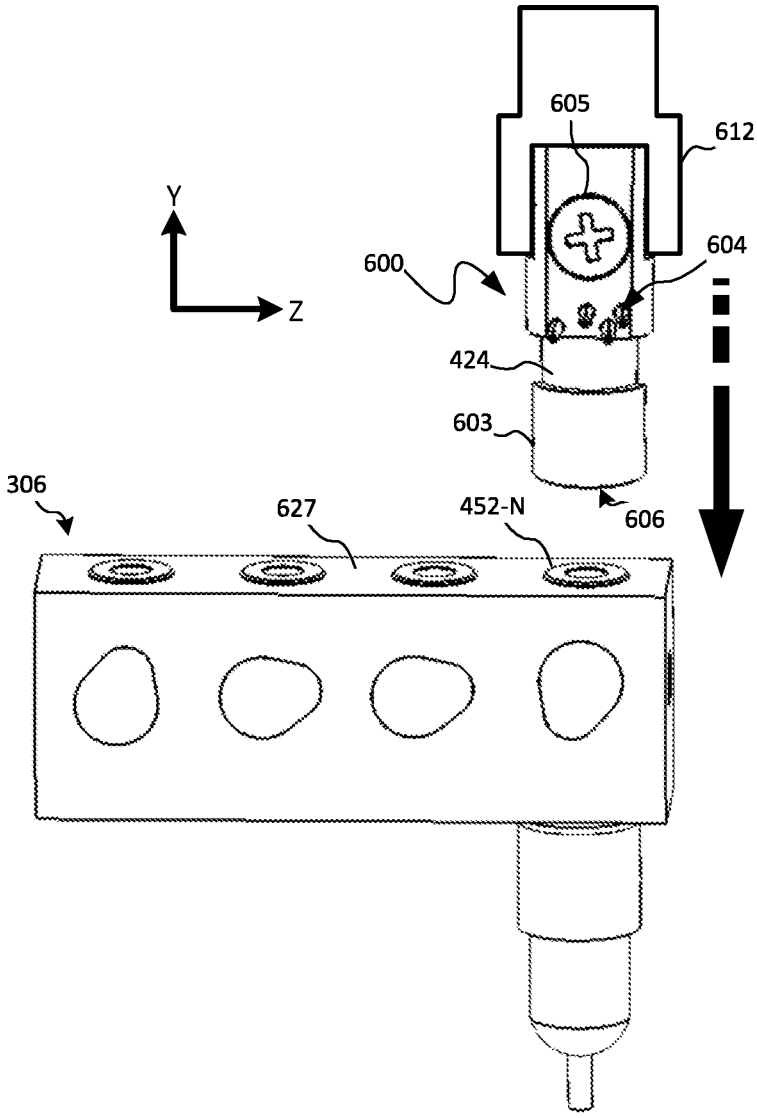
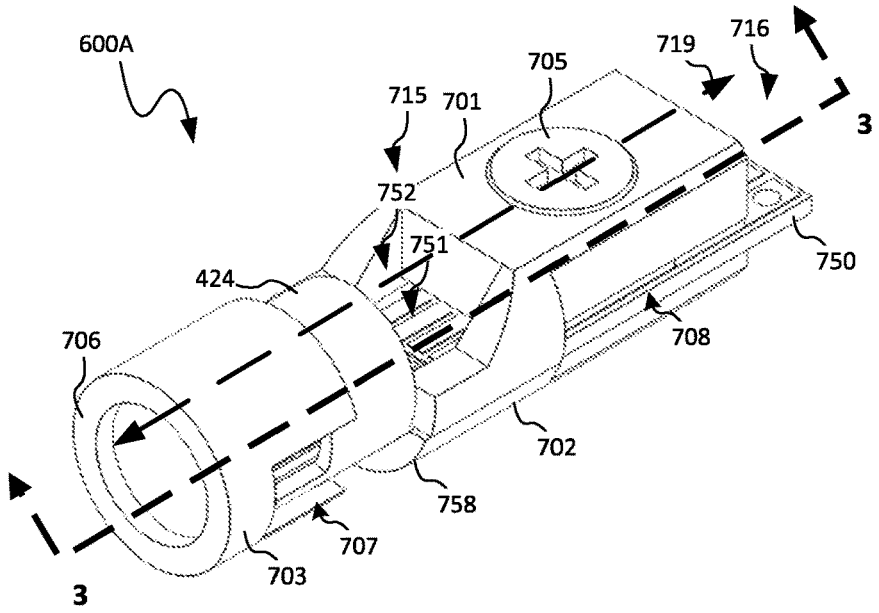

605
612
Y
Z
600
604
424
603
306
627
452-N
606

FIG. 10


600A
705
719
716
715
701
3
752
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750
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708
706
702
758
707
703
3

FIG. 11

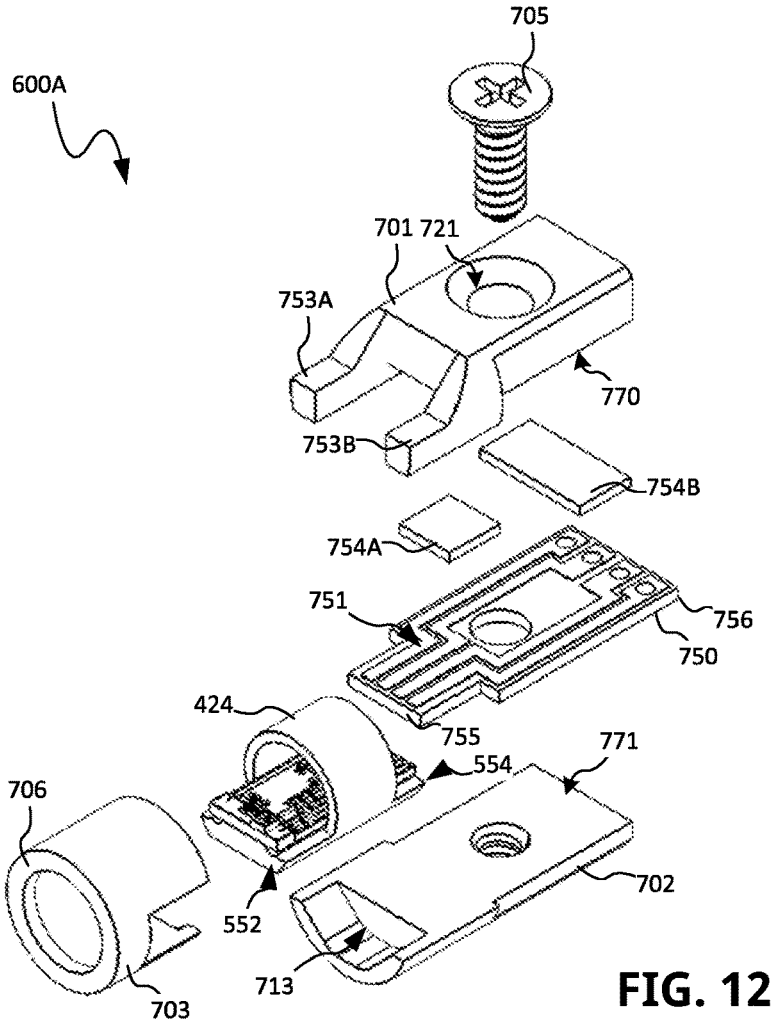
705
600A
701 721
753A
770
753B
754B
754A
751
756
750
424
755
771
554
706
702
552
713
703

