



APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	11/16/2021	11177887	PAT276US	7554

27543 7590 10/27/2021
APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional inventors):

Kai-Sheng LIN, Sugar Land, TX;
Hang XIE, Missouri City, TX;
Yi WANG, Katy, TX;

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Applied Optoelectronics, Inc., Sugar Land, TX;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

27543 7590 08/09/2021
APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

April Davis	(Typed or printed name)
/April Davis/	(Signature)
October 12, 2021	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554

TITLE OF INVENTION: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCIEVER IMPLEMENTING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	11/09/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
SEDIGHIAN, MOHAMMAD REZA	2636	398-135000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

Grossman Tucker Perreault
& Pfleger, PLLC
Norman S. Kinsella

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY AND STATE OR COUNTRY)

Applied Optoelectronics, Inc.

Sugar Land, TX

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-1705

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Kenneth M. Thompson/

Date October 12, 2021

Typed or printed name Kenneth M. Thompson

Registration No. 72,001

Electronic Patent Application Fee Transmittal				
Application Number:		16737438		
Filing Date:		08-Jan-2020		
Title of Invention:		SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		
First Named Inventor/Applicant Name:		Kai-Sheng LIN		
Filer:		Kenneth M. Thompson/April Davis		
Attorney Docket Number:		PAT276US		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1200	1200

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1200

Electronic Acknowledgement Receipt

EFS ID:	44013438
Application Number:	16737438
International Application Number:	
Confirmation Number:	7554
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME
First Named Inventor/Applicant Name:	Kai-Sheng LIN
Customer Number:	27543
Filer:	Kenneth M. Thompson/April Davis
Filer Authorized By:	Kenneth M. Thompson
Attorney Docket Number:	PAT276US
Receipt Date:	12-OCT-2021
Filing Date:	08-JAN-2020
Time Stamp:	20:46:49
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 1200
RAM confirmation Number	E20210BK47171023
Deposit Account	501705
Authorized User	April Davis

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
 37 CFR 1.20 (Post Issuance fees)
 37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	PAT276US_IssueFee_Transmittal.pdf	1465495	no	1
			8d1cdc6f89ca28ae353b8fff730108ceabf252fd		

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	38211	no	2
			c777fe61908e5bf2b1660b6f5c38d1eca228faa8		

Warnings:

Information:

Total Files Size (in bytes):	1503706
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE
COMMISSIONER FOR PATENTS
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ALEXANDRIA VA 22313-1451

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APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478



**Courtesy Reminder for
Application Serial No: 16/737,438**

Attorney Docket No: PAT276US

Customer Number: 27543

Date of Electronic Notification: 08/09/2021

This is a courtesy reminder that new correspondence is available for this application. If you have not done so already, please review the correspondence. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

An email notification regarding the correspondence was sent to the following email address(es) associated with your customer number:

docketing@gtpp.com

kcarroll@gtpp.com

Youngun_Kim@ao-inc.com

To view your correspondence online or update your email addresses, please visit us anytime at **<https://ppair-my.uspto.gov/pair/PrivatePair>**.

If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov or call 1-866-217-9197.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

27543 7590 08/09/2021
APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478

EXAMINER	
SEDIGHIAN, MOHAMMAD REZA	
ART UNIT	PAPER NUMBER

2636

DATE MAILED: 08/09/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554

TITLE OF INVENTION: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	11/09/2021

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

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SUGAR LAND, TX 77478

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(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554

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EXAMINER	ART UNIT	CLASS-SUBCLASS
SEDIGHIAN, MOHAMMAD REZA	2636	398-135000

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1 _____

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

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(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

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☐ Applicant asserting small entity status. See 37 CFR 1.27

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NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554
EXAMINER				
SEDIGHIAN, MOHAMMAD REZA				
ART UNIT			PAPER NUMBER	
2636				
DATE MAILED: 08/09/2021				

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 16/737,438	Applicant(s) LIN et al.	
	Examiner M R SEDIGHIAN	Art Unit 2636	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 5/19/2021.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 1-3, 5-8, 10-15, renumbered as 1-13. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov**.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some *c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)	5. ☐ Examiner's Amendment/Comment
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.	6. ☐ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.	

/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636	
---	--

<i>Search Notes</i> 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

CPC - Searched*		
Symbol	Date	Examiner
H04B 10/40, 503, 801	07/24/2021	MRS
H01L 23/52	07/24/2021	MRS

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
398	135	07/24/2021	MRS

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see search history	07/24/2021	MRS
searched google scholar	07/31/2021	MRS

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
see search history		07/24/2021	MRS

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Issue Classification 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

CPC						
Symbol					Type	Version
H04B	/	10	/	40	F	2013-01-01
H04B	/	10	/	801	I	2013-01-01
H04B	/	10	/	503	I	2013-01-01
H01L	/	23	/	52	I	2013-01-01

CPC Combination Sets					
Symbol				Type	Set
	/		/		

NONE (Assistant Examiner) (Date)		Total Claims Allowed: 13	
/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636 (Primary Examiner) (Date)		31 July 2021 (Date)	O.G. Print Claim(s) 1
			O.G. Print Figure 7A

Issue Classification 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

INTERNATIONAL CLASSIFICATION			
CLAIMED			
H04B	/	10	/ 00
NON-CLAIMED			
/	/		

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
398	135

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	13	
/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636	31 July 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	7A

Issue Classification 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	8	10												
2	2	9	11												
3	3	10	12												
	4	11	13												
4	5	12	14												
5	6	13	15												
6	7		16												
7	8														
	9														

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 13	
/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636 (Primary Examiner) _____ (Date) 31 July 2021		O.G. Print Claim(s) 1	O.G. Print Figure 7A

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	12,009	((Transmitter adj1 Optical adj1 Subassembly) or TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/31 16:49
L2	4	1 and ((vertical near5 surface) with stop\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/31 16:49
L3	101	1 and (recess\$3 same step\$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/31 16:52
L4	1,007	1 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/31 17:05
L5	33	4 and (offset near5 distance)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/31 17:06

7/31/2021 5:11:16 PM

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S64	12,414	H04B10/40.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 15:38
S65	3	S64 and ((vertical adj1 surface) same TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 15:40
S66	3,850	H04B10/503.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:34
S67	1	S66 and ((vertical adj1 surface) same TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:34
S68	4,336	H04B10/801.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:34
S69	1	S68 and ((vertical adj1 surface) same TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:34
S70	1,930	H01L23/52.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:38
S71	1	S70 and ((vertical adj1 surface) same TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:38
S72	2,243	398/135.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:38
S73	0	S72 and ((vertical adj1 surface) same TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:38
S74	3	S64 and ((vertical adj1 surface) and TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	2021/07/24 16:39

			JPO; DERWENT; IBM_TDB			
S75	1	S66 and ((vertical adj1 surface) and TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:41
S76	1	S68 and ((vertical adj1 surface) and TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:41
S77	1	S70 and ((vertical adj1 surface) and TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:41
S78	1	S72 and ((vertical adj1 surface) and TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:42
S79	4	S64 and (vertical adj1 surface) and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:44
S80	1	S66 and (vertical adj1 surface) and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:48
S81	1	S68 and (vertical adj1 surface) and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:48
S82	1	S70 and (vertical adj1 surface) and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:48
S83	1	S72 and (vertical adj1 surface) and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 16:48
S84	980	(mount\$3 near5 surface) and TOSA	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 23:21
S85	240	S84 and (vertical near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 23:22

S86	233	S84 and (vertical near3 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/24 23:22
S87	980	(mount\$3 near5 surface) and TOSA	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/25 17:18
S88	233	S87 and (vertical near3 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/25 17:19
S89	1	recess\$3 adj1 TOSA adj1 mount\$3 adj1 surface	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:01
S90	1	recess\$3 near5 TOSA near5 mount\$3 near5 surface	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:01
S91	22	recess\$3 near5 TOSA	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:02
S92	148	LIN near3 Kai near3 Sheng	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:21
S93	3	S92 and (recess\$3 near5 TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:21
S94	120	XIE near3 Hang	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:28
S95	1	S94 and (recess\$3 near5 TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:29
S96	32,762	WANG near3 Yi	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:29
S97	1	S96 and (recess\$3 near5 TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 00:29

S98	147	((Transmitter adj1 Optical adj1 Subassembly) or TOSA) same recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/26 20:12
S99	11,325	((vertical near5 surface) with stop\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 11:10
S100	4	S99 and ((Transmitter adj1 Optical adj1 Subassembly) or TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 11:11
S101	25,291	((vertical near5 surface) same stop\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 11:55
S102	12	S101 and ((Transmitter adj1 Optical adj1 Subassembly) or TOSA)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 11:55
S103	12,000	(Transmitter adj1 Optical adj1 Subassembly) or TOSA	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 15:48
S104	4	S103 and ((vertical near5 surface) with stop\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 15:49
S105	11,325	((vertical near5 surface) with stop\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 15:50
S106	131	S105 and (Transmitter or Transceiver)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/07/27 15:51

7/27/2021 8:00:57 PM

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US

CONFIRMATION NO. 7554

27543
APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478

PUBLICATION NOTICE



OC000000126832257

Title:SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

Publication No.US-2021-0211199-A1

Publication Date:07/08/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL **(Submitted Only via EFS-Web)**

Application Number	16737438	Filing Date	2020-01-08	Docket Number (if applicable)	PAT276US	Art Unit	2636
First Named Inventor	LIN			Examiner Name	Sedighian, Mohammad Reza		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.

Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, to any international application that does not comply with the requirements of 35 U.S.C. 371, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV.

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☒ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☒ Other Amendment filed on May 19, 2021

☐ Enclosed

☐ Amendment/Reply

☐ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
 (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to
 Deposit Account No 501705

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

Signature of Registered U.S. Patent Practitioner			
Signature	Kenneth M. Thomson/	Date (YYYY-MM-DD)	2021-06-21
Name	Kenneth M. Thompson	Registration Number	72001

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal				
Application Number:		16737438		
Filing Date:		08-Jan-2020		
Title of Invention:		SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		
First Named Inventor/Applicant Name:		Kai-Sheng LIN		
Filer:		Kenneth M. Thompson/April Davis		
Attorney Docket Number:		PAT276US		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension - 1 month with \$0 paid	1251	1	220	220
Miscellaneous:				
RCE- 1ST REQUEST	1801	1	1360	1360
Total in USD (\$)				1580

Electronic Acknowledgement Receipt

EFS ID:	43042202
Application Number:	16737438
International Application Number:	
Confirmation Number:	7554
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME
First Named Inventor/Applicant Name:	Kai-Sheng LIN
Customer Number:	27543
Filer:	Kenneth M. Thompson/April Davis
Filer Authorized By:	Kenneth M. Thompson
Attorney Docket Number:	PAT276US
Receipt Date:	21-JUN-2021
Filing Date:	08-JAN-2020
Time Stamp:	15:51:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 1580
RAM confirmation Number	E20216KF51591216
Deposit Account	501705
Authorized User	April Davis

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
 37 CFR 1.20 (Post Issuance fees)
 37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	PAT276US_RCE_062121.pdf	1350132	no	3
			a0d1017b3b77a28407a86aa98548204f66689343		

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	32695	no	2
			f8c92bf8d7c577b0e851143db5fae995a3e64b3f		

Warnings:

Information:

Total Files Size (in bytes):			1382827
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554
27543	7590	05/28/2021		
APPLIED OPTOELECTRONICS, INC.			EXAMINER	
13115 JESS PIRTLE BLVD.			SEDIGHIAN, MOHAMMAD REZA	
SUGAR LAND, TX 77478				
			ART UNIT	PAPER NUMBER
			2636	
			NOTIFICATION DATE	DELIVERY MODE
			05/28/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Youngun_Kim@ao-inc.com
docketing@gtp.com
kcarroll@gtp.com

Advisory Action Before the Filing of an Appeal Brief	Application No. 16/737,438	Applicant(s) LIN et al.	
	Examiner M R SEDIGHIAN	Art Unit 2636	AIA (FITF) Status Yes

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 19 May 2021 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☒ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:

a) ☒ The period for reply expires 3 months from the mailing date of the final rejection.

b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.

c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection. The current period for reply expires _____ months from the mailing date of the prior Advisory Action or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.

Examiner Note: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANTS FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37CFR 41.37(a).

AMENDMENTS

3. ☒ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because

a) ☒ They raise new issues that would require further consideration and/or search (see NOTE below);

b) ☐ They raise the issue of new matter (see NOTE below);

c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or

d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

NOTE: The newly added limitations of claims 1 and 12 requires further search and consideration. (See 37CFR 1.116 and 41.33(a)).

4. ☐ The amendments are not in compliance with 37CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).

5. ☐ Applicants reply has overcome the following rejection(s): _____

6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).

7. ☐ For purposes of appeal, the proposed amendment(s): (a) ☐ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____

9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).

10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).

11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☐ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: _____

13. ☐ Note the attached Information *Disclosure Statement(s)*. (PTO/SB/08) Paper No(s). _____

14. ☐ Other: _____

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:

Claim(s) allowed: _____

Claim(s) objected to: _____

Claim(s) rejected: 1-3,5-8 and 10-15.

Claim(s) withdrawn from consideration: _____

/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636	
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S/N: 16/737,438

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Lin, Kai-Sheng

Examiner: Sedighian, Mohammad Reza

Serial No.: 16/737,438

Group Art Unit: 2636 Conf. No.: 7554

Filed: January 8, 2020

Docket: PAT276US

Title: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER
OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR
TRANSCIEVER IMPLEMENTING SAME

RESPONSE UNDER 37 C.F.R. § 1.116 AND INTERVIEW SUMMARY

This is in response to the Official Action in this case mailed February 19, 2021. As this response is being filed within the three-month shortened statutory period of reply, which ends on May 19, 2021, no extension of time is believed necessary. However, Applicant conditionally petitions for an extension of time to provide for the possibility that the need for an extension has inadvertently been overlooked. As provided below, please charge Deposit Account No. 50-1705 for any required fee, or for any deficiency in the enclosed fee.

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 16/737,438		Filing Date 01/08/2020		☐ To be Mailed			
ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO											
APPLICATION AS FILED - PART I											
		(Column 1)		(Column 2)							
FOR		NUMBER FILED		NUMBER EXTRA		RATE (\$)		FEE (\$)			
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A		N/A		N/A					
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A		N/A		N/A					
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A		N/A		N/A					
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 =		*		x \$100 =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 =		*		x \$460 =					
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).									
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))											
* If the difference in column 1 is less than zero, enter "0" in column 2.						TOTAL					
APPLICATION AS AMENDED - PART II											
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT	05/19/2021	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	* 13	Minus	** 20	= 0		x \$100 =		0		
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x \$480 =		0		
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE		0	
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	*	Minus	**	=		x \$0 =				
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x \$0 =				
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE			
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.								SLIE			
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".								/JULIET MCMILLAN/			
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".											
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.											

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Lin, Kai-Sheng

Examiner: Sedighian, Mohammad Reza

Serial No.: 16/737,438

Group Art Unit: 2636 Conf. No.: 7554

Filed: January 8, 2020

Docket: PAT276US

Title: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER
OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR
TRANSCIVER IMPLEMENTING SAME

RESPONSE UNDER 37 C.F.R. § 1.116 AND INTERVIEW SUMMARY

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Electronic Acknowledgement Receipt

EFS ID:	42767148
Application Number:	16737438
International Application Number:	
Confirmation Number:	7554
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME
First Named Inventor/Applicant Name:	Kai-Sheng LIN
Customer Number:	27543
Filer:	Kenneth M. Thompson/April Davis
Filer Authorized By:	Kenneth M. Thompson
Attorney Docket Number:	PAT276US
Receipt Date:	19-MAY-2021
Filing Date:	08-JAN-2020
Time Stamp:	16:18:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		PAT276US_Response_asfiled.pdf	186007	yes	9
			d6be959fd0b9d2ab3af973d8fcd3e3301db72a9a		

Multipart Description/PDF files in .zip description			
Document Description	Start	End	
Applicant Arguments/Remarks Made in an Amendment	6	9	
Claims	2	5	
Response After Final Action	1	1	
Warnings:			
Information:			
Total Files Size (in bytes):		186007	
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.			

REMARKS

Please reconsider the application in view of the following remarks. Applicant submits that the claims, as presented, are in condition for allowance and respectfully requests the withdrawal of all pending rejections of the claims.