FIG. 12

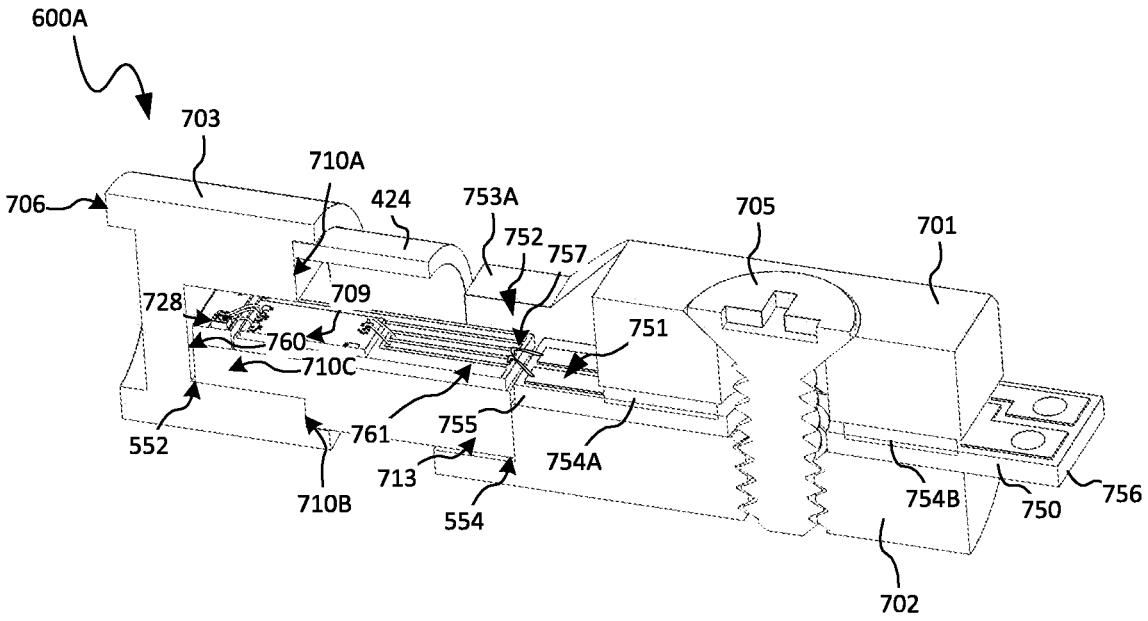
600A
703
710A
706
424
753A
752
757
705
701
728
709
751
760
710C
552
761
755
754A
713
710B
554
754B
750
756
702

FIG. 13

WELDING ASSEMBLY FOR COUPLING A TRANSMITTER OPTICAL SUBASSEMBLY (TOSA) MODULE TO AN OPTICAL TRANSMITTER OR TRANSCEIVER

CROSS-REFERENCE TO RELATED APPLICATIONS

This Application is related to co-pending U.S. application Ser. No. 15/334,753 titled "Transmitter Optical Subassembly (TOSA) Module With Integrated Welding Member For Use in Optical Transmitters or Transceivers" filed on Oct. 26, 2016, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

The present disclosure relates to optical transmitters and transceivers, and more particularly, to a welding assembly for coupling a laser package to an optical transmitter or transceiver.

BACKGROUND INFORMATION

Optical transceivers are used to transmit and receive optical signals for various applications including, without limitation, internet data centers, cable TV broadband, and fiber to the home (FTTH) applications. Optical transceivers provide higher speeds and bandwidth over longer distances, for example, as compared to transmission over copper cables. The desire to provide higher speeds in smaller optical transceiver modules for a lower cost has presented challenges, for example, with respect to maintaining optical efficiency (power), thermal management, and manufacturing yield. Optical transceivers can include one or more transmitter optical subassemblies (TOSAs) and receiver optical subassemblies (ROSAs) for the purpose of transmitting and receiving optical signals. As channel density and increased speed becomes an increasingly important aspect of optical transceivers, the ability to scale-down while maintaining nominal transceiver performance raises numerous non-trivial challenges. Optical efficiency or power may be lost, for example, as a result of insertion loss and/or polarization dependent loss (PDL) caused by optical components in an optical transceiver.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

FIG. **1** is a side view of a multi-channel transmitter optical sub-assembly (TOSA);

FIG. **2** is a schematic diagram of a multi-channel optical transceiver including a multi-channel transmitter optical sub-assembly (TOSA) and multi-channel receiver optical sub-assembly (ROSA), consistent with embodiments of the present disclosure;

FIG. **3**A is a perspective view of the multi-channel optical transceiver of FIG. **2** implemented as a small-form factor pluggable transceiver, in accordance with an embodiment of the present disclosure;

FIG. **3**B is a top plan view of the multi-channel optical transceiver of FIG. **3**A, in accordance with an embodiment of the present disclosures;

FIG. **4**A is a perspective view of a multi-channel optical transmitter including a plurality of TOSA modules in accordance with an embodiment of the present disclosure;

FIG. **4**B is an exploded view of a TOSA module in accordance with an embodiment of the present disclosure;

FIG. **4**C is a cross-sectional top view of the multi-channel optical transmitter shown in FIG. **4**A taken along line **4-4**;

FIG. **4**D is a cross-sectional side view of the multi-channel optical transmitter shown in FIG. **4**B taken along line **7-7**;

FIG. **5**A is a perspective view of a TOSA module used in the multi-channel transmitter shown in FIG. **4**A, consistent with embodiments of the present disclosure;

FIG. **5**B shows an enlarged partial side view of the TOSA module shown in FIG. **5**A;

FIG. **5**C is another perspective view of a TOSA module used in the multi-channel transmitter shown in FIG. **4**A, consistent with embodiments of the present disclosure;

FIG. **5**D is yet another perspective view of a TOSA module used in the multi-channel transmitter shown in FIG. **4**A, consistent with embodiments of the present disclosure;

FIGS. **6-7** are perspective views collectively showing an example welding assembly in accordance with an embodiment of the present disclosure;

FIG. **8** is an unassembled view of the example welding assembly of FIGS. **6-7** in accordance with an embodiment of the present disclosure;

FIG. **9** is a cross-sectional view of the example welding assembly of FIGS. **6-7** in accordance with an embodiment of the present disclosure;

FIG. **10** illustrates an example alignment and coupling process for a welding assembly configured in accordance with various aspects and embodiments disclosed herein;

FIG. **11** is another example welding assembly in accordance with an embodiment of the present disclosure;

FIG. **12** is an unassembled view of the example welding assembly of FIG. **11** in accordance with an embodiment of the present disclosure; and

FIG. **13** shows a cross-sectional view of the example welding assembly of FIG. **11** in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

Increased demand for high-speed optical transceivers, largely due to the adoption of network standards such as IEEE 802.3bm-2015 and others that prescribe 100 Gigabit Ethernet (100 GbE) and beyond, raises non-trivial challenges in the design of optical subassembly modules. For example, in multi-channel transmitter optical subassemblies (TOSAs) multiple optical component assemblies such as TO can laser assemblies may be coupled to openings of a TOSA housing to generate associated channel wavelengths. FIG. **1** shows one such example TOSA **10** having a plurality of TO can laser packages **12**. Each of the TO can laser packages **12** emit light into the TOSA housing **15**, with the TOSA housing **15** having an optical arrangement to combine channel wavelengths into an output wavelength division multiplexed (WDM) signal **16** for output via a waveguide or other device such as a fiber. Each of the TO can laser packages **12** may include a laser diode and associated optics (not shown) disposed in a hermetically or non-hermetically sealed package **17**, or TO can header **17**. Pins **19** of each TO can laser package **12** electrically couple to laser diode (LD) driver circuitry via flexible printed circuit boards (FPCs) **11** to receive power (e.g., direct current DC) and radio frequency (RF) signals.

To couple to the TOSA housing **15**, each TO can laser package **12** includes a separate welding cap **13**. During manufacturing, the welding cap **13** may be coupled to the TO can header **17**, e.g., via welding, adhesive or other suitable approach. The welding cap **13** may then be welded to the TOSA housing **15** via welding ring **14**, and "hammered" or otherwise adjusted during alignment procedures to ensure nominal optical performance of each TO can laser package **12**. As optical transceiver modules continue to scale (e.g., to comport with small form-factor (SFF) standards and requirements), the reduced tolerances make attachment and alignment of such multi-piece TO can laser packages **12** more complex and error prone. For example, the TOSA **10** shown in FIG. **1** may measure 10 millimeters, or less, in length from end to end. Existing attachment and alignment approaches at this scale are often error prone and can ultimately reduce yield. Optical misalignments in the tens of microns may adversely affect optical transmitter/transceiver performance.