Status of Claims

Claims 1-3, 5-8 and 10-15 were previously pending. Applicant amends claims 1 and 12 herein. Support for the amendments is discussed further below. No claims are cancelled, and no new claims are presented at this time. Accordingly, claims 1-3, 5-8 and 10-15 are pending for examination with claims 1 and 12 being independent claims.

Interview Summary

Applicant thanks Examiner Sedighian for his time and courtesy during a telephone interview conducted on May 11, 2021 with Applicant's undersigned Representative. The purpose of the interview was to discuss how the proposed combination of U.S. Pat. Pub. No. 2014/0105612 (Wu) and U.S. Pat. Pub. No. 2019/0278035 (Pezeshki) fails to teach or make obvious each and every feature of independent claims 1 and 12, as discussed in further detail below. Applicant further proposed an amendment to claims along the lines presented herein. No agreement was reached.

Rejections Under 35 U.S.C. § 112

Claims 1-3, 5-8 and 10-15 were rejected for allegedly failing to comply with the written description requirement. *See Office Action dated February 19, 2021; pages 2-3*. In particular, the Office found the features directed to the at least one TOSA module having at least a portion that extends from the optical coupling end of the substrate as unsupported by Applicant's specification.

Applicant respectfully disagrees and notes that FIGs. 2-3 show an example of at least one TOSA module, e.g., TOSA module 205-1, *edge mounted* to substrate 202. *See also, Applicant's originally filed disclosure; para. 0011 (“Continuing on, each of the plurality of TOSA modules 205-1 to 205-4 mount, e.g., edge mount, to the first end 203 of the substrate.”).* Therefore, the feature of at least one TOSA having at least a portion that extends from the optical coupling end of the substrate is supported by Applicant's originally filed specification, and thus, Applicant's claimed invention comports with the written description requirement under 35 U.S.C. 112.

However, and merely for purposes of advancing prosecution, Applicant herein amends the claims to remove the language “such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate when the at least one TOSA module is coupled thereto.”

Accordingly, Applicant respectfully requests reconsideration and withdrawal of the rejection of claims under 35 U.S.C. 112.

Rejections Under 35 U.S.C. § 103

Claims 1-3, 5, and 10-15 were rejected under 35 U.S.C. 103 for allegedly being unpatentable in view of Wu and Pezeshki.

Applicant respectfully requests reconsideration.

Independent claim 1 includes, *inter alia*, “wherein the second mounting region at the optical coupling end of the substrate is configured to edge mount to the at least one TOSA module.”

Independent claim 12 includes, *inter alia*, “at least one TOSA module edge mounted to the optical coupling end of the transceiver substrate.”

The Office Action correctly notes that Wu fails to teach at least the above-recited features. *See Office Action dated February 19, 2021; page 5.*

In effort to remedy this deficiency, the Office Action cites to FIG. 1 and para. 0026 of Pezeshki and asserts that it would have been obvious to modify Wu to include an edge mounted TOSA as “merely a matter of design choice and a specific system requirement.”

Applicant respectfully reminds the Examiner that an obviousness rejection based on a ‘rearrangement of parts’ is only applicable to reject the claims when the change does not modify the operation of the device. *See MPEP 2114.04 (VI)(C).*

In the approach of Wu, lasers 12 are mounted at a *midpoint* of the bench of Wu (See FIG. 4B of Wu reproduced below). Moreover, the components following the laser diodes (optoelectronic device) 12 of Wu include the fixed member 13 and optical fibers 14. Each of these components appear to depend on the bearing surface 111 for alignment. Indeed, the pins 211 of the MT connector 21 are secured via the bearing surface. *See Wu; para. 0037.*

Thus, to edge mount the laser diodes/optoelectronic device 12 of Wu would certainly change the operation, complicate optical alignment, *and likely prevent the use of the MT connector that Wu aims to utilize.*

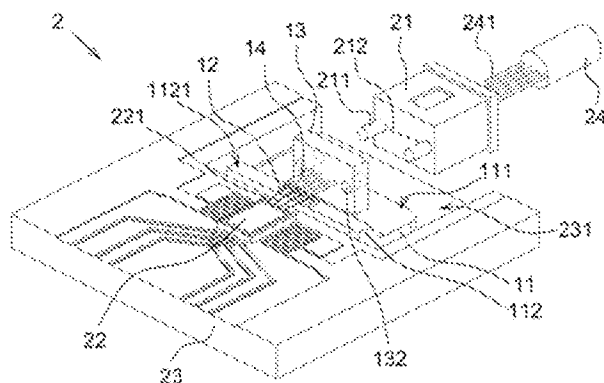


FIG. 4B

In any event, and without conceding the merits of the rejections, Applicant herein amends independent claims 1 and 12 to include, *inter alia*, “wherein the vertical surface provides a mechanical stop to engage a surface of the least one TOSA module and limit travel of the at least one TOSA module along one or more axis.”

Support for the amendments can be found at, for example, the Abstract, FIG. 7A and para. 0011 of Applicant’s originally filed disclosure.

As discussed in para. 0011, the vertical surface and stepped profile: “operate[s] as an alignment guide by providing mechanical stops/limits to limit travel along at least one axis. Alignment along the remaining axis, e.g., the Y axis, may therefore be performed by relatively simply lateral movement (e.g., along the X axis) of each TOSA module 205-1 to 205-4.”

Nothing in Wu, either alone or in combination with Pezeshki, teaches or makes obvious at least the above-recited features.

For at least these reasons, independent claims 1 and 12, and the claims dependent therefrom are allowable over the proposed combination of Wu and Pezeshki.

Claim 7 was rejected as allegedly unpatentable over Wu, Pezeshki and further in view of U.S. Pat. Pub. No. 2006/0043609 (Brennan). Claim 8 was rejected as allegedly unpatentable over Wu, Pezeshki and further in view of U.S. Pat. Pub. No. 2012/0267777 (Haba).

Claims 7 and 8 depend from independent claim 1 and are allowable by virtue of their dependency.

Accordingly, Applicant respectfully requests reconsideration and withdrawal of the rejections of the claims under 35 U.S.C. 103.

Conclusion

Having dealt with all the objections and rejections raised by the Examiner, it is respectfully submitted that the present application, as amended, is in condition for allowance. Thus, early allowance is earnestly solicited.

If the Examiner desires personal contact for further disposition of this case, the Examiner is invited to call the undersigned Attorney at 603.668.6560.

In the event there are any fees due, please charge them to our Deposit Account No. 50-1705 (Ref: PAT276US).

Respectfully submitted,

By: /Kenneth M. Thompson/

Date: May 19, 2021

Kenneth M. Thompson
Reg. No. 72,001

IN THE CLAIMS

1. (Currently Amended) An optical subassembly module, the optical subassembly module comprising:
 - a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end;
 - a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate;
 - a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface; and

wherein the vertical surface provides a mechanical stop to engage a surface of the at least one TOSA module and limit travel of the at least one TOSA module along one or more axis, and wherein the second mounting region at the optical coupling end of the substrate is configured to edge mount to the at least one TOSA module ~~such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate when the at least one TOSA module is coupled thereto.~~
2. (Previously Presented) The optical subassembly module of claim 1, wherein the optical subassembly module further comprises the at least one TOSA module edge mounted to the second mounting region of the substrate, the at least one TOSA module having a body that includes

a component mounting surface to couple to a laser arrangement and a substrate mating surface disposed opposite the component mounting surface of the body, the substrate mating surface of the body to couple to the recessed TOSA mounting surface of the optical coupling end of the substrate and extend from the substrate along an axis that is substantially parallel with a longitudinal axis of the substrate.

3. (Original) The optical subassembly module of claim 2, wherein the substrate mating surface of the body is vertically offset from the component mounting surface of the substrate by the first offset distance.

4. (Cancelled)

5. (Original) The optical subassembly module of claim 2, wherein the laser arrangement of the at least one TOSA module comprises a laser diode driver (LDD) disposed on the component mounting surface of the TOSA module.

6. (Original) The optical subassembly of claim 5, wherein the LDD is electrically coupled to radio frequency (RF) terminals disposed on the component mounting surface of the substrate adjacent the optical coupling end via a plurality of wire bonds.

7. (Original) The optical subassembly of claim 6, wherein each of the plurality of wire bonds extend from the component mounting surface of the substrate at an angle less than or equal to 45 degrees.

8. (Original) The optical subassembly of claim 6, wherein each of the plurality of wire bonds has an overall length of less than 500 microns.

9. (Cancelled)

10. (Original) The optical subassembly of claim 1, wherein the second mounting region is configured to couple to and support a plurality of TOSA modules.

11. (Original) The optical subassembly of claim 1, wherein the substrate is a printed circuit board, and wherein the optical subassembly is a multi-channel optical transmitter or multi-channel optical transceiver capable of transmitting multiple channel wavelengths.

12. (Currently Amended) An optical transceiver, the optical transceiver comprising:
a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end;
at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end; and
a recessed transmitter optical subassembly (TOSA) mounting surface at the optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface;
at least one TOSA module edge mounted to the optical coupling end of the transceiver substrate, wherein the vertical surface provides a mechanical stop to engage a surface of the least one TOSA module and limit travel of the at least one TOSA module along one or more axis ~~such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate~~; and
a receiver optical subassembly arrangement coupled to the transceiver substrate.

13. (Original) The optical transceiver of claim 12, further comprising radio frequency (RF) terminals disposed on the at least one component mounting surface proximate to the optical coupling end, wherein the at least one TOSA module electrically couples with the RF terminals via one or more wire bonds.

14. (Original) The optical transceiver of claim 12, wherein the recessed TOSA mounting surface is vertically offset relative to the at least one component mounting surface of the transceiver substrate by a first offset distance.

15. (Original) The optical transceiver of claim 12, wherein the at least one TOSA module comprises a plurality of TOSA modules, and wherein each TOSA module of the plurality of TOSA modules include a submount and a laser diode driver (LDD) coupled to the submount.

16. (Cancelled)



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554
27543	7590	05/14/2021		
APPLIED OPTOELECTRONICS, INC.			EXAMINER	
13115 JESS PIRTLE BLVD.			SEDIGHIAN, MOHAMMAD REZA	
SUGAR LAND, TX 77478				
			ART UNIT	PAPER NUMBER
			2636	
			NOTIFICATION DATE	DELIVERY MODE
			05/14/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Youngun_Kim@ao-inc.com
docketing@gtpp.com
kcarroll@gtpp.com

<i>Applicant-Initiated Interview Summary</i>	Application No. 16/737,438	Applicant(s) LIN et al.		
	Examiner M R SEDIGHIAN	Art Unit 2636	AIA (First Inventor to File) Status Yes	Page 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	Title	Type
M R SEDIGHIAN	Primary Examiner	Telephonic
Kennet Thompson	Attorney of Record	

Date of Interview: 11 May 2021

Issues Discussed:

35 U.S.C. 112

Discussed about the pending 112 rejections, related to the limitations of independent claims 1 and 12. Discussed about abstract, paragraphs 0036, 0037 of specification, and figures 2, 3, 4, related to the 112 issues. No agreement was reached.

35 U.S.C. 103

Also discussed about the 103 rejections of claims. Examiner stated the rejections of claims 1 and 12 is based on the modifying the primary reference of WU, by Pezeshki, that shows electro-optical circuit(s) can be edge mounted to a substrate, or a circuit board. Examiner further stated the rejections reads on the claims limitations and the Final rejection still stands. No agreement was reached.

/MOHAMMAD R SEDIGHIAN/ Primary Examiner, Art Unit 2636	
Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04 Please further see: MPEP 713.04 Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b) 37 CFR § 1.2 Business to be transacted in writing	

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.



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kcarroll@gtp.com

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.
2. This communication is responsive to applicant's amendments and remarks of 1/5/2021. The amendments have been entered. Claims 1-3, 5-8, 10-15 are now pending.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

(a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. Claims 1-3, 5-8, and 10-15 are rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

As to claim 1, specification does not disclose or describe about “ ... wherein the second mounting region at the optical coupling end of the substrate is configured to edge mount to the at least one TOSA module such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate when the at least one TOSA module is coupled thereto.”.

As to claim 12, specification does not disclose or describe about “ ... at least one TOSA module edge mounted to the optical coupling end of the transceiver substrate such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate; and ...”.

Specification in paragraph 0022 only discloses the TOSA mounting surface extends substantially parallel with the first component mounting surface, and is offset from the same by a first predetermined offset distance. Specification further in paragraph 0060 discloses the recessed TOSA mounting surface 702 extending substantially parallel with the first component mounting surface 245 and substantially transverse relative to vertical surface 704, with the vertical surface 704 adjoining the recessed mounting surface 702 and the first component mounting surface 245. Specification further in paragraph 0062 discloses the recessed TOSA mounting surface 702 underlies and supports at least a portion of the substrate mating surface 708-1, and thus by extension, the body 706 of the at least one TOSA module 205-1. However, specification as originally filed does not disclose or describe about the edge mounting of the TOSA module such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 1-3, 5, and 10-15 is/are rejected under 35 U.S.C. 103 as being unpatentable over WU et al. (US Patent Application Publication No: 2014/0105612 A1) in view of Pezeshki et al. (US Patent Application Publication No: 2019/0278035 A1).

Regarding claims 1 and 12, WU teaches an optical subassembly module (2, figs. 4A, 4B), the optical subassembly module (2, figs. 4A, 4B) comprising:

a substrate (23, fig. 4B) having an electrical coupling end (the electrical coupling end of substrate 23 in fig. 4B) for electrically coupling to external circuitry (paragraph 0036, lines 1-4) and an optical coupling end (the optical coupling end of substrate 23) for launching at least one channel wavelength (see paragraph 0031, lines 8-9) on a waveguide (241, fig. 4B), the electrical coupling end disposed opposite the optical coupling end;

a first mounting region (the mounting region for electrical circuits such circuitry 22, shown in figs. 4A, 4B) at the electrical coupling end of the substrate to provide traces (see the traces shown in fig. 4B) for electrical interconnection with the external circuitry (the external circuit to the transceiver 2), the first mounting region defined at least in part by a component mounting surface (the mounting surface for electrical circuits such as control chip 22) provided by a sidewall (see 112 in fig. 2) of the substrate (substrate 23 in figs. 4A, 4B);

a second mounting region (11, fig. 4B) at the optical coupling end of the substrate (23, fig. 4B) to couple to and support at least one transmitter optical subassembly (TOSA) module (12, figs. 4A, 4B) via a recessed (231, fig. 4A, 4B) TOSA mounting surface (1121, fig. 4B), the recessed TOSA mounting surface (1121 in fig. 4B) being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile (see paragraphs 0030, 0031, 0036), the stepped profile define at least in part by the recessed TOSA mounting surface (1121, fig. 4B) extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface (see 112 in figs. 2, 4A) adjoining the recessed TOSA mounting surface and the component mounting surface (see paragraphs 0030, 0031, lines 1-5). Wu differs from the claimed invention in that Wu does not specifically disclose the second mounting region at the optical coupling end of the substrate is configured to edge mount to the at least one TOSA module such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate when the at least one TOSA module is coupled thereto. However, positioning of a TOSA module, for example, edge mounting of TOSA module, such that a portion of TOSA module extends from the optical coupling end of a substrate, is merely a matter of design choice and a specific system requirement. For example, Pezeshki teaches an optical transceiver (see fig. 1) in a housing (see paragraph 0026), wherein lasers (113, fig. 1) are mounted on a submount, at a forward edge of a printed circuit board (see paragraph 0028, lines 7-13). Therefore, as it is taught and shown by Pezeshki, it would have been obvious before the effective filing date of the claimed invention to a person of ordinary skill in the art to provide and position the TOSA module 12 in bench 11 of Wu, for example, at an edge of the optical coupling end, on the substrate 23, for

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example, to reduce pitch such that circuit cards can be mounted with high density to further provide the system with high bandwidth in an efficient manner. As to claim 12, WU further teaches the use of at least a TOSA module (see 12, fig. 4B and paragraph 0038) coupled to optical coupling end of the transceiver substrate (23, fig. 4B), and a receiver optical subassembly (see paragraph 0031, lines 10-11, paragraph 0038, lines 10-12) arrangement coupled to the transceiver substrate (23 in figs. 4A, 4B).