Thus, in accordance with an embodiment of the present disclosure, a welding assembly (or welding fixture) is disclosed that allows for a TOSA module, which may also be referred to as a laser assembly, to be coupled into a socket of the same and held at a fixed position. During manufacture of an optical transmitter/transceiver, a mechanical grabber can grip the welding assembly and travel along one or more axis to bring the TOSA module into alignment with an associated opening of an optical subassembly housing. The welding assembly includes an alignment member (which may also be referred to as an alignment cap) configured to couple to an optical coupling end of the TOSA module, with the alignment member providing one or more alignment contact surfaces configured to be brought directly in contact with a surface of the subassembly housing. The one or more alignment contact surfaces may extend substantially parallel with an emission face (e.g., the output face of a laser diode) of the TOSA module. Thus, when the one or more alignment contact surfaces are "flush" with the surface of the subassembly housing the emission face of the TOSA module is substantially parallel with the associated opening of the subassembly housing. The alignment member may then be removed and subsequent active alignment processes (e.g., using laser hammering) may be performed to ensure nominal optical performance. The welding assembly may provide temporary electrical coupling between the TOSA module and driver circuitry during active alignment processes. For example, the welding assembly may be temporarily electrically coupled to the TOSA module and also electrically coupled to the welding system via a flexible printed circuit board (FPCB) or other suitable interconnect device.

In an embodiment, the TOSA module may be implemented as the TOSA module disclosed in greater detail in the co-pending U.S. application Ser. No. 15/334,753 titled "Transmitter Optical Subassembly (TOSA) Module With Integrated Welding Member For Use in Optical Transmitters or Transceivers" filed on Oct. 26, 2016, which is incorporated by reference herein in its entirety.

As used herein, "channel wavelengths" refer to the wavelengths associated with optical channels and may include a specified wavelength band around a center wavelength. In one example, the channel wavelengths may be defined by an International Telecommunication (ITU) standard such as the ITU-T coarse wavelength division multiplexing (CWDM) or dense wavelength division multiplexing (DWDM) grid. As used herein, "mounted" refers to physically attaching two structures together, for example, by welding or using an epoxy or other substance or device for attachment. The term "coupled" as used herein refers to any connection, coupling, link or the like and "optically coupled" refers to coupling such that light from one element is imparted to another element. Such "coupled" devices are not necessarily directly connected to one another and may be separated by intermediate components or devices that may manipulate or modify such signals. Likewise, the term "directly optically coupled" as used herein refers any optical connection that allows light to be imparted from one element to another without the use of an intermediate device such as a fiber. As used herein, "directly aligned" refers to an alignment between optical components that allows light to pass from one optical component to another optical component without changing the linear path of the light, for example, without using an optical fiber.

Example Optical Transceiver System

Referring to FIG. **2**, an optical transceiver **200**, consistent with embodiments of the present disclosure, is shown and described. In this embodiment, the optical transceiver **200** transmits and receives four (4) channels using four different channel wavelengths (λ_1, λ_2, λ_3, λ_4) and may be configured for coarse wavelength division multiplexing (CWDM), although other numbers of channels are possible and within the scope of this disclosure. In one example, the channel wavelengths λ_1, λ_2, λ_3, λ_4 may be about 1270 nm, 1290 nm, 1310 nm, and 1330 nm, respectively. The optical transceiver **200** may be capable of transmission rates of at least about 10 Gbps per channel. The optical transceiver **200** may also be capable of both short transmission distances of tens of meters, for example, to distances of 2 kilometers or more. The optical transceiver **200** may be used, for example, in internet data center applications or fiber to the home (FTTH) applications.

In an embodiment, the optical transceiver **200** implements a Quad Small Form-Factor Plugging (QSFP) transceiver. For example, the optical transceiver **200** may be implemented within a QSFP receiver that comports with the "SFF Committee Specification SFF-8665 for QSFP+ 28 Gb/s 4X Pluggable Transceiver Solution (QSFP28)" published on May 10, 2013. The aspects and embodiments disclosed herein may be used within other transceiver types and is not necessarily limited to QSFP or QFSP+ transceivers.

The optical transceiver **200** includes a multi-channel transmitter optical subassembly (TOSA) arrangement **220** for transmitting optical signals on the channel wavelengths (e.g., λ_1, λ_2, λ_3, λ_4) and a multi-channel receiver optical subassembly (ROSA) **230** arrangement for receiving optical signals on the channel wavelengths (e.g., λ_1, λ_2, λ_3, λ_4). The multi-channel TOSA arrangement **220** and the multi-channel ROSA arrangement **230** are located in a transceiver housing **202**. A transmit connecting circuit **204** and a receive connecting circuit **208** provide electrical connections to the multi-channel TOSA arrangement **220** and the multi-channel ROSA arrangement **230**, respectively, within the housing **202**. The transmit connecting circuit **204** is electrically connected to the electronic components (e.g., the lasers, monitor photodiodes, etc.) in the multi-channel TOSA arrangement **220** and the receive connecting circuit **208** is electrically connected to the electronic components (e.g., the photodiodes, the TIA, etc.) in the multi-channel ROSA arrangement **230**. The transmit connecting circuit **204** and the receive connecting circuit **208** include at least conductive paths to provide electrical connections and may also include additional circuitry. The transmit connecting circuit **204** and the receive connecting circuit **208** may communicate with external systems via a data bus, such as a 38-pin

connector that comports with physical connector QSFP standards and data communication protocols.

In this embodiment, the TOSA arrangement **220** includes a plurality of TOSA modules **224-1** to **224-4** optically coupled to an optical multiplexer **222** having mux input ports **226-1** to **226-4**, with each of the mux input ports **226-1** to **226-4** being located on a same side, and mux output port **228**. The TOSA modules **224-1** to **224-4** may be coupled to the mux input ports **226-1** to **226-4** of the optical multiplexer **222** directly. The TOSA modules **224-1** to **224-4** generate optical signals at different respective channel wavelengths (e.g., λ**1**, λ**2**, λ**3**, λ**4**) and the optical multiplexer **222** combines or multiplexes those optical signals to provide a multiplexed optical signal on the mux output port **228** coupled to an output optical fiber **215**. The output optical fiber **215** is coupled to an output optical connector **216**, such as an LC connector.

Each of the TOSA modules **224-1** to **224-4** may have a coaxial configuration such that the TOSA module is electrically connected at one end to conductive paths on the transmit connecting circuit **204** and optically coupled at the other end. Each of the TOSA modules **224-1** to **224-4** may include a laser for generating laser light at the assigned channel wavelength and optics for coupling the laser light into the respective mux input ports **226-1** to **226-4** of the optical multiplexer **222**. The lasers in the TOSA modules **224-1** to **224-4** thus convert electrical data signals (TX_D**1** to TX_D**4**) received via the transmit connecting circuit **204** into modulated optical signals coupled into the optical multiplexer **222**. The lasers may include, for example, distributed feedback (DFB) lasers with diffraction gratings. Each of the TOSA modules **224-1** to **224-4** may also include a monitor photodiode for monitoring the light emitted by the lasers. Each of the TOSA modules **224-1** to **224-4** may further include one or more temperature control devices, such as a resistive heater and/or a thermoelectric cooler (TEC), for controlling a temperature of the lasers, for example, to control or stabilize the laser wavelengths.

In this embodiment, the multi-channel ROSA arrangement **230** includes an optical demultiplexer **232** coupled to a photodetector array **234** including, for example, photodiodes. The optical demultiplexer **232** demultiplexes or separates a multiplexed optical signal received on an input optical fiber **217** to provide received optical signals at different channel wavelengths, which are detected by respective photodetectors in the photodetector array **234**. The input optical fiber **217** is coupled to an input optical connector **218**, such as an LC connector. The multi-channel ROSA **230** also includes a multi-channel transimpedance amplifier **236** electrically connected to the photodetector array **234**. The photodetector array **234** and the transimpedance amplifier **236** detect and convert optical signals received from the optical demultiplexer **232** into electrical data signals (RX_D**1** to RX_D**4**) that are output via the receive connecting circuit **208**. Although one example of the multi-channel ROSA **230** is described, the optical transceivers **200** may include other types or embodiments of ROSAs.