Regarding claim 2, WU also teaches the optical subassembly module (2, fig. 4B) further comprises the at least one TOSA module (12 in fig. 4B) coupled to the second mounting region (1121 in fig. 4B) of the substrate (23, fig. 4B), the at least one TOSA module (12, fig. 4B) having a body that includes a component mounting surface (1121, fig. 4B) to couple to a laser arrangement (12, fig. 4A) and a substrate mating surface (111, fig. 4B) disposed opposite the component mounting surface (1121, fig. 4B) of the body, the substrate mating surface (111, fig. 4B) of the body to couple to the recessed TOSA mounting surface (231, fig. 4B) of the optical coupling end of the substrate (23, fig. 4B) and extend from the substrate along an axis that is substantially parallel with a longitudinal axis of the substrate (note that substrate mating surface 111 is coupled to recessed TOSA mounting surface 231 of the optical coupling end of substrate 23 and extend from substrate 23 along an axis that is substantially parallel with a longitudinal axis of substrate 23). As to edge mounting the TOSA module 12 to the second mounting region, it would have been obvious to a person of ordinary skill in the art to position and edge mount the TOSA module 12 of bench 11, for example, at an edge of the optical

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coupling end, on the substrate 23, as it is taught and shown by Pezeshki, as discussed above in claim 1.

Regarding claim 3, WU also teaches the substrate mounting surface (111, fig. 4B) of the body is vertically offset (see 112 in figs. 2, 4B) from the component mounting surface (1121, fig. 4B) of the substrate (23, fig. 4B) by the first offset distance (see paragraph 0031, lines 1-4).

Regarding claim 5, WU teaches the laser arrangement of the TOSA module comprises a laser diode driver (LDD) (the LDD of each laser chip) disposed on the component mounting surface (1121, fig. 2) of the TOSA module (12, fig. 2, 4B).

Regarding claim 6, WU teaches the LDD is electrically coupled (221, figs. 4A, 4B) to RF terminals (22, figs. 4A, 4B) disposed on the component mounting surface (the mounting surface for the electrical circuits such as control chip 22) of the substrate (23, fig. 4B) adjacent the optical coupling end via a plurality of wire bonds (see 221 in fig. 4B and paragraph 0036, lines 12-14).

Regarding claim 10, WU teaches the second mounting region (11, fig. 4B) is configured to couple to and support a plurality of TOSA modules (see 121 in fig. 3A and paragraph 0031, lines 1-9).

Regarding claim 11, WU teaches the substrate is a printed circuit board (paragraph 0036, line 5), and wherein the optical subassembly (1, fig. 2 and 2, figs. 4A, 4B) is a multi-channel optical transmitter (paragraph 0031, lines 9) or multi-channel optical transceiver capable of transmitting multiple channel wavelengths (paragraph 0031).

Regarding claim 13, WU teaches RF terminals (22, fig. 4A, 4B) disposed on the at least one component mounting surface proximate to the optical coupling end, wherein the TOSA module (12, figs. 4A, 4B) electrically couples (221, fig. 4B) with RF terminals (22, fig. 4B) via one or more wire bonds (paragraph 0036, lines 12-14).

Regarding claim 14, WU teaches the recessed TOSA mounting surface (1121, fig. 4B) is vertically offset (paragraph 0031, lines 1-3) relative to the at least one component mounting surface of the transceiver substrate by a first offset distance (see 112 in figs. 2, 4A).

Regarding claim 15, WU teaches the at least one TOSA module (12, fig. 4A, 4B) comprises a plurality of TOSA modules (paragraph 0031, line 4, the "laser chips"), and wherein each TOSA module of the plurality of TOSA modules include a submount (1121, fig. 2, 4A, 4B) and a laser diode driver (LDD) (the LDD of respective laser chips) coupled to the submount (1121, figs. 2, 4B).

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7. Claim 7 is/are rejected under 35 U.S.C. 103 as being unpatentable over WU et al. (US Patent Application Publication No: 2014/0105612 A1) in view of Pezeshki et al. (US Patent Application Publication No: 2019/0278035 A1) and in further in view of Brennan et al. (US Patent Application Publication No: 2006/0043609 A1).

Regarding claim 7, the optical transceiver system of WU modified by Pezeshki differs from the claimed invention in that WU and Pezeshki do not specifically disclose each of the plurality of wire bonds (221 in figs. 4A, 4B) extend from the component mounting surface (1121, fig. 4B) of the substrate (23, fig. 4B) at an angle of less than or equal to 45 degrees. Brennan teaches the use of wire bonds (422, 424, 426, fig. 4) that extend from a mounting surface of a substrate (412, fig. 4) at an angle of less than or equal to 45 degrees (see paragraph 0031). Therefore, it would have been obvious before the effective filing date of the claimed invention to a person of ordinary skill in the art to provide and position the wire bonds 221 of WU, for example, at angles of less than or equal to 45 degrees, as it is taught by Brennan, to provide proper electrical coupling for signal transmission.

8. Claim 8 is/are rejected under 35 U.S.C. 103 as being unpatentable over WU et al. (US Patent Application Publication No: 2014/0105612 A1) in view of Pezeshki et al. (US Patent Application Publication No: 2019/0278035 A1) and in further in view of Haba et al. (US Patent Application Publication No: 2012/0267777 A1).

Regarding claim 8, the optical transceiver system of WU modified by Pezeshki differs from the claimed invention in that WU and Pezeshki do not specifically disclose the use of wire bonds with an overall length of less than 500 microns. Haba teaches the use of wire bonds (63

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in fig. 2) with length of about 500 microns (see paragraph 0060, lines 14-17). Therefore, it would have been obvious before the effective filing date of the claimed invention to a person of ordinary skill in the art to provide wire bonds of length 500 microns, such as the ones disclosed by Haba, for the wire bonds 221 of WU, to provide a proper and efficient electrical signal coupling between electro-optical components.

Conclusion

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

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10. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Gilliland et al. (US Patent No: 6,160,647) is cited to show TOSA and ROSA can be mounted beside one another along one edge of a printed circuit board (see col. 1, lines 45-49).

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to M R SEDIGHIAN whose telephone number is (571)272-3034.

The examiner can normally be reached on M-W 11 AM to 7 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kenneth Vanderpuye can be reached on (571) 272-3078. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <https://ppair-my.uspto.gov/pair/PrivatePair>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-

Art Unit: 2636

free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MOHAMMAD R SEDIGHIAN/
Primary Examiner, Art Unit 2636

Notice of References Cited	Application/Control No. 16/737,438		Applicant(s)/Patent Under Reexamination LIN et al.	
	Examiner M R SEDIGHIAN		Art Unit 2636	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20190278035-A1	09-2019	Pezeshki; Bardia	G02B6/421	1/1
*	B	US-6160647-A	12-2000	Gilliland; Patrick B.	H04B10/504	398/1
	C					
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FOREIGN PATENT DOCUMENTS

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	N					
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

CPC - Searched*		
Symbol	Date	Examiner
H04B 10/40, 503, 801	02/13/2021	MRS
H01L 23/52	02/13/2021	MRS

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
398	135	02/13/2021	MRS

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see search history	02/13/2021	MRS

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16737438
	Filing Date	2020-01-08
	First Named Inventor	LIN
	Art Unit	2636
	Examiner Name	SEDIGHIAN, MOHAMMAD REZA
	Attorney Docket Number	PAT276US

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/M.R.S./	1	20030206703	A1	2003-11-06	Chiu et al.	
/M.R.S./	2	20040240803	A1	2004-12-02	Rechberger David L. et al.	

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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	16737438
Filing Date	2020-01-08
First Named Inventor	LIN
Art Unit	2636
Examiner Name	SEDIGHIAN, MOHAMMAD REZA
Attorney Docket Number	PAT276US

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
/M.R.S./	1	US Office Action mailed December 24, 2020, received in US Application No. 16/737,414, 9 pgs.	

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EXAMINER SIGNATURE

Examiner Signature	/MOHAMMAD R SEDIGHIAN/	Date Considered	02/13/2021
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	16737438
Filing Date	2020-01-08
First Named Inventor	LIN
Art Unit	2636
Examiner Name	SEDIGHIAN, MOHAMMAD REZA
Attorney Docket Number	PAT276US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kenneth M. Thompson/	Date (YYYY-MM-DD)	2021-01-05
Name/Print	Kenneth M. Thompson	Registration Number	72001

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	("20030206703").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:29
L2	1	1 and edge	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:30
L3	2	("20040240803").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:32
L4	1	3 and edge	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:32
L5	11,899	H04B10/40.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:33
L6	76	5 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:34
L7	3,647	H04B10/503.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:48
L8	7	7 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:48
L9	2,241	398/135.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:50
L10	18	9 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:50
L11	2	("20190278035").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:52
L12	1	11 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:52
L13	3	("20140105612").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:53

L14	0	13 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:53
L15	3	13 and edge	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 17:53
L16	1,850	H01L23/52.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 19:12
L17	0	16 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 19:12
L18	4,265	H04B10/801.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 19:12
L19	33	18 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 19:12
L20	0	LIN near3 Ka near3 Sheng	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:10
L21	129	LIN near3 Kai near3 Sheng	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:10
L22	11	21 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:10
L23	112	XIE near3 Hang	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:11
L24	0	23 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:12
L25	31,010	WANG near3 Yi	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:12
L26	23	25 and (edge near3 mount\$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/02/13 20:12

2/13/2021 8:14:24 PM

C:\Users\msedighian\Documents\EAST\Workspaces\16737438.wsp

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 16/737,438		Filing Date 01/08/2020		☐ To be Mailed	
ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO									
APPLICATION AS FILED - PART I									
		(Column 1)	(Column 2)						
FOR		NUMBER FILED	NUMBER EXTRA		RATE (\$)		FEE (\$)		
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A	N/A		N/A				
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A	N/A		N/A				
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A	N/A		N/A				
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 = *		x \$100 =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 = *		x \$460 =					
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).							
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))									
* If the difference in column 1 is less than zero, enter "0" in column 2.					TOTAL				
APPLICATION AS AMENDED - PART II									
		(Column 1)		(Column 2)	(Column 3)				
AMENDMENT	01/05/2021	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	* 13	Minus	** 20	= 0	x \$100 =		0	
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0	x \$480 =		0	
	☐ Application Size Fee (37 CFR 1.16(s))								
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))								
						TOTAL ADD'L FEE		0	
		(Column 1)		(Column 2)	(Column 3)				
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	*	Minus	**	=	x \$0 =			
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x \$0 =			
	☐ Application Size Fee (37 CFR 1.16(s))								
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))								
						TOTAL ADD'L FEE			
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.						LIE			
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".						/MARQUITA D JONES/			
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".									
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.									

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16737438
	Filing Date	2020-01-08
	First Named Inventor	LIN
	Art Unit	2636
	Examiner Name	SEDIGHIAN, MOHAMMAD REZA
	Attorney Docket Number	PAT276US

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Add

U.S.PATENT APPLICATION PUBLICATIONS						Remove
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20030206703	A1	2003-11-06	Chiu et al.	
	2	20040240803	A1	2004-12-02	Rechberger David L. et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²ⁱ	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button

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NON-PATENT LITERATURE DOCUMENTS								Remove
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		16737438
	Filing Date		2020-01-08
	First Named Inventor	LIN	
	Art Unit	2636	
	Examiner Name	SEDIGHIAN, MOHAMMAD REZA	
	Attorney Docket Number	PAT276US	

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	US Office Action mailed December 24, 2020, received in US Application No. 16/737,414, 9 pgs.	

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	16737438
Filing Date	2020-01-08
First Named Inventor	LIN
Art Unit	2636
Examiner Name	SEDIGHIAN, MOHAMMAD REZA
Attorney Docket Number	PAT276US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kenneth M. Thompson/	Date (YYYY-MM-DD)	2021-01-05
Name/Print	Kenneth M. Thompson	Registration Number	72001

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	16737438			
Filing Date:	08-Jan-2020			
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME			
First Named Inventor/Applicant Name:	Kai-Sheng LIN			
Filer:	Kenneth M. Thompson/April Davis			
Attorney Docket Number:	PAT276US			
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	260	260
Total in USD (\$)				260

Electronic Acknowledgement Receipt

EFS ID:	41558921
Application Number:	16737438
International Application Number:	
Confirmation Number:	7554
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME
First Named Inventor/Applicant Name:	Kai-Sheng LIN
Customer Number:	27543
Filer:	Kenneth M. Thompson/April Davis
Filer Authorized By:	Kenneth M. Thompson
Attorney Docket Number:	PAT276US
Receipt Date:	05-JAN-2021
Filing Date:	08-JAN-2020
Time Stamp:	15:08:42
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 260
RAM confirmation Number	E202115F09038634
Deposit Account	501705
Authorized User	April Davis

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
37 CFR 1.20 (Post Issuance fees)
37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		PAT276US_Amendment_asfile d.pdf	180305	yes	9
			dfd4fc741edb39c1cdf91a5f9fe0a53878fefb7f		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
	Specification		2	2	
	Claims		3	6	
	Applicant Arguments/Remarks Made in an Amendment		7	9	
Warnings:					
Information:					
2	Specification	PAT276US_Clean_Substitute_S pecification.pdf	125369	no	18
			a5d0a8aeb839ba93113dc782bbc5785fbd4b6023		
Warnings:					
Information:					
3	Specification	PAT276US_Marked_Substitute _Specification.pdf	579903	no	18
			b78b8f1305743e37626056f2b867403bde271e47		
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Form (SB08)	PAT276US_IDS_signed.pdf	1034249	no	4
			84cab95a81c62ce823bde1e7c6f987b1034423a3		
Warnings:					
Information:					

5	Other Reference-Patent/App/Search documents	171_OfficeAction.pdf	319190	no	9
			f284125c697a53697835d7af3baa45f1bb9009ec		
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	30664	no	2
			0f2652af0b8f0cbf11e84c040f05cfec4a6788e7		
Warnings:					
Information:					
Total Files Size (in bytes):			2269680		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Lin, Kai-Sheng

Examiner: Sedighian, Mohammad Reza

Serial No.: 16/737,438

Group Art Unit: 2636 Conf. No.: 7554

Filed: January 8, 2020

Docket: PAT276US

Title: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER
OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR
TRANSCIVER IMPLEMENTING SAME

RESPONSE UNDER 37 C.F.R. § 1.111

This is in response to the Official Action in this case mailed October 5, 2020. As this response is being filed within the three-month shortened statutory period of reply, which ends on January 5, 2021, no extension of time is believed necessary. However, Applicant conditionally petitions for an extension of time to provide for the possibility that the need for an extension has inadvertently been overlooked. As provided below, please charge Deposit Account No. 50-1705 for any required fee, or for any deficiency in the enclosed fee.

IN THE SPECIFICATION

Applicant herewith submits a substitute specification including a clean and marked-up copy in accordance with 37 CFR 1.125(b) and (c). No new matter has been added.

IN THE CLAIMS

1. (Currently Amended) An optical subassembly module, the optical subassembly module comprising:
 - a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end;
 - a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate;
 - a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface; and

wherein the second mounting region at the optical coupling end of the substrate is configured to edge mount to the at least one TOSA module such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate when the at least one TOSA module is coupled thereto.

2. (Currently Amended) The optical subassembly module of claim 1, wherein the optical subassembly module further comprises the at least one TOSA module ~~coupled-edge mounted~~ to the second mounting region of the substrate, the at least one TOSA module having a body that includes a component mounting surface to couple to a laser arrangement and a substrate mating surface disposed opposite the component mounting surface of the body, the substrate

mating surface of the body to couple to the recessed TOSA mounting surface of the optical coupling end of the substrate and extend from the substrate along an axis that is substantially parallel with a longitudinal axis of the substrate ~~such that the recessed mounting TOSA mounting surface of the substrate underlies and supports at least a portion of the mating surface of the body of the TOSA module.~~

3. (Original) The optical subassembly module of claim 2, wherein the substrate mating surface of the body is vertically offset from the component mounting surface of the substrate by the first offset distance.

4. (Cancelled)

5. (Original) The optical subassembly module of claim 2, wherein the laser arrangement of the at least one TOSA module comprises a laser diode driver (LDD) disposed on the component mounting surface of the TOSA module.

6. (Original) The optical subassembly of claim 5, wherein the LDD is electrically coupled to radio frequency (RF) terminals disposed on the component mounting surface of the substrate adjacent the optical coupling end via a plurality of wire bonds.

7. (Original) The optical subassembly of claim 6, wherein each of the plurality of wire bonds extend from the component mounting surface of the substrate at an angle less than or equal to 45 degrees.

8. (Original) The optical subassembly of claim 6, wherein each of the plurality of wire bonds has an overall length of less than 500 microns.

9. (Cancelled)

10. (Original) The optical subassembly of claim 1, wherein the second mounting region is configured to couple to and support a plurality of TOSA modules.