Referring to FIG. **3**A, the optical transceiver **300** is shown as an optical transceiver **300** implementing the QSFP+ specification, or other applicable pluggable small-form factor specification. To this end, and in an embodiment, the optical transceiver **300** may be compliant with the QSFP28 MSA standard, and may include physical dimensions that conform to the SFF-8661 specification. In other cases, the optical transceiver **300** may implement the C form-factor pluggable (CFP) standard. In any such cases, the optical transceiver **300** may be configured to transmit and receive at a line rate of at least 100 Gb/s, respectively. This may be particularly advantageous when using the optical transceiver in, for example, a 100GBASE-LR4 application, per the IEEE 802.3bx standards. In an embodiment, the optical transceiver **300** implements the optical transceiver system **200** of FIG. **2**.

The optical transceiver **300** includes a transceiver housing **302** and a multi-channel TOSA arrangement **320** disposed within a region of the transceiver housing **302**. The multi-channel TOSA arrangement **320** includes a plurality TOSA modules **324-1** to **324**-N configured to generate associated channel wavelengths and associated circuitry, which are discussed in further detail below. The multi-channel TOSA arrangement **320** electrically couples to the transmit connecting circuit **304** and also couples to an optical interface port **314-2** of the transceiver housing **302** by way of a waveguide device such as an optical fiber (not shown). The transmit connecting circuit **304** may be implemented as a printed circuit board (PCB) or any other suitable substrate for supporting the transmit connecting circuit **304**.

The plurality of TOSA modules **324-1** to **324**-N (which may also be referred to as laser packages) may each includes, for example, distributed feedback (DFB) laser diode package. Other laser types are also within the scope of this disclosure such as, for example, other directly modulated laser (DML) diodes and TO can-type laser diodes. The particular laser type chosen may be based on a desired application. For instance, applications that require long-distance, e.g., about **10**km or greater, may favor EML lasers. Conversely, applications requiring shorter distances may use DMLs. In any event, and in accordance with an embodiment, each of the TOSA modules **324-1** to **324**-N of the multi-channel TOSA arrangement **320** can be configured to transmit at about 25 Gb/s, or greater. Each laser package **324-1** to **324**-N of the multi-channel TOSA arrangement **320** may provide a relatively narrow spectrum of channel wavelengths such as a single channel wavelength, or may be configured to provide a broad spectrum of channel wavelengths based on associated optics. In an embodiment, the lasers can provide center wavelengths 375 nm to 1650 nm, for example. The TOSA modules **324-1** to **324**-N are discussed in greater detail further below.

The optical transceiver **300** further includes a multi-channel ROSA arrangement **312** disposed within a region of the transceiver housing **302**. The multi-channel ROSA arrangement **312** may include an optical demultiplexing device **332**. The optical demultiplexing device **332** may comprise an arrayed waveguide grating (AWG) device, for example. The ROSA arrangement **312** electrically is coupled to a receive connecting circuit **308**, and optically coupled to an optical interface receptacle **314-1** at an end of the transceiver housing **302** by way of a waveguide device such as an optical fiber (not shown). The receive connecting circuit **308** may be configured as a PCB, for example, although other embodiments are within the scope of this disclosure. The multi-channel ROSA arrangement **312** may use the detectors and the associated circuitry **318** (e.g., a TIA) to detect, amplify and convert de-multiplexed channel wavelengths and may provide the same as electrical data signals, e.g., RX_D**1** to RX_D**4**.

Turning to FIG. **3**B, a top plan view of the optical transceiver **300** is shown in accordance with an embodiment of the present disclosure. For the purpose of clarity and practicality, FIG. **3**B omits the multi-channel ROSA arrangement **312**. As shown, the multi-channel TOSA **320** is shown in a perpendicular orientation, e.g., the longitudinal axis **390** of the TOSA **320** is substantially perpendicular relative to

the longitudinal axis **391** of the transceiver housing **302**. The multi-channel TOSA **320** includes a housing **306** defined by a plurality of sidewalls **406-1** to **406-6**, which are shown and described greater detail below with regard to FIG. **4**A. The housing **306** of the multi-channel TOSA **320** is disposed adjacent to the transmit connecting circuit **304**.

Turning to FIG. **4**A, the multi-channel TOSA **320** is shown isolated from the optical transceiver **300** for the purposes of clarity and practicality. In an embodiment, the multi-channel TOSA **320** may include a plurality of sidewalls **406-1** to **406-6**, which may also be referred to as a first sidewall **406-1**, a second sidewall **406-2**, a third sidewall **406-3**, a fourth sidewall **406-4**, a fifth sidewall **406-5** and a sixth sidewall **406-6**, respectively. The first and second sidewalls **406-1** and **406-2** are disposed opposite each other with at least the third sidewall **406-3** adjoining the two. The fourth and fifth sidewalls **406-4** and **406-5** define a first and second end, respectively, with the first and second sidewalls **406-1** and **406-2** extending between the two along the longitudinal center line **432**.

In this embodiment, the first sidewall **406-1** may include the plurality of laser assemblies in an array collectively indicated at **411** and individually indicated as laser assemblies **411-1** to **411-4**. The TOSA **320** may further include optical filters collectively shown as **410** and individually shown as **410-1** to **410-4**. Each of the optical filters **410** may be disposed adjacent an associated laser assembly.

FIG. **4**B shows an example laser assembly **411**-N in an exploded view in accordance with an embodiment of the present disclosure. As shown, the laser assembly **411**-N includes a welding ring **450**-N or z-ring **450**-N, a collimating lens **452**-N and a TOSA module **424**-N. The welding ring **450**-N may be integral to the body of the multi-channel TOSA **320**, e.g., formed as a single piece, or may be separate pieces as shown. The welding ring **450**-N may be attached to a respective input port (or opening) of the multi-channel TOSA **320** to allow the TOSA module **424**-N to properly align and couple to the multi-channel TOSA **320**. As discussed below, the body of the TOSA module **424**-N may have a cylindrical shape to allow the same to be easily inserted into an associated welding ring **450**-N for mounting to the TOSA housing **306** without the use of an intermediate welding device such as a welding cap. The TOSA module **424** may be concentric with the welding ring **450**-N when attached to the TOSA housing, as shown.

Referring to FIGS. **4**C and **4**D, an embodiment of a multi-channel transmitter **320** may include a plurality of TOSA modules **424-1** to **424-4** optically coupled to and directly aligned with mux input ports **426-1** to **426-4** of the multi-channel TOSA **320**. The multi-channel TOSA **320** may be used, for example, as the multiplexing device **222** in the multi-channel transceiver **200** shown in FIG. **2** or may be used separately as a transmitter. Although four (4) TOSA modules **424-1** to **424-4** are shown to support four (4) channels, other numbers of TOSA modules and channels are within the scope of the present disclosure.

In this embodiment, the multi-channel TOSA **320** includes a multiplexer housing **306** with a cavity **401** configured to receive an optical multiplexing arrangement **442**. The multiplexer housing **306** may be further configured to receive the TOSA modules **424-1** to **424-4**, which are shown as mounted to the multiplexer housing **306**. The multiplexer housing **306** includes at least one side wall **406-1** and a plurality of input apertures, e.g., aperture **441-1**, through the side wall **406-1** and aligned with the mux input ports **426-1** to **426-4**. The TOSA modules **424-1** to **424-4** are optically coupled to and directly aligned with the respective mux input ports **426-1** to **426-4** through the respective input apertures of the sidewall **406-2**, e.g., aperture **441-4** shown more clearly in FIG. **4**D.

When directly aligned, as shown in FIG. **4**D, a laser output **413** from a TOSA module **424-4** passes into the mux input port **426-4** without using an optical fiber or other optical component to change the path of the laser output **413**. The laser output **413** may then be coupled via port **428** into fiber **415**. The TOSA **320** is designed such that the mux input ports **426-1** to **426-4** are spaced sufficiently to allow the multiple TOSA modules **424-1** to **424-4** to be mounted side-by-side, e.g., in a linear array, on the side wall **406-1** and directly aligned with the mux input ports **426-1** to **426-4**. The input apertures of the TOSA **320** may thus have the same spacing, center-to-center, to align with the mux input ports **426-1** to **426-4**. In one example, the mux input ports **426-1** to **426-4** may be spaced about 3 mm, or less, for example.