11. (Original) The optical subassembly of claim 1, wherein the substrate is a printed circuit board, and wherein the optical subassembly is a multi-channel optical transmitter or multi-channel optical transceiver capable of transmitting multiple channel wavelengths.

12. (Currently Amended) An optical transceiver, the optical transceiver comprising:
a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end;
at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end; and
a recessed transmitter optical subassembly (TOSA) mounting surface at the optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface;
at least one TOSA module ~~coupled~~ edge mounted to the optical coupling end of the transceiver substrate such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate; and
a receiver optical subassembly arrangement coupled to the transceiver substrate.

13. (Original) The optical transceiver of claim 12, further comprising radio frequency (RF) terminals disposed on the at least one component mounting surface proximate to the optical coupling end, wherein the at least one TOSA module electrically couples with the RF terminals via one or more wire bonds.

14. (Original) The optical transceiver of claim 12, wherein the recessed TOSA mounting surface is vertically offset relative to the at least one component mounting surface of the transceiver substrate by a first offset distance.

15. (Original) The optical transceiver of claim 12, wherein the at least one TOSA module comprises a plurality of TOSA modules, and wherein each TOSA module of the plurality of TOSA modules include a submount and a laser diode driver (LDD) coupled to the submount.

16. (Cancelled)

REMARKS

Please reconsider the application in view of the following remarks. Applicant submits that the claims, as presented, are in condition for allowance and respectfully requests the withdrawal of all pending rejections of the claims.

Status of Claims

Claims 1-16 were previously pending. Claims 1, 2 and 12 are amended herein. Support for the amendments is discussed further below. Claims 4, 9 and 16 are cancelled herein without prejudice or disclaimer. No new claims are presented at this time. Accordingly, claims 1-3, 5-8 and 10-15 are pending for examination with claims 1 and 12 being independent claims.

Drawing Objections

The Office objected to the drawings for allegedly failing to show each and every feature of the claims. *See Office Action dated October 5, 2020; page 2.* In particular, the Office objected to the claims for allegedly failing to show features of dependent claims 4 and 16. *See id.* Without conceding as to the merits of the objection, Applicant herein cancels claims 4 and 16 herein without prejudice or disclaimer. Accordingly, Applicant believes this objection to now be moot and respectfully requests reconsideration and withdrawal of the objection.

Objection to the Specification

The Office Objected to the specification due to an informality with the paragraph numbering. Applicant herein submits a substitute specification in accordance with 37 CFR 1.125(b) and (c) to correct a paragraph numbering error that appeared in pages 6-17 of Applicant's originally filed disclosure. No new matter has been added.

Applicant therefore respectfully requests reconsideration and withdrawal of the objection to the specification.

Rejections Under 35 U.S.C. § 112

Claims 2-9 and 16 were rejected under 35 U.S.C. 112 for allegedly being indefinite. *See Office Action dated October 5, 2020; pages 3-5.*

Regarding claim 2, the Office asserts: "It is not clear about 'the substrate mating surface; the recessed TOSA mounting surface; the recessed mounting TOSA mounting surface; the mating surface.'" *See id; page 4.* Without conceding the merits of this rejection, Applicant herein amends claim 2 and respectfully requests reconsideration and withdrawal of the rejection.

Independent claim 12 has been amended to require, *inter alia*, “at least one TOSA module edge mounted to the optical coupling end of the transceiver substrate such that a portion of the at least one TOSA module extends from the optical coupling end of the substrate.”

As discussed above, Wu fails to disclose at least the feature of edge-mounting TOSA modules to an optical coupling end of a transceiver substrate.

For at least these reasons, Wu fails to identically disclose each and every feature of independent claim 12 and the claims dependent therefrom.

Accordingly, Applicant respectfully requests reconsideration and withdrawal of the rejections of the claims under 35 U.S.C. 102.

Rejections Under 35 U.S.C. § 103

Claim 7 was rejected as allegedly unpatentable under 35 U.S.C. 103 over Wu in view of U.S. Pat. Pub. No. 2006/0043609 (Brennan). Claim 8 was rejected as allegedly unpatentable under 35 U.S.C. 103 over Wu, Brennan, and further in view of U.S. Pat. Pub. No. 2012/0267777 (Haba).

Claims 7 and 8 depend from independent claim 1 and are allowable by virtue of their dependencies.

Accordingly, Applicant respectfully requests reconsideration and withdrawal of the rejections of claims 7 and 8 under 35 U.S.C. 103.

Conclusion

Having dealt with all the objections and rejections raised by the Examiner, it is respectfully submitted that the present application, as amended, is in condition for allowance. Thus, early allowance is earnestly solicited.

If the Examiner desires personal contact for further disposition of this case, the Examiner is invited to call the undersigned Attorney at 603.668.6560.

In the event there are any fees due, please charge them to our Deposit Account No. 50-1705 (Ref:PAT276US).

Respectfully submitted,

By: /Kenneth M. Thompson/

Date: January 5, 2021

Kenneth M. Thompson
Reg. No. 72,001

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to co-pending Application Ser. No. 16/737,414 (Atty. Docket No. PAT275US) entitled “Monitor Photodiode (MPD) Submount for Vertical Mounting and Alignment of Monitoring Photodiodes” filed concurrently herewith on January 8, 2020, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to optical communication devices, and more particularly, to a substrate with a stepped profile for simplifying mounting and alignment of transmitter optical subassemblies (TOSA) modules, e.g., via edge mounting, and to reduce the vertical offset between TOSA modules and radio frequency (RF) terminals of the substrate to allow for relatively short electrical interconnect lengths, e.g., via wire bonds.

BACKGROUND

[0003] Optical transceivers are used to transmit and receive optical signals for various application including, without limitation, internet data center, 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 has presented challenges, for example, with respect to space management and manufacturing yield.

[0004] Optical transceiver modules generally include one or more transmitter optical subassemblies (TOSAs) for transmitting optical signals and one or more receiver optical subassemblies (ROSAs) for receiving optical signals. In general, TOSAs include one or more lasers to emit one or more channel wavelengths and associated circuitry for driving the lasers and

monitoring power to ensure nominal performance. However, continued scaling and the standardization of transmission speeds of up to and exceeding 400 Gbp/s presents numerous technical challenges that complicates mounting and electrical interconnection between TOSA modules and a supporting substrate, e.g., a printed circuit board (PCB).

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0006] FIG. 1 shows a block diagram of an example multi-channel optical transceiver module in accordance with an embodiment of the present disclosure.

[0007] FIG. 2 is a perspective view of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1, in accordance with an embodiment of the present disclosure.

[0008] FIG. 3 shows an enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0009] FIG. 4 shows a top view of the enlarged portion shown in FIG. 3, in accordance with an embodiment of the present disclosure.

[0010] FIG. 5 shows another enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0011] FIG. 6A shows a front view of a monitor photodiode submount suitable for use in the multi-channel optical transceiver module of FIG. 2, in accordance with an embodiment.

[0012] FIG. 6B shows a perspective view of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0013] FIG. 6C shows another perspective view of a rear side of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0014] FIG. 7A shows a cross-sectional view of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment.

[0015] FIG. 7B shows an enlarged portion of a multi-channel optical transceiver module consistent with an embodiment of the present disclosure.

[0016] FIG. 8 shows an example approach to mounting and electrical coupling of transmitter optical subassemblies (TOSA) modules on a transceiver substrate.

DETAILED DESCRIPTION

[0017] As discussed above, scaling and increased transmission speeds raise numerous challenges in optical subassembly design. One such challenge includes reducing the impact of electrical interconnection devices, e.g., wire bonds, on high frequency signals such as radio frequency (RF) signals that drive TOSA modules.

[0018] These challenges are better understood by way of illustration. FIG. 8 shows a portion of a transceiver substrate 804, e.g., a printed circuit board, that edge-mounts to a plurality of TOSA modules, e.g., TOSA module 802. In this example, the TOSA modules 802 can be at least partially formed/configured separate from the transceiver substrate 804 and then subsequently coupled “on board” the transceiver substrate 804. Such “on board” mounting of optical subassemblies can significantly simplify manufacturing and design of transceivers and other devices that transmit and/or receive optical signals.

[0019] As further shown in FIG. 8, this on-board mounting can include the laser diode driver (LDD) of each TOSA module electrically coupling with adjacent RF terminals, e.g., RF terminals 806, to receive RF driving signals to modulate an associated laser by way of wire bonds 808. However, electrical interconnects such as wire bonds 808 can introduce time of flight (ToF) issues for RF signals, as well as impedance matching issues which can significantly degrade signaling performance. Wire bonds also tend to be fragile and can easily break by inadvertent contact.

[0020] In the context of wire bonding specifically, one approach to mitigate the impact of such issues on signaling performance includes having wire bonds with relatively short overall lengths. While this solution seems relatively simple, space constraints and other factors such as component layout can complicate or otherwise prevent shortening wire bond lengths. For instance, in the context of FIG. 8, the TOSA 802 includes a submount that vertically displaces the LDD, and importantly, the electrodes of the LDD that receive RF signaling. This vertical displacement results in wire bonds 808 extending at substantially 90 degrees from the RF terminals and having an overall length of about 800-900 microns to reach corresponding LDD terminals. Such overall

wire bond lengths significantly impact signal quality, particularly high frequency RF signals, and ultimately can limit the maximum achievable transmission speeds of the TOSA module.

[0021] Continued development to achieve ever-higher optical transmission speeds, e.g., up to and beyond 400 Gbp/s, depends at least in part on optical subassembly module designs that significantly reduce the length of electrical interconnections between associated components without increasing design and manufacturing complexity. Moreover, continued development and rapid adoption of such high-speed transmission systems further depends at least in part on optical subassembly module designs that both shorten electrical interconnect lengths and allow for continued scaling without substantial redesign of existing components, such as PCBs and TOSA modules.

[0022] Thus, in accordance with an embodiment, a stepped profile for substrates that support “on board” optical subassembly arrangements is disclosed that allows for mounting of TOSA modules to the substrate in a recessed orientation to reduce the overall distance between terminals of the substrate and associated components of the TOSA, e.g., RF terminals of the substrate and an LDD of the TOSA. In an embodiment, the substrate comprises a printed circuit board PCB or PCB assembly (PCBA) that includes an electrical coupling end to electrically couple with external circuitry and an optical coupling end to couple to one or more TOSA modules. The substrate provides at least a first component mounting surface for coupling to circuitry to provide power and driving signals to the one or more TOSA modules. The substrate further defines a recessed TOSA mounting surface at the optical coupling end. The TOSA mounting surface extends substantially parallel with the first component mounting surface, and is offset from the same by a first predetermined offset distance. Thus, TOSA modules mount to the substrate via the recessed TOSA mounting surface, and components such as LDDs that would otherwise have a vertical offset relative to the supporting traces of the substrate (e.g., as shown in FIG. 8) get displaced towards the same based on the first predetermined offset distance. The TOSA module components may therefore get “countersunk” via the recessed TOSA mounting surface to allow for relatively shorter electrical interconnection with the substrate.

[0023] Substrates having stepped profiles consistent with the present disclosure advantageously utilize the recessed TOSA mounting surface to allow for mounting of TOSA modules in a manner that maintains the advantages and simplicity of “on board” TOSA arrangements while also significantly reducing the overall length of electrical interconnections to

provide RF and/or power signals to the same. In an embodiment, the stepped profile reduces electrical interconnection lengths by up to and exceeding 50% relative to approaches that do not feature substrates with stepped profiles (e.g., compare FIG. 8 with FIG. 7B), and as a result, the stepped profile significantly reduces the introduction of signal degradation when utilizing relatively longer electrical interconnections.

[0024] 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 dense wavelength division multiplexing (DWDM) grid. This disclosure is equally applicable to coarse wavelength division multiplexing (CWDM). In one specific example embodiment, the channel wavelengths are implemented in accordance with local area network (LAN) wavelength division multiplexing (WDM), which may also be referred to as LWDM. 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.

[0025] The term substantially, as generally referred to herein, refers to a degree of precision within acceptable tolerance that accounts for and reflects minor real-world variation due to material composition, material defects, and/or limitations/peculiarities in manufacturing processes. Such variation may therefore be said to achieve largely, but not necessarily wholly, the stated characteristic. To provide one non-limiting numerical example to quantify “substantially,” minor variation may cause a deviation of up to and including $\pm 5\%$ from a particular stated quality/characteristic unless otherwise provided by the present disclosure.

[0026] Referring to the Figures, FIG. 1 illustrates an optical transceiver module 100, consistent with embodiments of the present disclosure. The optical transceiver module 100 is shown in a highly simplified form for clarity and ease of explanation and not for purposes of limitation. In this embodiment, the optical transceiver module 100 can be pluggable (e.g., conforms with pluggable small form factor (SFFP) standards) and transmits and receives four (4) channels using four different channel wavelengths ($\lambda_1, \lambda_2, \lambda_3, \lambda_4$) and may be capable of transmission rates of at least about 25 Gbps per channel. In one example, the channel wavelengths $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ may be within a ± 13 nm range and have respective channel wavelengths of 1270 nm, 1290 nm, 1310 nm,

and 1330 nm, respectively. Other channel wavelengths and configurations are within the scope of this disclosure including those associated with local area network (LAN) wavelength division multiplexing (WDM). For instance, the optical transceiver module 100 can include up to eight (8) or more channels and provide transmission rates of at least 25 Gbps per channel.

[0027] The optical transceiver module 100 may also be capable of transmission distances of 2 km to at least about 10 km. The optical transceiver module 100 may be used, for example, in internet data center applications or fiber to the home (FTTH) applications.

[0028] In an embodiment, the optical transceiver module 100 is disposed in a transceiver housing 103. The transceiver housing 103 can be configured with one or more cavities to receive one or more optical transceiver modules, depending on a desired configuration.

[0029] The optical transceiver module 100 may include a number of components to support transceiver operations. The optical transceiver module 100 may include an optical transceiver substrate 102, a plurality of transmitter optical subassemblies (TOSA) modules 104 for transmitting optical signals having different channel wavelengths, transmit connecting circuit 106, a multi-channel receiver optical subassembly (ROSA) arrangement 108 for receiving optical signals on different channel wavelengths, an optical fiber receptacle 110 to receive and align a fiber connector (e.g., a ferrule) with the ROSA, and a receiver connecting circuit 112.

[0030] The optical transceiver substrate 102 includes traces, connector pads, and other circuitry to support transceiver operations. The optical transceiver substrate 102 may include TOSA connector pads 114 (or terminals 114) that enable each of the TOSA modules 104 to mount and electrically couple to the optical transceiver substrate 102. The TOSA connector pads 114 may also be referred to herein as a simply connector pads. The optical transceiver substrate 102 may include traces 116 that couple the TOSA connector pads 114 to the transmit connecting circuit 106. As discussed in greater detail below, monitor photodiode (PD) submounts/modules may be disposed on (e.g., directly) the traces 116 and/or the TOSA connector pads 114.

[0031] The optical transceiver substrate 102 may include traces 118 that electrically couple the ROSA arrangement 108 to the receiver connecting circuit 112. The optical transceiver substrate 102 may provide an optical transceiver module that may be “plugged” into an optical transceiver cage. Therefore, the transmit connecting circuit 106 and the receiver connecting circuit 112 may electrically couple to external circuitry of the optical transceiver cage. The optical transceiver

substrate 102 may be manufactured from a multi-layer printed circuitry board (PCB), although other types of substrates may be utilized and are within the scope of this disclosure.

[0032] Each of the TOSA modules 104 may be configured to receive driving electrical signals (TX_D1 to TX_D4), convert the electrical signals to a multiplexed optical signal (e.g., a signal with channel wavelengths $\lambda_1.. \lambda_n$) and output the same to a multiplexer (not shown). Each of the TOSA modules 104 may be electrically coupled to the TOSA connector pads 114 and to the traces 116 through TOSA module connector pads 120. Each of the TOSA modules 104 may include a laser diode device and supporting circuitry. The laser diode devices of the TOSA modules 104 may include distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. In an embodiment, monitor photodiodes 131 may be used to monitor the lasers' output power, as discussed below.

[0033] Referring to FIG. 2, an example embodiment of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1 is shown. As shown, the multi-channel optical transceiver module 200 includes an optical transceiver substrate 202 coupled to a TOSA arrangement 206. The optical transceiver substrate 202 may also be referred to herein as a substrate. The optical transceiver substrate 202 may be manufactured from a multi-layer printed circuitry board, although other types of substrates may be utilized and are within the scope of this disclosure.

[0034] The optical transceiver substrate 202 includes a first end 203 that extends to a second end 207 along a longitudinal axis 250. The first end 203 couples to one or more TOSA modules, such as shown, for launching channel wavelengths onto transmit waveguides, e.g., optical fibers 209. The second end 207 includes terminals/pads for electrical coupling with external circuitry to receive power and data signals. Accordingly, the first end 203 may also be referred to herein as an optical coupling end, and the second end 207 may be referred to as an electrical coupling end.

[0035] The transceiver substrate 202 further includes at least a first mounting surface 245 disposed opposite a second mounting surface 246 for supporting passive and/or active optical components. The first and second mounting surfaces 245, 246 may also be referred to as first and second component mounting surfaces. Although not shown in the embodiment of FIG. 2, the optical transceiver substrate 202 can include a multi-channel ROSA arrangement mounted to and supported by the first and/or second mounting surfaces 245, 246.

[0036] Continuing on, the TOSA arrangement 206 includes a plurality of TOSA modules 205-1 to 205-4. Each TOSA module of the plurality of TOSA modules 205-1 to 205-4 includes a base/body portion, and in the particular embodiment illustrated in FIG. 2, cuboid-type base portions. The plurality of TOSA modules 205-1 to 205-4 each support and align an associated laser arrangement with optical coupling ports 204-1 to 204-4, respectively. Thus, channel wavelengths generated by the laser arrangements get launched on to associated optical fibers 209 by way of optical coupling receptacles 204-1 to 204-5. Each laser arrangement may be configured to emit a different channel wavelength and can be monitored by an associated MPD module of an array of MPD modules to ensure nominal optical power, as will be discussed in greater detail below.

[0037] Continuing on, each of the plurality of TOSA modules 205-1 to 205-4 mount, e.g., edge mount, to the first end 203 of the substrate. The transceiver substrate 202 further includes a stepped profile, with the stepped profile being at least partially defined by a step/shoulder 211 proximate the first end 203. Additional aspects of the stepped profile are discussed below with reference to FIGs. 7A-7B. Each of the TOSA modules 205-1 to 205-4 can include a base with a plurality of sidewalls that define a generally L-shaped profile that corresponds with the step 211. The profile of the base may therefore advantageously align along at least two axis, e.g., the X and Z axis, by simply engaging/bottoming out against surfaces of the step 211, e.g., vertical surface 704 shown and discussed below with reference to FIG. 7A, that operate as an alignment guide by providing mechanical stops/limits to limit travel along at least one axis. Alignment along the remaining axis, e.g., the Y axis, may therefore be performed by relatively simply lateral movement (e.g., along the X axis) of each TOSA module 205-1 to 205-4.

[0038] Once aligned, each of the plurality of TOSA modules electrically couple to the transceiver substrate 202, and more particularly TOSA module connector pads disposed proximate the first end 203 of the transceiver substrate 202, which is shown more clearly in FIGs. 3 and 4. The TOSA module connector pads allow each of the TOSA modules 204-1 to 204-5 to receive driving signals and power from transmit connecting circuitry, e.g., via traces 116 and TX connecting circuit 106 (See FIG. 1).

[0039] Referring to FIGs. 3-4, an enlarged region of the multi-channel optical transceiver module of FIG. 2 is shown in accordance with embodiments of the present disclosure. As shown, each TOSA module of the TOSA arrangement 206 includes a laser arrangement having, for example, a

filtering capacitor 401, laser diode (LD) 402, and focusing lens 403. One such laser arrangement 712 is shown in further detail in FIGs. 7A. The components of the TOSA arrangement 206, such as LD 402, can directly mount to the body of the associated TOSA module, or indirectly via an LD submount 404, such as shown. The LD submount 404 can support components of each laser arrangement and provide electrical traces and other circuitry to support TOSA operations. Note the LD submount 404 may also couple directly to the body of the TOSA module, or indirectly by way of one or more baseplates, such as base plate 709 shown more clearly in FIG. 7A.

[0040] The LD 402 can be implemented as a distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. Preferably, the LD 402 is implemented as an electro-absorption modulator laser (EML). In an embodiment, the LD 402 can be uncooled (e.g., operate without an associated thermoelectric cooler). Instead, the LD 402 is in thermal communication with the body of the TOSA module to dissipate heat. In addition, the body of the TOSA module may also be in thermal communication with the transceiver substrate 202 via the step 211 to further increase heat dissipation. Accordingly, in an embodiment each TOSA module can provide a thermal communication path 311 that extends between each LD and the transceiver substrate 202 by way of an associated LD submount, TOSA body, and the step 211 of the transceiver substrate 202.

[0041] Continuing with reference to FIGs. 3-5, the components of each laser arrangement may be disposed coaxially, or substantially coaxially and be aligned with a longitudinal center line of a corresponding optical coupling receptacle (See FIG. 2). Each TOSA module of the TOSA arrangement 206 may therefore also be referred to as cuboid-type coaxial TOSA assemblies, or simply coaxial TOSA assemblies. Notably, cuboid-type TOSA bases allow for each laser assembly to be mounted in close proximity with adjacent cuboid-type TOSAs, e.g., directly contacting each other in a side-by-side relationship. Alternatively, spacing between the cuboid-type TOSA bases can provide for thermal isolation between adjacent TOSA modules (e.g., based on an air gap) while ensuring a relatively small overall footprint for the TOSA arrangement 206.

[0042] In operation, each TOSA module 205-1 to 205-4 of the TOSA arrangement 206 can emit associated channel wavelengths and launch the same along optical fibers 209, for example. Associated MPDs monitor and ensure nominal power for each of the TOSA modules 205-1, 205-4. As discussed above, each of the TOSA modules includes at least a LD, e.g., LD 402, and at least one corresponding monitor photodiode (MPD), e.g., provided by MPD module 252, to

monitor the optical output power. As shown in FIG. 3, for example, the MPD module 252 optically aligns with a back surface of the LD 402 to receive and measure a small percentage of light emitted therefrom, e.g., 1-3%. Laser threshold current and slope efficiency are both functions of temperature and aging time. To maintain nominal optical output power, the electrical bias current and modulation current applied to the laser may be varied to compensate the change brought about by the variations in temperature and/or aging time. The optical transceiver module 200 can vary the current applied to the LD 402 based on the measured light to, for instance, maintain a stable output power based on an average output current of the MPD module 252.

[0043] Referring to FIGs. 6A-6C, an example monitor photodiode submount 610 suitable for use with the MPD module 252 is shown in accordance with an embodiment. The monitor photodiode (MPD) submount 610 is configured to couple to and align a MPD 251 with an associated laser diode, as discussed above. The MPD submount 610 comprises a base 617 having a plurality of sidewalls to provide at least one mounting surface for supporting an MPD and supporting circuitry and at least one mating surface for coupling to an associated transceiver substrate. The base 617 can comprise, for instance, Silicon (Si), or any other non-conductive suitably rigid material. The base 617 may be formed monolithically from a single piece of material or from multiple pieces. While the following discussion includes reference to disposing/patterning metallic material on to a non-conductive base, e.g., formed from Si to provide electrically conductive paths, the base 617 may be at least partially formed from a conductive material such as a metal to provide integrated traces. In this instance, multiple independent electrical traces/paths may be provided by disposing an electrical insulating layer therebetween.

[0044] Continuing on, at least one sidewall defining the base 617 of the submount 610 provides a mounting surface 609 for coupling to and supporting MPD 251, such as shown. At least one sidewall defining the base 617 of the submount 610 further provides mating surface 614 for mounting to and being supported by TOSA connecting pads, as will be discussed in greater detail below. As shown, the mounting surface 609 extends substantially transverse relative to the mating surface 614 to provide a vertical mounting orientation for the MPD 251.

[0045] The base 617 further provides at least first and second electrically conductive paths 611, 613 disposed along multiple sidewalls of the base 617 using a plurality of conductive traces disposed/patterned thereon. In particular, the first electrically conductive path 611 is collectively provided by at least first and second conductive traces 612-1, 612-2 (or conductive segments)

disposed on the base 617. Likewise, the second electrically conductive path 613 is collectively provided by at least third and fourth conductive traces 612-3 and 612-4 (or conductive segments) disposed on the base 617. Patterning of the conductive traces 612-1 to 612-4 can comprise deposition of one or more layers of metallic material such as copper, silver, or other suitable material on to sidewalls of the base 617.

[0046] At least a portion of the first conductive trace 612-1 defines the mounting surface 609 for both physically and electrically coupling to the MPD 251. Further, the first conductive trace 612-1 includes a region with a relatively rectangular profile having a width that is about 1.2x to 1.3x the width of the MPD 251. This rectangular profile may be dimensioned such that corner(s) of the same get disposed at substantially a center of the mounting surface 609. Alignment of the MPD 251 relative to the base 617, and more importantly relative to an associated laser diode, may therefore be initially accomplished along the X, Y and Z axis by ensuring that the edges 619-1 and 619-2 of MPD 251 mount substantially flush with a far edge of rectangular pad provided by the first conductive trace 612-1. Stated differently, alignment of MPD 251 can include mounting the same at a predetermined position on the first conductive trace 612-1 such that edges 619-1 and 612-2 extend parallel with the edges defining the rectangular pad and include a relatively uniform gap therebetween measuring about 0 to 100 microns. The first conductive trace 612-1 may therefore provide a visual alignment indicator, e.g., in the form of a rectangular pad or other regular or non-regular geometric shape, to provide a visual representation of a predefined mounting location for the MPD to simplify mounting and alignment of the same.

[0047] The above-discussed mounting and alignment of MPD 251 on to the MPD submount 610 can occur prior to attachment to the transceiver substrate 202 (FIG. 2). The MPD submount 610 may therefore get mounted to the transceiver substrate 202 with the MPD 251 being aligned along at least the X and Z axis with the associated laser diode. Alignment along the Y axis can include simply shifting the MPD submount 610 laterally until nominal optical coupling with an associated laser diode gets achieved.

[0048] Continuing on, the first conductive trace 612-1 extends towards the transceiver substrate 202 when the MPD submount is coupled thereto. The first conductive trace 612-1 also extends substantially transverse relative to the first mounting surface 245 of substrate 202 when coupled thereto (See FIG. 3). The first conductive trace 612-1 then transitions to the second conductive trace 612-2 based on an edge/intersection between associated sidewalls of the base

617. The second conductive trace 612-2 extends substantially transverse relative to the mounting surface 609, and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202 when coupled thereto (See e.g., FIGs. 3-5).

[0049] As further shown, third and fourth conductive traces 612-3 and 612-4 are disposed on the base 617 to collectively define a second electrically conductive path to electrically couple the MPD 251 to the transceiver substrate 202. The third conductive trace 612-3 is disposed on the mounting surface 609 and is configured to electrically couple to the MPD 251 via, for instance, wire bonding such as shown. The third conductive trace 612-3 extends towards the transceiver substrate 202 when the MPD submount 610 is coupled thereto. The third conductive trace 612-3 transitions to the fourth conductive trace 612-4 at an edge/intersection between sidewalls of the base 617. The fourth conductive trace 612-4 extends substantially transverse relative to the mounting surface 609 and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202.

[0050] The first and second conductive paths 611, 613 therefore include at least one region/segment that extend substantially in parallel, and proximate, to an interface formed between the mating surface 614 and the first mounting surface 245 of the transceiver substrate 202 when the MPD submount 610 is coupled thereto. As discussed in greater detail below, the first and second conductive paths 611, 613 can be electrically coupled to the transceiver substrate 202 utilizing a conductive epoxy or other conductive material that can be disposed around MPD submount 610.

[0051] The MPD 251 can comprise a surface MPD having a detecting surface/region 603 having a receiving area 602 that is configured to be optically coupled with an associated laser diode by being aligned along the X, Y and Z axis. In particular, alignment includes the receiving area being disposed at a position that intersects with an optical path extending from a back surface of the associated laser diode towards the MPD. An anode 604 is disposed on the detecting surface 603. A cathode (not shown) of the MPD 251 is provided on a surface opposite the detecting surface 603. The MPD 251 mounts (e.g., directly) on the first conductive trace 612-1, with the associated cathode electrically connected to the first conductive path 611. The anode 604 electrically couples to the second conductive path 613 by wire bonding, for instance.

[0052] As shown in FIGs. 6A-6C, the body 617 of the MPD submount 610 can include channels/notches 631-1, 631-2. The channels 631-1, 631-2 extend substantially transverse relative

to mounting surface 609 and include a curved/arcuate profile (such as shown). Other shapes and configurations for the channels 631-1, 631-2 are within the scope of this disclosure. As further shown, the second conductive trace 612-2 and the fourth conductive trace 612-4 are at least partially disposed on the channels 631-1, 631-2. The channels 631-1, 631-2 can advantageously facilitate flow and adhesion of a layer of epoxy 509 (FIG. 5) to securely attach the MPD submount 610 to an associated transceiver substrate, e.g., transceiver substrate 202. In addition, the channels 631-1, 631-2 reduce the overall footprint of the mating surface 614 by providing a taper, and by extension, reducing the overall footprint of the MPD submount 610 when coupled to the transceiver substrate 202 (See FIG. 5). The channels 631-1, 631-2, may thus define a tapered region that at least partially defines the mating surface 614.

[0053] When the MPD submount 610 mounts to the transceiver substrate 202 via mating surface 614, conductive epoxy 509 can flow into the channels 631-1, 631-2 to securely attached the MPD submount 610 at a predetermined position, as discussed further below. The rounded profile/shape of the channels 631-1, 631-2 can encourage increased adhesion and allow for a relatively larger amount of conductive epoxy to be utilized and substantially confined without the same inadvertently contacting adjacent conductive pads/traces. Note that while the embodiment of FIGs. 6A-6C show two channels 631-1, 631-2, this disclosure is not limited in this regard. An MPD submount consistent with the present disclosure can have a single channel, or a plurality of channels (as shown), or no channels depending on a desired configuration.

[0054] As shown in FIG. 6C, the first and second conductive paths 611, 613 can also include fifth and sixth conductive traces 612-5, 612-6, respectively. The fifth and sixth conductive traces 612-5, 612-6 can be disposed on back surface 616, with back surface 616 being disposed opposite the mounting surface 609. In this embodiment, the fifth and sixth conductive traces 612-5, 612-6 can further increase electrical conductivity via the conductive epoxy and can balance bonding stresses applied to the MPD submount 610.

[0055] Referring back to FIGs. 3-5, with additional reference to FIGs. 6A-6C, the MPD submount 610 is shown implemented as MPD module 252. These MPD module 252 is configured to be disposed on the TOSA connector pads 423, 424, and when coupled thereto, an interface 504 gets formed between the MPD module 252 and the surfaces defining the transceiver substrate 202 (See FIG. 5). A layer of conductive epoxy 509, e.g., silver epoxy, may be disposed along the

interface 504 between MPD module 252 and surfaces defining the transceiver substrate 202, and in particular, the connector pads 423, 424.

[0056] Therefore, the first and the second conductive paths 611, 613 (FIG. 6A) electrically couple to a pad/trace of the transceiver substrate based at least in part on the layer of conductive epoxy 509. Minor adjustment to MPD orientation along the Y axis, e.g., relative to an associated laser diode, can be achieved while the layer of conductive epoxy 509 cures, thus allowing for greater tolerances and multiple manufacturing phases to occur at potentially the same time. To avoid or otherwise reduce reflection losses, the receiving area 602 may be disposed at an angle with respect to the light path of the laser diode. The angle may be, for example, 0-15°, and preferably about 8° relative to normal.

Stepped Profile Architecture

[0057] Turning to FIGs. 7A an enlarged cross-sectional view of the substrate 202 is shown in accordance with an embodiment. Note, the embodiment of FIG. 7A shows a laser arrangement having a vertically-mounted monitored photodiode, as discussed above. However, the stepped profile is equally applicable to other TOSA configurations including designs where an MPD is mounted to the TOSA body (e.g., See FIG. 7B).

[0058] As shown in FIG. 7A, the first component mounting surface 245 defines at least a portion of a first mounting region to allow for mounting of components and to provide traces for electrical interconnection with external circuitry. The first mounting region can therefore extend from the electrical coupling end 207 to a second mounting region disposed at the optical coupling end 203.