In the illustrated embodiment, Z-rings, e.g., Z-ring **450**, are used to mount the TOSA modules **424-1** to **424-4** to the side wall **406-1** of the TOSA housing **306** and to facilitate alignment of the laser output from the TOSA modules **424-1** to **424-4** with the mux input ports **426-1** to **426-4** on the TOSA **320**. One example process for coupling TOSA modules **424-1** to **424-4** in a linear array to housing **306** using a welding assembly, e.g., welding assembly **600** and **600**A, is discussed further below in greater detail.

As shown in FIGS. **5**A-**5**B and described in greater detail below, each TOSA module **424-4** include a base **510**, or body **510**, having an optical coupling end **552** that is received inside and secured to a respective Z-ring **450**. In the illustrated embodiment, the optical coupling end **552** of the base **510** is adjacent a cylindrical shaped region **556** of the base **510**, with the cylindrical shaped region **556** being received in a cylindrical aperture in the Z-ring **450**, although other shapes are within the scope of the present disclosure. The Z-ring **450** may be made of a metal material such as stainless steel, for example. The material of the Z-ring **450** may be the same as the material of the base **510**.

The TOSA housing **306** may be made of a metal material, such as stainless steel, or other suitable material. In some cases, the TOSA housing **306**, Z-ring **450** and the base **510** of the TOSA module **424-4** comprise the same metal or alloy, such as stainless steel, copper, aluminum, for example.

FIG. **5**A shows an example TOSA module **424** in greater detail. The base **510** includes an electrical coupling end **554** disposed opposite the optical coupling end **552** and walls **558** between the optical coupling end **552** and the electrical coupling end **554** along longitudinal axis **501**. The base **510** includes a cylindrical region **556**, with the cylindrical region **556** having an outer surface **559** and an inner surface **560** disposed opposite the outer surface **559**. As shown in FIG. **5**D, the cylindrical region **556** provides the base **510** with a substantially cylindrical shape that allows the TOSA module **424** to be coupled, e.g., via welds, to an associated Z-ring during manufacturing, as discussed in greater detail below. The base **510** may also include notches/channels **514** adjacent to the mounting region **512** and also extending substantially along the longitudinal axis **501**.

The base **510** further includes a mounting region **512**, with the mounting region **512** including at least one substantially planar mounting surface that extends along the longitudinal axis **501**, which is shown more clearly in FIG. **5**C. The mounting region receives and couples to surface mount optical devices and circuitry, which are described in greater detail below.

Referring to FIGS. **5**C and **5**D, the body **510** includes a first flange **580** and a second flange **582**, with the first and second flange extending in parallel along the longitudinal axis **501**. The first flange **580** (or arm portion **580**) defines a tapered portion having an overall height of H1, with H1 measuring about 0.48 mm. The first flange **580** may be formed by, for example, removing a portion of the body **510** generally indicated at **589**. As shown, the first flange **580** defines the optical coupling end **552** and the second flange **582** defines the electrical coupling end **554**. The first and second flanges **580** and **582** include profiles that do not increase the overall width of the body **510**, and thus, the width of the body **510** remains constant along its entire length, although in other embodiments the body **510** may taper at one or both ends width-wise depending on a desired configuration.

Returning to FIGS. **5**A and **5**B, with additional reference to FIG. **5**C, the laser diode **522** and monitor photodiode **524** are mounted on a diode sub-mount **516**, and the laser driver circuitry **518** is mounted on a laser driver sub-mount **517** including conductive paths or traces, e.g., traces **520**, for providing electrical connections. The diode sub-mount **516** and laser driver sub-mount **517** may comprise a printed circuit board (PCB) or other suitable substrate. The inner surface **560** of the cylindrical region **556** may act, essentially, as a stop to prevent lateral movement of the laser driver sub-mount **517**. The laser driver sub-mount **517** may extend at least partially through a passageway of the cylindrical region, with the passageway having a semi-cylindrical shape. In some cases, such as shown, the laser driver sub-mount **517** may extend out from the cylindrical region **559** towards the electrical coupling end **554**, as shown. Therefore, when a TOSA module is coupled to a TOSA and disposed in a housing, the traces **520** may be disposed in close proximity to allow for direct coupling with transmit circuitry. For example, as shown in FIG. **3**B, the electrical traces **520** are disposed within 20 to 100 μm of the transmit connecting circuit **304**, thus allowing for direct coupling, e.g., using wire bonding, between the traces **520** and the pads **321** of the transmit connecting circuit.

The laser diode **522** may be configured to emit a single channel wavelength, e.g., **1270** nm, **1290** nm, **1310** nm, or **1330** nm, generally along direction **526** towards the TOSA **320**, for example. Other TOSA modules having different configurations are also within the scope of this disclosure. Optical signals at different channel wavelengths (e.g., λ**1**, λ**2**, λ**3**, λ**4**) may thus be coupled into the respective ports **226-1** to **226-4** of the optical mux **222** (FIG. **1**) via respective TOSA modules **224-1** to **224-4**. The optical mux **222** may then generate a multiplexed optical signal combining the channel wavelengths and output the same from the port **228**.

Referring to FIG. **5**B, with additional reference to FIG. **5**A, the laser diode **522** and monitor photodiode **524** and diode sub-mount **516** may be mounted in a sandwich fashion to the mounting region **512**, and more particularly, to a surface thereof. Likewise, the laser driver circuitry **518** and laser driver sub-mount **517** may also be mounted in a sandwich fashion with a surface of the mounting region **512**. Accordingly, the laser diode **522**, monitor photodiode **524**, and laser driver sub-mount **517** may thermally conduct heat to the base **510** during operation. The base **510** (or body **510**) may comprise any material that provides suitable thermal conductivity, such as copper, aluminum, or any metal/alloy having a desired thermal conductivity. The base **510** may be formed from a single piece to ensure optimal thermal conductivity, or may be formed from multiple pieces of a same or different material. An associated Z-ring, e.g., Z-ring **450**-N, and the TOSA housing **306** may comprise an identical material, or material having substantially similar thermal conductivity, to that of the base **510** to allow heat to dissipate during operation. For example, each of the base **510**, Z-ring **450**-N and TOSA housing **206** may comprise copper, aluminum, brass, steel, bronze, or an alloy thereof.

Referring to FIG. **5**B, the laser driver circuitry **518** and laser driver sub-mount **517** may be separated by a gap **571** from the laser diode **522**, monitor photodiode **524** and diode sub-mount **516**. The gap **571** may measure a distance D**1**, with distance D**1** measuring about 0.1 to 1.0 mm, depending on a desired configuration. The gap **571** may comprise air or another material such as a gel. The gap **571** may be generally uniform in distance such as shown, but this disclosure is not necessarily limited in this regard. In any event, the gap **571** may advantageously prevent heat from the laser driver circuitry **518** from directly conducting onto the laser diode **522** and monitor photodiode **524**, and vice-versa. The gap **571** may be sized to allow for wire bonding **570** to extend across the gap **571** to electrically couple the laser driver circuitry **518** to the laser diode **522** and the monitor photodiode **524** to the traces **520**, for example.

Turning to FIGS. **6** and **7**, an example welding assembly **600** for coupling a TOSA module, e.g., TOSA module **424**, to a subassembly housing is shown in accordance with an embodiment of the present disclosure. The welding assembly **600** may be utilized to mechanically align and couple a TOSA module, e.g., TOSA module **424**, to an associated housing, e.g., housing **306**. One example process for utilizing the example welding assembly **600** during a coupling and active alignment process is discussed further below with reference to FIG. **10**.