[0059] The second mounting region is defined at least in part by the step 211. The step 211 defines at least a portion of the stepped profile which can simplify alignment and coupling processes for TOSA modules, as discussed above. The stepped profile, and in particular, step 211 is defined at least in part by a recessed TOSA mounting surface 702, which may be referred to herein as simply a recessed mounting surface. The recessed mounting surface 702 is offset/recessed from the first component mounting surface 245 by a first offset distance (OD1). The offset distance OD1 measures between 10 and 50 microns, and preferably, 10-20 microns

[0060] The stepped profile may therefore be provided by the recessed TOSA mounting surface 702 extending substantially parallel with the first component mounting surface 245 and substantially transverse relative to vertical surface 704, with the vertical surface 704 adjoining the

recessed mounting surface 702 and the first component mounting surface 245. The overall height of vertical surface 704 can be predetermined to establish the first offset distance OD1. As shown in FIGs. 2 and 7A, the first mounting region is shown as the portion of the substrate 202 having a first overall width W1. The first mounting region preferably includes a uniform width, or may vary along the longitudinal axis 250 (See FIG. 2) up to a maximum width equal to W1. On the other hand, the second mounting region is shown as the portion of the substrate 202 having a second overall width W2, with the second overall width W2 being less than the first overall width. The second mounting region also includes, preferably, a uniform width although this disclosure is not limited in this regard and the second overall width W2 can vary along the longitudinal axis up to a maximum width equal to W2.

[0061] As further shown in FIG. 7A, the first TOSA module 205-1 includes a body 706 (or base) configured to securely mount, e.g., edge mount, to the second mounting region of the substrate 202. The body 706 includes a plurality of sidewalls that provide a substrate mating surface 708-1 and a component mounting surface 708-2. The substrate mating surface 708-1 is disposed opposite the component mounting surface 708-2, and in the embodiment shown in FIGs. 7A-7B, the component mounting surface is accessible via an opening 710 defined by sidewalls of the body 706 that extend substantially transverse from the component mounting surface 708-2.

[0062] Thus, the recessed TOSA mounting surface 702 underlies and supports at least a portion of the substrate mating surface 708-1, and thus by extension, the body 706 of the at least one TOSA module 205-1. In an embodiment, epoxy or other adhesive material may be disposed between the recessed TOSA mounting surface 702 and the substrate mating surface 708-1 to securely attach the body 706 to the substrate 202, although other attachment methods are within the scope of this disclosure such as welding. In this embodiment, the stepped profile operates, in a general sense, as a dam to prevent epoxy from contacting other surfaces such as the substrate mating surface 708-1. Accordingly, the stepped profile also aids in containing and confining epoxy during manufacturing, which can reduce component failure and the time required for post-processing stages to remove excess epoxy.

[0063] The recessed TOSA mounting surface 702 can include one or more layers of metallic material disposed thereon (See FIG. 7B), e.g., such as Gold (Au) or Copper (Cu), to increase thermal communication between the TOSA module 205-1 and the substrate 202 and/or to allow for attachment via welding/soldering.

[0064] Turning to FIG. 7B, with additional reference to FIG. 7A, the body 706 includes at least one laser arrangement 712 mounted to the component mounting surface 708-2 of the body 706. As shown, the laser arrangement 712 includes a laser diode driver 714, a laser diode 716, a monitor photodiode 718 and a focus lens 720. The laser arrangement 712 may include more or fewer active and/or passive optical components depending on a desired configuration, and the embodiment shown in FIG. 7B is not intended to be limiting.

[0065] As further shown, the at least one laser arrangement 712 mounts to the body 706, and more particularly, the component mounting surface 708-2 by way of a submount 722 and optional base plate 709. The submount 722 can provide traces/terminals for electrical connectivity with components of the at least one laser arrangement 712. The overall height H1 of the submount 722 (e.g., including the base plate 709) may therefore measure substantially equal to or greater than the first offset distance OD1. Accordingly, an invisible line drawn at the first component mounting surface 245, and parallel thereto, can intersect with the submount 722 and/or at least one component of the at least one laser arrangement 712 such as the LDD 714 and LD 716.

[0066] Stated differently, the submount 722 vertically displaces the components of the at least one laser arrangement 712 relative to the component mounting surface 708-2 of the body 706, e.g., by overall height H1, but the vertical displacement gets 'offset' based on stepped profile of the substrate 202, and more particularly, the first offset distance (OD1) of the recessed TOSA mounting surface 702 relative to the first component mounting surface 245 of the substrate 202. Stated simply, the recessed TOSA mounting surface 702 gets countersunk relative to the first component mounting surface 245. The overall height H2 between the first component mounting surface 245 and a top surface of the submount 722 that supports the optical components of the at least one laser arrangement 712 is less than 400 microns, and preferably, less than 200 microns.

[0067] Accordingly, relatively short electrical interconnects, e.g., wire bonds 724, electrically couple the LDD 714 to RF terminals/traces 726 disposed on the first component mounting surface 245. In the shown embodiment, the overall length of each of the wire bonds 724 measures between 400 and 500 microns, and preferably, less than 400 microns. In addition, each of the wire bonds 724 extend at an angle θ relative to the first component surface 245, with angle θ being less than or equal to 45 degrees.

[0068] Substrates having stepped profiles consistent with the present disclosure advantageously position components such as LDDs in close proximity with supporting terminals

of the substrate 202. By way of contrast, consider the embodiment of FIG. 8 which shows a substrate and TOSA modules with a substantially similar size and dimension to that of the embodiments shown in FIGs. 7A-7B. However, the stepped profile of the substrate 202 shown in FIGs. 7A and 7B allows for wire bonds 724 to be shortened/reduced in length by up to and exceeding 50% relative to wire bonds 808 of FIG. 8. Moreover, the wire bonds 724 extend at a relatively acute angle θ to provide a low-profile implementation. On the other hand, the wire bonds 808 shown in FIG. 8 extend from substrate 804 at roughly a 90 degree angle, which increases the risk of inadvertent contact and damage. In any event, this reduction in wire bond length translates directly to improved signal quality, and in addition, enables maximum transmission speeds otherwise unachievable with longer electrical interconnections.

[0069] In accordance with an aspect of the present disclosure an optical subassembly module is disclosed. The optical subassembly module comprising a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end, a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate, a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface.

[0070] In accordance with another aspect of the present disclosure an optical transceiver is disclosed. The optical transceiver comprising a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end, at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end, and a recessed transmitter optical subassembly (TOSA) mounting surface at the optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least

one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface, at least one TOSA module coupled to optical coupling end of the transceiver substrate, and a receiver optical subassembly arrangement coupled to the transceiver substrate.

[0071] 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.

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to co-pending Application Ser. No. 16/737,414 (Atty. Docket No. PAT275US) entitled “Monitor Photodiode (MPD) Submount for Vertical Mounting and Alignment of Monitoring Photodiodes” filed concurrently herewith on January 8, 2020, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to optical communication devices, and more particularly, to a substrate with a stepped profile for simplifying mounting and alignment of transmitter optical subassemblies (TOSA) modules, e.g., via edge mounting, and to reduce the vertical offset between TOSA modules and radio frequency (RF) terminals of the substrate to allow for relatively short electrical interconnect lengths, e.g., via wire bonds.

BACKGROUND

[0003] Optical transceivers are used to transmit and receive optical signals for various application including, without limitation, internet data center, 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 has presented challenges, for example, with respect to space management and manufacturing yield.

[0004] Optical transceiver modules generally include one or more transmitter optical subassemblies (TOSAs) for transmitting optical signals and one or more receiver optical subassemblies (ROSAs) for receiving optical signals. In general, TOSAs include one or more lasers to emit one or more channel wavelengths and associated circuitry for driving the lasers and

monitoring power to ensure nominal performance. However, continued scaling and the standardization of transmission speeds of up to and exceeding 400 Gbp/s presents numerous technical challenges that complicates mounting and electrical interconnection between TOSA modules and a supporting substrate, e.g., a printed circuit board (PCB).

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0006] FIG. 1 shows a block diagram of an example multi-channel optical transceiver module in accordance with an embodiment of the present disclosure.

[0007] FIG. 2 is a perspective view of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1, in accordance with an embodiment of the present disclosure.

[0008] FIG. 3 shows an enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0009] FIG. 4 shows a top view of the enlarged portion shown in FIG. 3, in accordance with an embodiment of the present disclosure.

[0010] FIG. 5 shows another enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0011] FIG. 6A shows a front view of a monitor photodiode submount suitable for use in the multi-channel optical transceiver module of FIG. 2, in accordance with an embodiment.

[0012] FIG. 6B shows a perspective view of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0013] FIG. 6C shows another perspective view of a rear side of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0014] FIG. 7A shows a cross-sectional view of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment.

[0015] FIG. 7B shows an enlarged portion of a multi-channel optical transceiver module consistent with an embodiment of the present disclosure.

[0016] FIG. 8 shows an example approach to mounting and electrical coupling of transmitter optical subassemblies (TOSA) modules on a transceiver substrate.

DETAILED DESCRIPTION

[0017] As discussed above, scaling and increased transmission speeds raise numerous challenges in optical subassembly design. One such challenge includes reducing the impact of electrical interconnection devices, e.g., wire bonds, on high frequency signals such as radio frequency (RF) signals that drive TOSA modules.

[0018] These challenges are better understood by way of illustration. FIG. 8 shows a portion of a transceiver substrate 804, e.g., a printed circuit board, that edge-mounts to a plurality of TOSA modules, e.g., TOSA module 802. In this example, the TOSA modules 802 can be at least partially formed/configured separate from the transceiver substrate 804 and then subsequently coupled “on board” the transceiver substrate 804. Such “on board” mounting of optical subassemblies can significantly simplify manufacturing and design of transceivers and other devices that transmit and/or receive optical signals.

[0019] As further shown in FIG. 8, this on-board mounting can include the laser diode driver (LDD) of each TOSA module electrically coupling with adjacent RF terminals, e.g., RF terminals 806, to receive RF driving signals to modulate an associated laser by way of wire bonds 808. However, electrical interconnects such as wire bonds 808 can introduce time of flight (ToF) issues for RF signals, as well as impedance matching issues which can significantly degrade signaling performance. Wire bonds also tend to be fragile and can easily break by inadvertent contact.

[0020] In the context of wire bonding specifically, one approach to mitigate the impact of such issues on signaling performance includes having wire bonds with relatively short overall lengths. While this solution seems relatively simple, space constraints and other factors such as component layout can complicate or otherwise prevent shortening wire bond lengths. For instance, in the context of FIG. 8, the TOSA 802 includes a submount that vertically displaces the LDD, and importantly, the electrodes of the LDD that receive RF signaling. This vertical displacement results in wire bonds 808 extending at substantially 90 degrees from the RF terminals and having an overall length of about 800-900 microns to reach corresponding LDD terminals. Such overall

wire bond lengths significantly impact signal quality, particularly high frequency RF signals, and ultimately can limit the maximum achievable transmission speeds of the TOSA module.

[0021] Continued development to achieve ever-higher optical transmission speeds, e.g., up to and beyond 400 Gbp/s, depends at least in part on optical subassembly module designs that significantly reduce the length of electrical interconnections between associated components without increasing design and manufacturing complexity. Moreover, continued development and rapid adoption of such high-speed transmission systems further depends at least in part on optical subassembly module designs that both shorten electrical interconnect lengths and allow for continued scaling without substantial redesign of existing components, such as PCBs and TOSA modules.

[0022] Thus, in accordance with an embodiment, a stepped profile for substrates that support “on board” optical subassembly arrangements is disclosed that allows for mounting of TOSA modules to the substrate in a recessed orientation to reduce the overall distance between terminals of the substrate and associated components of the TOSA, e.g., RF terminals of the substrate and an LDD of the TOSA. In an embodiment, the substrate comprises a printed circuit board PCB or PCB assembly (PCBA) that includes an electrical coupling end to electrically couple with external circuitry and an optical coupling end to couple to one or more TOSA modules. The substrate provides at least a first component mounting surface for coupling to circuitry to provide power and driving signals to the one or more TOSA modules. The substrate further defines a recessed TOSA mounting surface at the optical coupling end. The TOSA mounting surface extends substantially parallel with the first component mounting surface, and is offset from the same by a first predetermined offset distance. Thus, TOSA modules mount to the substrate via the recessed TOSA mounting surface, and components such as LDDs that would otherwise have a vertical offset relative to the supporting traces of the substrate (e.g., as shown in FIG. 8) get displaced towards the same based on the first predetermined offset distance. The TOSA module components may therefore get “countersunk” via the recessed TOSA mounting surface to allow for relatively shorter electrical interconnection with the substrate.

[0023] Substrates having stepped profiles consistent with the present disclosure advantageously utilize the recessed TOSA mounting surface to allow for mounting of TOSA modules in a manner that maintains the advantages and simplicity of “on board” TOSA arrangements while also significantly reducing the overall length of electrical interconnections to

provide RF and/or power signals to the same. In an embodiment, the stepped profile reduces electrical interconnection lengths by up to and exceeding 50% relative to approaches that do not feature substrates with stepped profiles (e.g., compare FIG. 8 with FIG. 7B), and as a result, the stepped profile significantly reduces the introduction of signal degradation when utilizing relatively longer electrical interconnections.

[0024] 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 dense wavelength division multiplexing (DWDM) grid. This disclosure is equally applicable to coarse wavelength division multiplexing (CWDM). In one specific example embodiment, the channel wavelengths are implemented in accordance with local area network (LAN) wavelength division multiplexing (WDM), which may also be referred to as LWDM. 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.

[0025] The term substantially, as generally referred to herein, refers to a degree of precision within acceptable tolerance that accounts for and reflects minor real-world variation due to material composition, material defects, and/or limitations/peculiarities in manufacturing processes. Such variation may therefore be said to achieve largely, but not necessarily wholly, the stated characteristic. To provide one non-limiting numerical example to quantify “substantially,” minor variation may cause a deviation of up to and including $\pm 5\%$ from a particular stated quality/characteristic unless otherwise provided by the present disclosure.

[0026] Referring to the Figures, FIG. 1 illustrates an optical transceiver module 100, consistent with embodiments of the present disclosure. The optical transceiver module 100 is shown in a highly simplified form for clarity and ease of explanation and not for purposes of limitation. In this embodiment, the optical transceiver module 100 can be pluggable (e.g., conforms with pluggable small form factor (SFFP) standards) and transmits and receives four (4) channels using four different channel wavelengths ($\lambda_1, \lambda_2, \lambda_3, \lambda_4$) and may be capable of transmission rates of at least about 25 Gbps per channel. In one example, the channel wavelengths $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ may be within a ± 13 nm range and have respective channel wavelengths of 1270 nm, 1290 nm, 1310 nm,

and 1330 nm, respectively. Other channel wavelengths and configurations are within the scope of this disclosure including those associated with local area network (LAN) wavelength division multiplexing (WDM). For instance, the optical transceiver module 100 can include up to eight (8) or more channels and provide transmission rates of at least 25 Gbps per channel.

[0027] The optical transceiver module 100 may also be capable of transmission distances of 2 km to at least about 10 km. The optical transceiver module 100 may be used, for example, in internet data center applications or fiber to the home (FTTH) applications.

~~{0002}{0028}~~ In an embodiment, the optical transceiver module 100 is disposed in a transceiver housing 103. The transceiver housing 103 can be configured with one or more cavities to receive one or more optical transceiver modules, depending on a desired configuration.

~~{0004}{0029}~~ The optical transceiver module 100 may include a number of components to support transceiver operations. The optical transceiver module 100 may include an optical transceiver substrate 102, a plurality of transmitter optical subassemblies (TOSA) modules 104 for transmitting optical signals having different channel wavelengths, transmit connecting circuit 106, a multi-channel receiver optical subassembly (ROSA) arrangement 108 for receiving optical signals on different channel wavelengths, an optical fiber receptacle 110 to receive and align a fiber connector (e.g., a ferrule) with the ROSA, and a receiver connecting circuit 112.

~~{0002}{0030}~~ The optical transceiver substrate 102 includes traces, connector pads, and other circuitry to support transceiver operations. The optical transceiver substrate 102 may include TOSA connector pads 114 (or terminals 114) that enable each of the TOSA modules 104 to mount and electrically couple to the optical transceiver substrate 102. The TOSA connector pads 114 may also be referred to herein as a simply connector pads. The optical transceiver substrate 102 may include traces 116 that couple the TOSA connector pads 114 to the transmit connecting circuit 106. As discussed in greater detail below, monitor photodiode (PD) submounts/modules may be disposed on (e.g., directly) the traces 116 and/or the TOSA connector pads 114.

~~{0003}{0031}~~ The optical transceiver substrate 102 may include traces 118 that electrically couple the ROSA arrangement 108 to the receiver connecting circuit 112. The optical transceiver substrate 102 may provide an optical transceiver module that may be “plugged” into an optical transceiver cage. Therefore, the transmit connecting circuit 106 and the receiver connecting circuit 112 may electrically couple to external circuitry of the optical transceiver cage. The optical

transceiver substrate 102 may be manufactured from a multi-layer printed circuitry board (PCB), although other types of substrates may be utilized and are within the scope of this disclosure.