As shown, the example welding assembly **600** includes a first clamp portion **601** and a second clamp portion **602**. The first and second clamp portions **601** and **602** are configured to couple together and hold the TOSA module **424** at a fixed position during coupling and optical alignment of the same into the housing **306**. The first and second clamp portions **601** and **602** may be comprised of a metal, polymer, plastic or other suitably rigid material. The first and second clamp portions **601**, **602** may be formed from a same material or a different material.

The first and second clamp portions **601** and **602** may each include a plurality of sidewalls and collectively form a body portion **615**, or multi-part body **615**, when coupled together. The body portion **615** may include a substantially cylindrical shape as shown although other embodiments are within the scope of this disclosure. A fixation member **605** such as a screw, peg, or other suitable device may couple the first and second clamp portions **601** and **602** together. The body portion **615** may define a tapered wall **608** that allows for a mechanical gripper of a welding system, for example, to securely hold the body portion **615** during welding processes. One such example mechanical gripper **612** (or gripper **612**) is shown in FIG. **10**.

The tapered wall **608** may include a textured surface (e.g., ridges, bumps, protrusions) to increase friction when in communication with gripper **612**. The tapered wall **608** may extend from an end of the body **615** to a predetermined distance along longitudinal axis **619**, with the predetermined distance being sufficient to allow for a secure connection between the gripper **612** and the tapered wall **608**. A surface **617** disposed a distal end of the of the tapered wall **608** extends substantially perpendicular to a surface defining the tapered wall **608** and may act as a stop to ensure that the gripper **612** can provide suitable counter-force when the welding assembly **600** is pressed against the housing **306**.

The tapered wall **608** may be defined at least in part by surfaces **618**A and **618**B which extend substantially perpendicular to the surface defining the tapered wall **608**. The surfaces **618**A and **618**B may act as a guide and allow the gripper **612** to securely hold the welding assembly **600** and prevent lateral movement of the same during alignment and coupling processes as variously disclosed herein. Each of the first and second clamp portions **601** and **602** may define at least a portion of the tapered wall **608**, although this disclosure is not necessarily limited in this regard. For example, the tapered wall **608** may be provided by only one of the first and second clamp portions **601** and **602**.

Continuing with FIGS. **6** and **7**, the body portion **615** may include an overall width that allows a linear array of laser assemblies to be coupled to the housing **306** in relatively close proximity to each other (e.g., within **3**mm or less). For instance, and as more clearly shown in FIG. **3**C, each of the laser assemblies **424-1** to **424-4** are coupled to the housing **306** in a linear array with a relatively small distance, e.g., <3 mm, between adjacent laser assemblies. To this end, the body portion **615** of the welding assembly **600** may include an overall width along longitudinal axis **619** that is about equal to or less than the diameter of associated Z-rings, e.g., Z-ring **450**-N. Stated differently, the welding assembly **600** may include a relatively small footprint that is no wider than a given laser assembly once coupled to the housing **306**. This ensures that a chosen spacing between adjacent laser assemblies is based on a desired configuration rather than a spacing that is necessitated by the width of the welding assembly **600**. In addition, the low-profile of the body portion **615** ensures that a laser welding fixture has an unobstructed "view" of a TOSA module and associated components during welding processes.

The body portion **615** provides a TOSA module receptacle (which may be referred to as a socket or opening) for removably engaging and holding the TOSA module **424** securely in place, which is discussed in greater detail below with regard to FIGS. **8**-**9**. The first and second body portions **601** and **602** may be shifted relative to each other to perform minor pitch corrections for the TOSA module **424**. For example, the fixation member **605** and associated fixation passageway **621**, which is more clearly shown in FIG. **8**, may be oversized relative to the driving head **623** to provide a relatively wide tolerance to allow the first clamp portion **601** to be shifted/offset longitudinally relative to the second clamp portion **602**. For example, offset **620** (FIG. **7**) may occur relative to the tightening/loosening of the fixation member **605**. The offset **620** may proportionally adjust the pitch of the TOSA module **424** at a non-zero pitch angle relative to the longitudinal axis **619**. These fine-grain pitch adjustments may be utilized during alignment processes to ensure nominal laser performance prior to welding.

A shown, the alignment member **603** includes a substantially cylindrical shape. The alignment member **603** may include a tapered female opening **609** (or TOSA module receptacle **609**), which is more clearly shown in FIG. **8**, which includes a shape that generally corresponds to an optical coupling end of the TOSA module **424**. Thus, the tapered female opening **609** may be configured to receive at least a portion of the TOSA module **424** and couple thereto to form a frictional connection. The alignment member **603** may include side opening **607** to allow for the alignment member **603** to be decoupled from the TOSA module **424** by longitudinal movement, e.g., by gripper **612**, away from the TOSA module **424** followed by lateral movement, with the lateral movement causing a flange portion (and associated circuitry) of the TOSA module **424** to pass through the side opening **607** without disturbing/displacing the position of the welding assembly **600**.

The alignment member **603** includes at least one alignment contact surface, such as alignment contact surface **606**. The alignment contact surface **606** extends substantially perpendicular to that of the longitudinal axis **619**. The alignment contact surface **606** is configured to extend substantially in parallel with an emission face **628** (FIG. **9**) of a laser diode coupled to an optical coupling end **552** of the TOSA module **424** when the same is coupled into the tapered female opening **609**. During an alignment and coupling process the alignment contact surface **606** therefore acts as a guide to ensure the TOSA module **424** is substantially perpendicular to the housing **306** prior to welding to ensure nominal optical performance. One such example coupling and alignment process is discussed in greater detail below with reference to FIG. **10**. The alignment member **603** may further include a recessed region **650** to receive a portion of a collimating lens **452**-N that extends from the housing **306** such as shown in FIG. **10**. Thus the alignment contact surface **606** may directly contact and be flush with a surface of the housing **306** during an alignment and coupling process without being obstructed by the collimating lens **452**-N. Note that the collimating lens **452**-N may be coupled to an associated opening at various points during manufacture and may not necessarily be present when the TOSA module **424** is aligned via direct contact with the surface of the housing **306**.

The temporary electrical connection members **604** may comprise, for example, spring-loaded pogo pins or other similar devices that allow for temporary electrical connectivity without wire bonding or other more permanent fixation approaches. The temporary electrical connection members **604** may be disposed in respective passageways **669** (FIG. **9**) that extend substantially perpendicular to that of the longitudinal axis **619**. A first end of each of the temporary electrical connection members **604** may electrically couple to a respective trace **624** (FIG. **8**) of the TOSA module **424**. A second end of each of the temporary electrical connection members **604** may extend from the first clamp portion **601** and couple to driver circuitry in order to receive a voltage/current to drive the TOSA module **424** during active alignment processes.

Turning to FIG. **8**, an unassembled view of the welding assembly **600** is shown in accordance with an embodiment of the present disclosure. As shown, the first and second clamp portions **601** and **602** collectively define a TOSA module receptacle **613** (or TOSA module socket **613**) based at least in part on tapered regions **613**A and **613**B, which are more clearly shown in the cross-sectional view of FIG. **9**. The first and second clamp portions **601** and **602** also include a fixation passageway **621** that is coaxial with the fixation passageway **622** when the first and second clamp portions **601** and **602** are coupled to each other. Also shown is mating surface **670** that extends along the longitudinal axis of the first clamp portion **601**. The second clamp portion **602** also includes a mating surface **671** that extends along the longitudinal axis of the second clamp portion. The first and second mating surfaces **670** and **671** may be substantially flat, as shown, although other embodiments are within the scope of this disclosure.

The TOSA module receptacle **613** may include a shape that corresponds with an electrical coupling end **554** of the TOSA module **424** and may receive at least a portion of the same and form a frictional connection therewith. For example, the tapered region **613**B may include a generally

hemispherical (or arcuate) shape, although other shapes are within the scope of this disclosure depending on the particular contours chosen for the TOSA module **424**.