{0004}{0032} Each of the TOSA modules 104 may be configured to receive driving electrical signals (TX_D1 to TX_D4), convert the electrical signals to a multiplexed optical signal (e.g., a signal with channel wavelengths $\lambda_1.. \lambda_n$) and output the same to a multiplexer (not shown). Each of the TOSA modules 104 may be electrically coupled to the TOSA connector pads 114 and to the traces 116 through TOSA module connector pads 120. Each of the TOSA modules 104 may include a laser diode device and supporting circuitry. The laser diode devices of the TOSA modules 104 may include distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. In an embodiment, monitor photodiodes 131 may be used to monitor the lasers' output power, as discussed below.

{0005}{0033} Referring to FIG. 2, an example embodiment of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1 is shown. As shown, the multi-channel optical transceiver module 200 includes an optical transceiver substrate 202 coupled to a TOSA arrangement 206. The optical transceiver substrate 202 may also be referred to herein as a substrate. The optical transceiver substrate 202 may be manufactured from a multi-layer printed circuitry board, although other types of substrates may be utilized and are within the scope of this disclosure.

{0006}{0034} The optical transceiver substrate 202 includes a first end 203 that extends to a second end 207 along a longitudinal axis 250. The first end 203 couples to one or more TOSA modules, such as shown, for launching channel wavelengths onto transmit waveguides, e.g., optical fibers 209. The second end 207 includes terminals/pads for electrical coupling with external circuitry to receive power and data signals. Accordingly, the first end 203 may also be referred to herein as an optical coupling end, and the second end 207 may be referred to as an electrical coupling end.

{0007}{0035} The transceiver substrate 202 further includes at least a first mounting surface 245 disposed opposite a second mounting surface 246 for supporting passive and/or active optical components. The first and second mounting surfaces 245, 246 may also be referred to as first and second component mounting surfaces. Although not shown in the embodiment of FIG. 2, the optical transceiver substrate 202 can include a multi-channel ROSA arrangement mounted to and supported by the first and/or second mounting surfaces 245, 246.

{0008}{0036} Continuing on, the TOSA arrangement 206 includes a plurality of TOSA modules 205-1 to 205-4. Each TOSA module of the plurality of TOSA modules 205-1 to 205-4 includes a base/body portion, and in the particular embodiment illustrated in FIG. 2, cuboid-type base portions. The plurality of TOSA modules 205-1 to 205-4 each support and align an associated laser arrangement with optical coupling ports 204-1 to 204-4, respectively. Thus, channel wavelengths generated by the laser arrangements get launched on to associated optical fibers 209 by way of optical coupling receptacles 204-1 to 204-5. Each laser arrangement may be configured to emit a different channel wavelength and can be monitored by an associated MPD module of an array of MPD modules to ensure nominal optical power, as will be discussed in greater detail below.

{0009}{0037} Continuing on, each of the plurality of TOSA modules 205-1 to 205-4 mount, e.g., edge mount, to the first end 203 of the substrate. The transceiver substrate 202 further includes a stepped profile, with the stepped profile being at least partially defined by a step/shoulder 211 proximate the first end 203. Additional aspects of the stepped profile are discussed below with reference to FIGs. 7A-7B. Each of the TOSA modules 205-1 to 205-4 can include a base with a plurality of sidewalls that define a generally L-shaped profile that corresponds with the step 211. The profile of the base may therefore advantageously align along at least two axis, e.g., the X and Z axis, by simply engaging/bottoming out against surfaces of the step 211, e.g., vertical surface 704 shown and discussed below with reference to FIG. 7A, that operate as an alignment guide by providing mechanical stops/limits to limit travel along at least one axis. Alignment along the remaining axis, e.g., the Y axis, may therefore be performed by relatively simply lateral movement (e.g., along the X axis) of each TOSA module 205-1 to 205-4.

{0010}{0038} Once aligned, each of the plurality of TOSA modules electrically couple to the transceiver substrate 202, and more particularly TOSA module connector pads disposed proximate the first end 203 of the transceiver substrate 202, which is shown more clearly in FIGs. 3 and 4. The TOSA module connector pads allow each of the TOSA modules 204-1 to 204-5 to receive driving signals and power from transmit connecting circuitry, e.g., via traces 116 and TX connecting circuit 106 (See FIG. 1).

{0011}{0039} Referring to FIGs. 3-4, an enlarged region of the multi-channel optical transceiver module of FIG. 2 is shown in accordance with embodiments of the present disclosure. As shown, each TOSA module of the TOSA arrangement 206 includes a laser arrangement having, for

example, a filtering capacitor 401, laser diode (LD) 402, and focusing lens 403. One such laser arrangement 712 is shown in further detail in FIGs. 7A. The components of the TOSA arrangement 206, such as LD 402, can directly mount to the body of the associated TOSA module, or indirectly via an LD submount 404, such as shown. The LD submount 404 can support components of each laser arrangement and provide electrical traces and other circuitry to support TOSA operations. Note the LD submount 404 may also couple directly to the body of the TOSA module, or indirectly by way of one or more baseplates, such as base plate 709 shown more clearly in FIG. 7A.

~~{0013}~~{0040} The LD 402 can be implemented as a distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. Preferably, the LD 402 is implemented as an electro-absorption modulator laser (EML). In an embodiment, the LD 402 can be uncooled (e.g., operate without an associated thermoelectric cooler). Instead, the LD 402 is in thermal communication with the body of the TOSA module to dissipate heat. In addition, the body of the TOSA module may also be in thermal communication with the transceiver substrate 202 via the step 211 to further increase heat dissipation. Accordingly, in an embodiment each TOSA module can provide a thermal communication path 311 that extends between each LD and the transceiver substrate 202 by way of an associated LD submount, TOSA body, and the step 211 of the transceiver substrate 202.

~~{0013}~~{0041} Continuing with reference to FIGs. 3-5, the components of each laser arrangement may be disposed coaxially, or substantially coaxially and be aligned with a longitudinal center line of a corresponding optical coupling receptacle (See FIG. 2). Each TOSA module of the TOSA arrangement 206 may therefore also be referred to as cuboid-type coaxial TOSA assemblies, or simply coaxial TOSA assemblies. Notably, cuboid-type TOSA bases allow for each laser assembly to be mounted in close proximity with adjacent cuboid-type TOSAs, e.g., directly contacting each other in a side-by-side relationship. Alternatively, spacing between the cuboid-type TOSA bases can provide for thermal isolation between adjacent TOSA modules (e.g., based on an air gap) while ensuring a relatively small overall footprint for the TOSA arrangement 206.

~~{0014}~~{0042} In operation, each TOSA module 205-1 to 205-4 of the TOSA arrangement 206 can emit associated channel wavelengths and launch the same along optical fibers 209, for example. Associated MPDs monitor and ensure nominal power for each of the TOSA modules 205-1, 205-4. As discussed above, each of the TOSA modules includes at least a LD, e.g., LD 402, and at

least one corresponding monitor photodiode (MPD), e.g., provided by MPD module 252, to monitor the optical output power. As shown in FIG. 3, for example, the MPD module 252 optically aligns with a back surface of the LD 402 to receive and measure a small percentage of light emitted therefrom, e.g., 1-3%. Laser threshold current and slope efficiency are both functions of temperature and aging time. To maintain nominal optical output power, the electrical bias current and modulation current applied to the laser may be varied to compensate the change brought about by the variations in temperature and/or aging time. The optical transceiver module 200 can vary the current applied to the LD 402 based on the measured light to, for instance, maintain a stable output power based on an average output current of the MPD module 252.

~~{0015}~~~~{0043}~~ Referring to FIGs. 6A-6C, an example monitor photodiode submount 610 suitable for use with the MPD module 252 is shown in accordance with an embodiment. The monitor photodiode (MPD) submount 610 is configured to couple to and align a MPD 251 with an associated laser diode, as discussed above. The MPD submount 610 comprises a base 617 having a plurality of sidewalls to provide at least one mounting surface for supporting an MPD and supporting circuitry and at least one mating surface for coupling to an associated transceiver substrate. The base 617 can comprise, for instance, Silicon (Si), or any other non-conductive suitably rigid material. The base 617 may be formed monolithically from a single piece of material or from multiple pieces. While the following discussion includes reference to disposing/patterning metallic material on to a non-conductive base, e.g., formed from Si to provide electrically conductive paths, the base 617 may be at least partially formed from a conductive material such as a metal to provide integrated traces. In this instance, multiple independent electrical traces/paths may be provided by disposing an electrical insulating layer therebetween.

~~{0016}~~~~{0044}~~ Continuing on, at least one sidewall defining the base 617 of the submount 610 provides a mounting surface 609 for coupling to and supporting MPD 251, such as shown. At least one sidewall defining the base 617 of the submount 610 further provides mating surface 614 for mounting to and being supported by TOSA connecting pads, as will be discussed in greater detail below. As shown, the mounting surface 609 extends substantially transverse relative to the mating surface 614 to provide a vertical mounting orientation for the MPD 251.

~~{0017}~~~~{0045}~~ The base 617 further provides at least first and second electrically conductive paths 611, 613 disposed along multiple sidewalls of the base 617 using a plurality of conductive traces disposed/patterned thereon. In particular, the first electrically conductive path 611 is collectively

provided by at least first and second conductive traces 612-1, 612-2 (or conductive segments) disposed on the base 617. Likewise, the second electrically conductive path 613 is collectively provided by at least third and fourth conductive traces 612-3 and 612-4 (or conductive segments) disposed on the base 617. Patterning of the conductive traces 612-1 to 612-4 can comprise deposition of one or more layers of metallic material such as copper, silver, or other suitable material on to sidewalls of the base 617.

~~{0018}{0046}~~ At least a portion of the first conductive trace 612-1 defines the mounting surface 609 for both physically and electrically coupling to the MPD 251. Further, the first conductive trace 612-1 includes a region with a relatively rectangular profile having a width that is about 1.2x to 1.3x the width of the MPD 251. This rectangular profile may be dimensioned such that corner(s) of the same get disposed at substantially a center of the mounting surface 609. Alignment of the MPD 251 relative to the base 617, and more importantly relative to an associated laser diode, may therefore be initially accomplished along the X, Y and Z axis by ensuring that the edges 619-1 and 619-2 of MPD 251 mount substantially flush with a far edge of rectangular pad provided by the first conductive trace 612-1. Stated differently, alignment of MPD 251 can include mounting the same at a predetermined position on the first conductive trace 612-1 such that edges 619-1 and 612-2 extend parallel with the edges defining the rectangular pad and include a relatively uniform gap therebetween measuring about 0 to 100 microns. The first conductive trace 612-1 may therefore provide a visual alignment indicator, e.g., in the form of a rectangular pad or other regular or non-regular geometric shape, to provide a visual representation of a predefined mounting location for the MPD to simplify mounting and alignment of the same.

~~{0019}{0047}~~ The above-discussed mounting and alignment of MPD 251 on to the MPD submount 610 can occur prior to attachment to the transceiver substrate 202 (FIG. 2). The MPD submount 610 may therefore get mounted to the transceiver substrate 202 with the MPD 251 being aligned along at least the X and Z axis with the associated laser diode. Alignment along the Y axis can include simply shifting the MPD submount 610 laterally until nominal optical coupling with an associated laser diode gets achieved.

~~{0020}{0048}~~ Continuing on, the first conductive trace 612-1 extends towards the transceiver substrate 202 when the MPD submount is coupled thereto. The first conductive trace 612-1 also extends substantially transverse relative to the first mounting surface 245 of substrate 202 when coupled thereto (See FIG. 3). The first conductive trace 612-1 then transitions to the second

conductive trace 612-2 based on an edge/intersection between associated sidewalls of the base 617. The second conductive trace 612-2 extends substantially transverse relative to the mounting surface 609, and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202 when coupled thereto (See e.g., FIGs. 3-5).

~~{0024}{0049}~~ As further shown, third and fourth conductive traces 612-3 and 612-4 are disposed on the base 617 to collectively define a second electrically conductive path to electrically couple the MPD 251 to the transceiver substrate 202. The third conductive trace 612-3 is disposed on the mounting surface 609 and is configured to electrically couple to the MPD 251 via, for instance, wire bonding such as shown. The third conductive trace 612-3 extends towards the transceiver substrate 202 when the MPD submount 610 is coupled thereto. The third conductive trace 612-3 transitions to the fourth conductive trace 612-4 at an edge/intersection between sidewalls of the base 617. The fourth conductive trace 612-4 extends substantially transverse relative to the mounting surface 609 and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202.

~~{0022}{0050}~~ The first and second conductive paths 611, 613 therefore include at least one region/segment that extend substantially in parallel, and proximate, to an interface formed between the mating surface 614 and the first mounting surface 245 of the transceiver substrate 202 when the MPD submount 610 is coupled thereto. As discussed in greater detail below, the first and second conductive paths 611, 613 can be electrically coupled to the transceiver substrate 202 utilizing a conductive epoxy or other conductive material that can be disposed around MPD submount 610.

~~{0023}{0051}~~ The MPD 251 can comprise a surface MPD having a detecting surface/region 603 having a receiving area 602 that is configured to be optically coupled with an associated laser diode by being aligned along the X, Y and Z axis. In particular, alignment includes the receiving area being disposed at a position that intersects with an optical path extending from a back surface of the associated laser diode towards the MPD. An anode 604 is disposed on the detecting surface 603. A cathode (not shown) of the MPD 251 is provided on a surface opposite the detecting surface 603. The MPD 251 mounts (e.g., directly) on the first conductive trace 612-1, with the associated cathode electrically connected to the first conductive path 611. The anode 604 electrically couples to the second conductive path 613 by wire bonding, for instance.

~~{0024}~~~~{0052}~~ As shown in FIGs. 6A-6C, the body 617 of the MPD submount 610 can include channels/notches 631-1, 631-2. The channels 631-1, 631-2 extend substantially transverse relative to mounting surface 609 and include a curved/arcuate profile (such as shown). Other shapes and configurations for the channels 631-1, 631-2 are within the scope of this disclosure. As further shown, the second conductive trace 612-2 and the fourth conductive trace 612-4 are at least partially disposed on the channels 631-1, 631-2. The channels 631-1, 631-2 can advantageously facilitate flow and adhesion of a layer of epoxy 509 (FIG. 5) to securely attach the MPD submount 610 to an associated transceiver substrate, e.g., transceiver substrate 202. In addition, the channels 631-1, 631-2 reduce the overall footprint of the mating surface 614 by providing a taper, and by extension, reducing the overall footprint of the MPD submount 610 when coupled to the transceiver substrate 202 (See FIG. 5). The channels 631-1, 631-2, may thus define a tapered region that at least partially defines the mating surface 614.

~~{0025}~~~~{0053}~~ When the MPD submount 610 mounts to the transceiver substrate 202 via mating surface 614, conductive epoxy 509 can flow into the channels 631-1, 631-2 to securely attached the MPD submount 610 at a predetermined position, as discussed further below. The rounded profile/shape of the channels 631-1, 631-2 can encourage increased adhesion and allow for a relatively larger amount of conductive epoxy to be utilized and substantially confined without the same inadvertently contacting adjacent conductive pads/traces. Note that while the embodiment of FIGs. 6A-6C show two channels 631-1, 631-2, this disclosure is not limited in this regard. An MPD submount consistent with the present disclosure can have a single channel, or a plurality of channels (as shown), or no channels depending on a desired configuration.

~~{0026}~~~~{0054}~~ As shown in FIG. 6C, the first and second conductive paths 611, 613 can also include fifth and sixth conductive traces 612-5, 612-6, respectively. The fifth and sixth conductive traces 612-5, 612-6 can be disposed on back surface 616, with back surface 616 being disposed opposite the mounting surface 609. In this embodiment, the fifth and sixth conductive traces 612-5, 612-6 can further increase electrical conductivity via the conductive epoxy and can balance bonding stresses applied to the MPD submount 610.

~~{0027}~~~~{0055}~~ Referring back to FIGs. 3-5, with additional reference to FIGs. 6A-6C, the MPD submount 610 is shown implemented as MPD module 252. These MPD module 252 is configured to be disposed on the TOSA connector pads 423, 424, and when coupled thereto, an interface 504 gets formed between the MPD module 252 and the surfaces defining the transceiver substrate 202

(See FIG. 5). A layer of conductive epoxy 509, e.g., silver epoxy, may be disposed along the interface 504 between MPD module 252 and surfaces defining the transceiver substrate 202, and in particular, the connector pads 423, 424.