As further shown, the alignment member **603** includes the female tapered opening **609** that may also be accurately referred to as a TOSA module receptacle **609**. In this embodiment, the tapered opening **609** includes a first recessed region **610**A, with the first recessed region **610**A having a shape that corresponds with an integrated welding member portion **625**. For example, the first recessed region **610**A may include a partial hemispherical shape that corresponds with the spherical shape of the integrated welding member **625**. Therefore, at least a portion of the integrated welding member **625** may be received within the recessed region **610**A. Likewise, a second recessed region **610**B may be configured with a shape that corresponds with the integrated welding member **625** such that same may be at least partially received therein. A third recessed region **610**C may be configured to receive at least a portion of the optical coupling end **552** of the TOSA module **424**.

FIG. **9** shows a cross-sectional view of the welding assembly **600** taken along the line **9-9** of FIG. **6**, in accordance with an embodiment of the present disclosure. As shown, the first and second clamp portions **601** and **602** couple in a sandwich fashion and securely hold an electrical coupling end **554** of the TOSA module **424** in a fixed position. The temporary electrical connection members **604** extend through a portion of the first clamp portion **601** via passageways **669** and electrically couple with traces **624**. A spring element (not shown) within each of the temporary electrical connection members allow the same to directly contact an associated electrical trace **624** and to retract and allow the TOSA module **424** to be removed from the TOSA module receptacle **613** after the TOSA module **424** has been coupled to the housing **306**. As further shown, the emission face **628** of a laser diode of the TOSA module **424** may be substantially parallel with a surface **660** that defines a portion of the third tapered region **610**C. The surface **660** may be substantially parallel with the alignment contact surface **606**.

Turning to FIG. **10**, the welding assembly **600** is illustrated adjacent the TOSA housing **306** during a coupling and active alignment process, in accordance with an embodiment of the present disclosure. The process begins with securing a TOSA module, e.g., TOSA module **424**, into the welding assembly **600**. This may include coupling the first and second clamp portions **601** and **602** over the TOSA module **424**. The fixation member **605** may be utilized to securely couple the first and second clamp portions **601** and **602** over the TOSA module **424**. Next, the alignment member **603** may be coupled to the optical coupling end **552** of the TOSA module **424**. The welding assembly **600** may then be inserted into the gripper **612**, with the gripper **612** being associated with a welding system (not shown) that allows the gripper **612** to move along various axis for alignment purposes. The gripper **612** may then travel along the Y axis until the alignment contact surface **606** is in direct contact and flush with a surface **627** of the housing **306**.

When the alignment contact surface **606** directly contacts and is flush with the surface **627** of the housing **306** the TOSA module **424** is considered in alignment, wherein alignment includes the TOSA module **424** extending substantially perpendicular relative to the surface **627** to cause the emission face **628** of a laser diode of the TOSA module **424** to be substantially parallel relative to the surface **627** of the housing **306**. Thus the alignment contact surface **606** contacts the surface **627** of the associated subassembly housing to mechanically align an emission face **628** of the TOSA module substantially in parallel with the surface **627** of the associated subassembly housing. The alignment contact surface **606** advantageously provides an indication of successful alignment based on the same being flush with the surface **627**.

The welding assembly **600** may then retract via gripper **612** while maintaining the X and Z axis position. Once retracted a suitable distance the alignment member **603** may be removed to expose the optical coupling end **552** of the TOSA module **424**. At this time, and if not already added, the collimating lens **452**-N may be coupled into an associated opening of the housing **306**. A welding member, e.g., Z-ring **450**-N, may then be placed over the collimating lens **452**-N and the welding assembly **600** may then travel again along the Y axis to cause the TOSA module **452**-N to pass through the welding member. The gripper **612** may continue to travel along the Y axis in this fashion until the optical coupling end **552** of the TOSA module **424** makes direct contact with or is otherwise in close proximity with the surface **627**. At this stage the gripper **612** may be in a "locked" configuration wherein the TOSA module **424** remains perpendicular relative to the housing **306**. The TOSA module **424** may then be moved along the Z and X axis to center the TOSA module **424** over the associated collimating lens **452**-N.

Next, and with the TOSA module **424** in position relative to the housing **306**, an electrical signal may be supplied via the temporary electrical connection members **604** to drive the TOSA module **424**. Power measurements may then be analyzed to determine whether the TOSA module **424** is optically aligned with the housing **306**. One or more welds may then be introduced between the TOSA module **424** and the welding member as well as the welding member and the housing **306**, e.g., via a hammering process, with subsequent power measurements taken to ensure proper optical alignment. This process may be repeated N number of times to couple a linear array of TOSA modules to the housing **306**, with the linear array having a spacing of 3 mm or less between adjacent TOSA modules.

Turning to FIG. **11**, another embodiment of a welding assembly **600**A is shown in accordance with an embodiment of the present disclosure. The welding assembly **600**A may be utilized to mechanically align and couple a TOSA module, e.g., TOSA module **424**, to an associated housing, e.g., housing **306** of FIG. **3**B. One example process for utilizing the example welding assembly **600**A is discussed above with reference to FIG. **10**.

The welding assembly **600**A includes a first clamp portion **701**, a second clamp portion **702**, and an alignment member **703**. The first and second clamp portions **701** and **702** may be defined by a plurality of sidewalls that extend along a longitudinal axis **719** from a first end **716** (which may be referred to as an electrical coupling end **716**) to a second end **758** (which may be referred to as a TOSA module receptacle **758**). The first and second clamp portions **701** and **702** include mating surfaces **770** and **771**, respectively, to couple to each other. The mating surface **770** and **771** may be substantially flat although other embodiments are within the scope of this disclosure.

When the first and second clamp portions **701** and **702** are coupled together via the mating surfaces **770** and **771** they may collectively form a body **715**. A printed circuit board (PCB) **750** is disposed between the first and second clamp portions **701** and **702**. The PCB **750** includes a plurality of electrical traces **751** that extend along the longitudinal axis **719** from the first end **755** to the second end **756**.

Adjacent the electrical coupling end **716** a portion of the electrical traces **751** are exposed to allow for electrical coupling to driver circuitry, e.g., via temporary wire bonding, with the driver circuitry being configured to provide electrical signals during active alignment processes, for example. The first clamp portion **701** includes at least two arm portions, e.g., arms **753**A and **753**B, which define a port or opening **752**. The portion of the electrical traces **751** exposed via the port **752** allow for the PCB **750** to be electrically coupled to the TOSA module **424**, e.g., via temporary wire bonding, to provide electrical signals received via the electrical coupling end **716**.

The welding assembly **600**A may be configured substantially similar to that of the welding assembly **600** of FIGS. **6-9**, and may be utilized in the coupling and alignment process of FIG. **10** with minor modification, and for this reason the description of which is equally applicable and will not be repeated for brevity. For example, the tapered wall **708** allows a gripper, such as gripper **612**, to couple to the welding assembly **600**A. Likewise, the alignment contact surface **706** may be utilized to ensure the emission face of the TOSA module **424** is flush relative to the housing **306**. In addition, the alignment member **703** may include opening **707** to allow for easy decoupling of the alignment member **703** from the TOSA module **424**.

Turning to FIG. **12**, the welding assembly **600**A is shown unassembled in accordance with an embodiment of the present disclosure. As shown, one or more insulating members, e.g., insulator members **754**A and **754**B, may be disposed between the electrical traces **751** and the first clamp portion **701** to provide electrical isolation and prevent an electrical short therebetween. The insulator members **754**A and **754**B may comprise, for example, tape or any other suitable substrate for providing electrical isolation between electrical elements. The fixation passageway **721** extends through the first clamp portion **701**, PCB **750**, and second clamp portion **702**. The fixation member **705** may comprise a screw, as shown, or any other suitably fixation member such as a peg. The fixation member **705** may be coupled into the fixation passageway **721** to couple each of the first clamp portion **701**, PCB **750**, and second clamp portion **702** together in a sandwich/stacked fashion.

FIG. **13**, with additional reference to FIGS. **11** and **12**, shows a cross-sectional view of the welding assembly **600**A taken along the line **3-3** of FIG. **11**, in accordance with an embodiment of the present disclosure. As shown, the TOSA module **424** may be coupled to the first and second clamp portions **701** and **702** via a frictional connection. For example, arms **753**A and **753**B of the first clamp portion **701** may supply a force sufficient to hold the TOSA module **424** in place when the first and second clamp portions **701** and **702** are coupled together, e.g., via fixation member **705**.

As further shown, the alignment member **703** includes a female tapered receptacle **709**, or a TOSA module receptacle **709**, which includes a shape that generally corresponds with an optical coupling end **552** of the TOSA module **424**. The female tapered receptacle **709** is defined by at least a first recessed region **710**A and a second recessed region **710**B. The female tapered region may further be defined by a third tapered region **710**C. The emission face **728** of a laser diode of the TOSA module **424** may be substantially parallel with a surface **760** that defines a portion of the third tapered region **710**C. The surface **760** may be substantially parallel with the alignment contact surface **706**. The body portion **715** may further define a tapered region **713**, or TOSA module receptacle **713**, which includes a shape that generally corresponds with the shape of an electrical coupling end **554** of the TOSA module **424**.

The traces **751** of the PCB **750** may be electrically coupled to electrical traces **761** of the TOSA module **424** via, for example, wire bonds **757** or other suitable approaches. The wire bonds **757** may be removed after an active alignment process completes in order to electrically couple the TOSA module **424** to a flexible printed circuit board within an optical transceiver system, for example.

Additional Example Embodiments

Consistent with an aspect of the present disclosure a system for coupling a transceiver optical subassembly (TOSA) module to an associated subassembly housing is disclosed. The system including a first clamp portion having a plurality of walls that define a first tapered region and a mating surface, the mating surface extending along a longitudinal axis of the first clamp portion from a first end to a second end of the first clamp portion and being configured to couple to a second clamp portion and, a second clamp portion having a plurality of walls that define a second tapered region and a mating surface configured to couple to the mating surface of the first clamp portion, and wherein the first and second tapered regions of the first and second clamp portions, respectively, collectively form at least a portion of a TOSA module receptacle when the first and second clamp portions are coupled to each other, the TOSA module receptacle configured to securely hold the TOSA module at a fixed position.

In accordance with another aspect of the present disclosure a system for coupling a transceiver optical subassembly (TOSA) module to an associated subassembly housing is disclosed. The system comprising a multi-part clamp body comprising a first clamp portion having a plurality of walls that define a first tapered region and a mating surface, the mating surface extending along a longitudinal axis of the first clamp portion from a first end to a second end and being configured to couple to a second clamp portion and, a second clamp portion having a plurality of walls that define a second tapered region and a mating surface configured to couple to the mating surface of the first clamp portion, a TOSA module receptacle defined at least in part by the first and second clamp portions for receiving and coupling to an electrical coupling end of the TOSA module, and a printed circuit board (PCB) coupled between the first and second clamp portions, an alignment member having a recess with a shape that corresponds with an optical coupling end of the TOSA module, the alignment member further comprising an alignment contact surface for contacting a surface of the associated subassembly housing to mechanically align an emission face of the TOSA module substantially in parallel with the surface of the associated subassembly housing.

In accordance with another aspect a method for coupling a transceiver optical subassembly (TOSA) module to an associated subassembly housing is disclosed. The method including coupling an electrical coupling end of the TOSA module between a first and second clamp portion, the first and second clamp portions forming a clamp body when coupled to each other, coupling the clamp body into a mechanical grabber, coupling an alignment member to an optical coupling end of the TOSA module, the alignment member providing an alignment contact surface that extends substantially parallel with an emission face of the TOSA module; and moving the mechanical grabber along an axis towards a surface of the associated subassembly housing until the alignment contact surface directly contacts the surface of the associated subassembly housing.

While the principles of the disclosure have been described herein, it is to be understood by those skilled in the art that this description is made only by way of example and not as a limitation as to the scope of the disclosure. Other embodiments are contemplated within the scope of the present disclosure in addition to the exemplary embodiments shown and described herein. Modifications and substitutions by one of ordinary skill in the art are considered to be within the scope of the present disclosure, which is not to be limited except by the following claims.

What is claimed is:

1. A system for coupling a transceiver optical subassembly (TOSA) module to an associated subassembly housing:

a first clamp portion having a plurality of walls that define a first tapered region and a mating surface, the mating surface extending along a longitudinal axis of the first clamp portion from a first end to a second end of the first clamp portion and being configured to couple to a second clamp portion;

a second clamp portion having a plurality of walls that define a second tapered region and a mating surface configured to couple to the mating surface of the first clamp portion;

wherein the first and second tapered regions of the first and second clamp portions, respectively, collectively form at least a portion of a TOSA module receptacle when the first and second clamp portions are coupled to each other, the TOSA module receptacle configured to securely hold the TOSA module at a fixed position; and

wherein the first clamp portion includes a plurality of passageways extending there through to receive temporary electrical connection members, the plurality of passageways extending substantially transverse relative to the longitudinal axis of the first clamp portion.

2. The system of claim **1**, further comprising an alignment member having a recess with a shape that corresponds with an optical coupling end of the TOSA module, the alignment member further comprising an alignment contact surface for contacting a surface of the associated subassembly housing to mechanically align an emission face of the TOSA module substantially in parallel with the surface of the associated subassembly housing.

3. The system of claim **1**, wherein the TOSA module receptacle includes a female tapered recess to receive an electrical coupling end of the TOSA module.

4. The system of claim **1**, further comprising the plurality of temporary electrical connection members, each of the plurality of temporary electrical connection members being disposed in a respective passageway of the plurality of passageways and having a first end to electrically couple to the TOSA module and a second end extending from the first clamp portion to electrically couple to associated driver circuitry.

5. The system of claim **4**, wherein the temporary electrical connection members comprise spring-loaded pogo pins.

6. The system of claim **1**, further comprising a printed circuit board (PCB) for coupling between the first and second clamp portions.

7. The system of claim **6**, wherein the first tapered region includes first and second arm portions that extend along the longitudinal axis of the first clamp portion and form an opening therebetween, and wherein the opening is configured to expose a portion of the PCB when the PCB is coupled between the first and second clamp portions.

8. The system of claim **7**, wherein a portion of the PCB exposed by the opening is configured to be wire bonded to an electrical coupling end of the TOSA module when the TOSA module is disposed in the TOSA module receptacle.

9. The system of claim **6**, further comprising at least one electrical insulation member configured to be coupled between the PCB and the first clamp portion to provide electrical isolation therebetween.

10. The system of claim **1**, wherein a fixation passageway extends through each of the first and second clamp portions and is configured to receive a fixation member to couple the first and second clamp portions together.

11. The system of claim **10**, wherein the fixation passageway is configured to receive a fixation member.

12. The system of claim **11**, wherein the fixation member comprises a screw.

13. A system for coupling a transceiver optical subassembly (TOSA) module to an associated subassembly housing:

a multi-part clamp body comprising:

a first clamp portion having a plurality of walls that define a first tapered region and a mating surface, the mating surface extending along a longitudinal axis of the first clamp portion from a first end to a second end and being configured to couple to a second clamp portion;

a second clamp portion having a plurality of walls that define a second tapered region and a mating surface configured to couple to the mating surface of the first clamp portion;

a TOSA module receptacle defined at least in part by the first and second clamp portions for receiving and coupling to an electrical coupling end of the TOSA module;

a printed circuit board (PCB) coupled between the first and second clamp portions;

wherein the first clamp portion includes a plurality of passageways extending there through to receive temporary electrical connection members; and

the plurality of temporary electrical connection members, each of the plurality of temporary electrical connection members being disposed in a respective passageway of the plurality of passageways and having a first end to electrically couple to the TOSA module and a second end extending from the first clamp portion to electrically couple to associated driver circuitry;

an alignment member having a recess with a shape that corresponds with an optical coupling end of the TOSA module, the alignment member further comprising an alignment contact surface for contacting a surface of the associated subassembly housing to mechanically align an emission face of the TOSA module substantially in parallel with the surface of the associated subassembly housing.

14. The system of claim **13**, wherein the multi-part clamp body portion further defines a tapered wall for coupling to a mechanical grabber.

15. The system of claim **13**, further comprising the TOSA module, and wherein the TOSA module is wire bonded to one or more electrical traces of the PCB.

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