{0028}{0056} Therefore, the first and the second conductive paths 611, 613 (FIG. 6A) electrically couple to a pad/trace of the transceiver substrate based at least in part on the layer of conductive epoxy 509. Minor adjustment to MPD orientation along the Y axis, e.g., relative to an associated laser diode, can be achieved while the layer of conductive epoxy 509 cures, thus allowing for greater tolerances and multiple manufacturing phases to occur at potentially the same time. To avoid or otherwise reduce reflection losses, the receiving area 602 may be disposed at an angle with respect to the light path of the laser diode. The angle may be, for example, 0-15°, and preferably about 8° relative to normal.

Stepped Profile Architecture

{0029}{0057} Turning to FIGs. 7A an enlarged cross-sectional view of the substrate 202 is shown in accordance with an embodiment. Note, the embodiment of FIG. 7A shows a laser arrangement having a vertically-mounted monitored photodiode, as discussed above. However, the stepped profile is equally applicable to other TOSA configurations including designs where an MPD is mounted to the TOSA body (e.g., See FIG. 7B).

{0030}{0058} As shown in FIG. 7A, the first component mounting surface 245 defines at least a portion of a first mounting region to allow for mounting of components and to provide traces for electrical interconnection with external circuitry. The first mounting region can therefore extend from the electrical coupling end 207 to a second mounting region disposed at the optical coupling end 203.

{0031}{0059} The second mounting region is defined at least in part by the step 211. The step 211 defines at least a portion of the stepped profile which can simplify alignment and coupling processes for TOSA modules, as discussed above. The stepped profile, and in particular, step 211 is defined at least in part by a recessed TOSA mounting surface 702, which may be referred to herein as simply a recessed mounting surface. The recessed mounting surface 702 is offset/recessed from the first component mounting surface 245 by a first offset distance (OD1). The offset distance OD1 measures between 10 and 50 microns, and preferably, 10-20 microns

{0032}{0060} The stepped profile may therefore be provided by the recessed TOSA mounting surface 702 extending substantially parallel with the first component mounting surface 245 and

substantially transverse relative to vertical surface 704, with the vertical surface 704 adjoining the recessed mounting surface 702 and the first component mounting surface 245. The overall height of vertical surface 704 can be predetermined to establish the first offset distance OD1. As shown in FIGs. 2 and 7A, the first mounting region is shown as the portion of the substrate 202 having a first overall width W1. The first mounting region preferably includes a uniform width, or may vary along the longitudinal axis 250 (See FIG. 2) up to a maximum width equal to W1. On the other hand, the second mounting region is shown as the portion of the substrate 202 having a second overall width W2, with the second overall width W2 being less than the first overall width. The second mounting region also includes, preferably, a uniform width although this disclosure is not limited in this regard and the second overall width W2 can vary along the longitudinal axis up to a maximum width equal to W2.

{0033}{0061} As further shown in FIG. 7A, the first TOSA module 205-1 includes a body 706 (or base) configured to securely mount, e.g., edge mount, to the second mounting region of the substrate 202. The body 706 includes a plurality of sidewalls that provide a substrate mating surface 708-1 and a component mounting surface 708-2. The substrate mating surface 708-1 is disposed opposite the component mounting surface 708-2, and in the embodiment shown in FIGs. 7A-7B, the component mounting surface is accessible via an opening 710 defined by sidewalls of the body 706 that extend substantially transverse from the component mounting surface 708-2.

{0034}{0062} Thus, the recessed TOSA mounting surface 702 underlies and supports at least a portion of the substrate mating surface 708-1, and thus by extension, the body 706 of the at least one TOSA module 205-1. In an embodiment, epoxy or other adhesive material may be disposed between the recessed TOSA mounting surface 702 and the substrate mating surface 708-1 to securely attach the body 706 to the substrate 202, although other attachment methods are within the scope of this disclosure such as welding. In this embodiment, the stepped profile operates, in a general sense, as a dam to prevent epoxy from contacting other surfaces such as the substrate mating surface 708-1. Accordingly, the stepped profile also aids in containing and confining epoxy during manufacturing, which can reduce component failure and the time required for post-processing stages to remove excess epoxy.

{0035}{0063} The recessed TOSA mounting surface 702 can include one or more layers of metallic material disposed thereon (See FIG. 7B), e.g., such as Gold (Au) or Copper (Cu), to

increase thermal communication between the TOSA module 205-1 and the substrate 202 and/or to allow for attachment via welding/soldering.

~~{0036}~~~~{0064}~~ Turning to FIG. 7B, with additional reference to FIG. 7A, the body 706 includes at least one laser arrangement 712 mounted to the component mounting surface 708-2 of the body 706. As shown, the laser arrangement 712 includes a laser diode driver 714, a laser diode 716, a monitor photodiode 718 and a focus lens 720. The laser arrangement 712 may include more or fewer active and/or passive optical components depending on a desired configuration, and the embodiment shown in FIG. 7B is not intended to be limiting.

~~{0037}~~~~{0065}~~ As further shown, the at least one laser arrangement 712 mounts to the body 706, and more particularly, the component mounting surface 708-2 by way of a submount 722 and optional base plate 709. The submount 722 can provide traces/terminals for electrical connectivity with components of the at least one laser arrangement 712. The overall height H1 of the submount 722 (e.g., including the base plate 709) may therefore measure substantially equal to or greater than the first offset distance OD1. Accordingly, an invisible line drawn at the first component mounting surface 245, and parallel thereto, can intersect with the submount 722 and/or at least one component of the at least one laser arrangement 712 such as the LDD 714 and LD 716.

~~{0038}~~~~{0066}~~ Stated differently, the submount 722 vertically displaces the components of the at least one laser arrangement 712 relative to the component mounting surface 708-2 of the body 706, e.g., by overall height H1, but the vertical displacement gets ‘offset’ based on stepped profile of the substrate 202, and more particularly, the first offset distance (OD1) of the recessed TOSA mounting surface 702 relative to the first component mounting surface 245 of the substrate 202. Stated simply, the recessed TOSA mounting surface 702 gets countersunk relative to the first component mounting surface 245. The overall height H2 between the first component mounting surface 245 and a top surface of the submount 722 that supports the optical components of the at least one laser arrangement 712 is less than 400 microns, and preferably, less than 200 microns.

~~{0039}~~~~{0067}~~ Accordingly, relatively short electrical interconnects, e.g., wire bonds 724, electrically couple the LDD 714 to RF terminals/traces 726 disposed on the first component mounting surface 245. In the shown embodiment, the overall length of each of the wire bonds 724 measures between 400 and 500 microns, and preferably, less than 400 microns. In addition, each of the wire bonds 724 extend at an angle θ relative to the first component surface 245, with angle θ being less than or equal to 45 degrees.

~~{0040}{0068}~~ Substrates having stepped profiles consistent with the present disclosure advantageously position components such as LDDs in close proximity with supporting terminals of the substrate 202. By way of contrast, consider the embodiment of FIG. 8 which shows a substrate and TOSA modules with a substantially similar size and dimension to that of the embodiments shown in FIGs. 7A-7B. However, the stepped profile of the substrate 202 shown in FIGs. 7A and 7B allows for wire bonds 724 to be shortened/reduced in length by up to and exceeding 50% relative to wire bonds 808 of FIG. 8. Moreover, the wire bonds 724 extend at a relatively acute angle θ to provide a low-profile implementation. On the other hand, the wire bonds 808 shown in FIG. 8 extend from substrate 804 at roughly a 90 degree angle, which increases the risk of inadvertent contact and damage. In any event, this reduction in wire bond length translates directly to improved signal quality, and in addition, enables maximum transmission speeds otherwise unachievable with longer electrical interconnections.

~~{0041}{0069}~~ In accordance with an aspect of the present disclosure an optical subassembly module is disclosed. The optical subassembly module comprising a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end, a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate, a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface.

~~{0042}{0070}~~ In accordance with another aspect of the present disclosure an optical transceiver is disclosed. The optical transceiver comprising a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end, at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end, and a recessed transmitter optical subassembly (TOSA) mounting surface at the

optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface, at least one TOSA module coupled to optical coupling end of the transceiver substrate, and a receiver optical subassembly arrangement coupled to the transceiver substrate.

~~{0043}{0071}~~ 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.



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/737,438	01/08/2020	Kai-Sheng LIN	PAT276US	7554
27543	7590	10/05/2020	EXAMINER	
APPLIED OPTOELECTRONICS, INC.			SEDIGHIAN, MOHAMMAD REZA	
13115 JESS PIRTLE BLVD.				
SUGAR LAND, TX 77478				
			ART UNIT	PAPER NUMBER
			2636	
			NOTIFICATION DATE	DELIVERY MODE
			10/05/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Youngun_Kim@ao-inc.com
docketing@gtp.com
kcarroll@gtp.com

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Drawings

2. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the “an invisible line drawn at the component surface of the substrate, and parallel thereto, that intersects with the submount and/or a laser diode of at least one laser arrangement; an invisible line drawn at a component mounting surface, and parallel thereto, that intersects with each LDD and/or submount of a plurality of TOSA modules” must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as “amended.” If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either “Replacement Sheet” or

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“New Sheet” pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Specification

4. Specification is objected because the reference numeral “**0001** through **0026**”, used for numbering paragraphs, on pages 6-13 of specification, have been used in previous pages 1-5 in the specification. A new renumbering of paragraphs is required.

Claim Rejections - 35 USC § 112

5. The following is a quotation of 35 U.S.C. 112(b):

(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 2-9, 16, are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor (or for applications subject to pre-AIA 35 U.S.C. 112, the applicant), regards as the invention.

As to claim 2, it is not clear about “... the optical subassembly module further comprises the at least one TOSA module coupled to the second mounting region of the substrate, the at least one TOSA module having a body that includes a component mounting surface to couple to a laser arrangement and a substrate mating surface disposed opposite the

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component mounting surface of the body, the substrate mating surface of the body to couple to the recessed TOSA mounting surface of the optical coupling end of the substrate such that the recessed mounting TOSA mounting surface of the substrate underlies and supports at least a portion of the mating surface of the body of the TOSA module.” It is not clear about the the substrate mating surface of the body that is coupled to the recessed TOSA mounting surface of the optical coupling end of the substrate so that the recessed mounting TOSA mounting surface of the substrate underlies and supports at least a portion of the mating surface of the body. It is not clear about “the substrate mating surface; the recessed TOSA mounting surface; the recessed mounting TOSA mounting surface; the mating surface”.

As to claim 4, it is not clear about “... the laser arrangement of the TOSA module comprises a submount and a laser diode coupled to the submount, and wherein an invisible line drawn at the component surface of the substrate, and parallel thereto, intersects with the submount and/or the laser diode of the at least one laser arrangement.” It is not clear about an invisible line that can be drawn at the component surface of the substrate, and parallel thereto, which intersects with a submount and/or a laser diode.

As to claim 9, it is not clear about “... the stepped profile of the substrate provides an alignment guide, whereby the vertical surface defining the stepped profile provide a mechanical stop to limit travel of the at least one TOSA module along a first axis, and the recessed TOSA module mounting surface supports the at least one TOSA module and limits travel of the TOSA module along a second axis, the second axis being different that the first

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axis.” It is not clear how the stepped profile provides an alignment guide to further provide mechanical stop to limit the travel of the TOSA module along a first or a second axis.

As to claim 16, it is not clear about “... each LDD of the plurality of TOSA modules is disposed proximate the at least one component mounting surface, and wherein an invisible line drawn at the at least one component mounting surface, and parallel thereto, intersects with each LDD and/or submount of the plurality of TOSA modules.” It is not clear about an invisible line that can be drawn at a component mounting surface, and parallel thereto, which intersects with each LDD and/or submount of plurality of TOSA modules.

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention.

8. Claim(s) 1-6 and 9-16 is/are rejected under 35 U.S.C. 102(a)(1) as being anticipated by WU et al. (US Patent Application Publication No: 2014/0105612 A1).

Regarding claims 1 and 12, WU teaches an optical subassembly module (2, figs. 4A, 4B), the optical subassembly module (2, figs. 4A, 4B) comprising:

a substrate (23, fig. 4B) having an electrical coupling end (the electrical coupling end of substrate 23 in fig. 4B) for electrically coupling to external circuitry (paragraph 0036, lines 1-4) and an optical coupling end (the optical coupling end of substrate 23) for launching at least one

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channel wavelength (see paragraph 0031, lines 8-9) on a waveguide (241, fig. 4B), the electrical coupling end disposed opposite the optical coupling end;

a first mounting region (the mounting region for electrical circuits such circuitry 22, shown in figs. 4A, 4B) at the electrical coupling end of the substrate to provide traces (see the traces shown in fig. 4B) for electrical interconnection with the external circuitry (the external circuit to the transceiver 2), the first mounting region defined at least in part by a component mounting surface (the mounting surface for electrical circuits such as control chip 22) provided by a sidewall (see 112 in fig. 2) of the substrate (substrate 23 in figs. 4A, 4B);

a second mounting region (11, fig. 4B) at the optical coupling end of the substrate (23, fig. 4B) to couple to and support at least one transmitter optical subassembly (TOSA) module (12, figs. 4A, 4B) via a recessed (231, fig. 4A, 4B) TOSA mounting surface (1121, fig. 4B), the recessed TOSA mounting surface (1121 in fig. 4B) being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile (see paragraphs 0030, 0031, 0036), the stepped profile define at least in part by the recessed TOSA mounting surface (1121, fig. 4B) extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface (see 112 in figs. 2, 4A) adjoining the recessed TOSA mounting surface and the component mounting surface (see paragraphs 0030, 0031, lines 1-5). As to claim 12, WU further teaches the use of at least a TOSA module (see 12, fig. 4B and paragraph 0038) coupled to optical coupling end of the transceiver substrate (23, fig. 4B), and a receiver optical subassembly (see paragraph 0031, lines 10-11, paragraph 0038, lines 10-12) arrangement coupled to the transceiver substrate (23 in figs. 4A, 4B).

Regarding claim 2, as it is understood in view of the above 112 problem, WU teaches the optical subassembly module (2, fig. 4B) further comprises the at least one TOSA module (12 in figs. 4A, 4B) coupled to the second mounting region (11 in fig. 4A, 4B) of the substrate (23, figs. 4A, 4B), the at least one TOSA module (12, fig. 4A, 4B) having a body that includes a component mounting surface (111, fig. 4A) to couple to a laser arrangement (12, fig. 4A) and a substrate mating surface (1121, fig. 2) disposed opposite the component mounting surface (111, fig. 4A) of the body, the substrate mating surface (1121, fig. 2) of the body to couple to the recessed TOSA mounting surface (231, fig. 4A, 4B) of the optical coupling end of the substrate such that the recessed mounting TOSA mounting surface (231, fig. 4A, 4B) of the substrate underlies and supports at least a portion of the mating surface (1121, fig. 2) of the body of the TOSA module (12, fig. 2, 4A, 4B, see paragraphs 0029, 0030, 0031).

Regarding claim 3, WU also teaches the substrate mounting surface (1121, fig. 4B) of the body is vertically offset (see 112 in figs. 2, 4A, 4B) from the component mounting surface (111, fig. 4B) of the substrate (23, fig. 4A, 4B) by the first offset distance (see paragraph 0031, lines 1-4).

Regarding claim 4, as it is understood in view of the above 112 problem, WU teaches the laser arrangement of the TOSA module (12, fig. 2, 4A, 4B) comprises a submount (1121, figs. 2, 4B) and a laser diode (paragraph 0031, lines 1-4) coupled to the submount (1121, fig. 2, 4B), and wherein an invisible line drawn at the component surface of the substrate, and parallel thereto, intersects with the the laser diode of the at least one laser arrangement (note that an

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invisible line can be drawn from the component mounting surface 111, or parallel thereto, to further intersect with the LDD 12 extended sidewall 112, shown in fig. 2).

Regarding claim 5, WU teaches the laser arrangement of the TOSA module comprises a laser diode driver (LDD) (the LDD of each laser chip) disposed on the component mounting surface (1121, fig. 2) of the TOSA module (12, fig. 2, 4B).

Regarding claim 6, WU teaches the LDD is electrically coupled (221, figs. 4A, 4B) to RF terminals (22, figs. 4A, 4B) disposed on the component mounting surface (the mounting surface for the electrical circuits such as control chip 22) of the substrate (23, fig. 4B) adjacent the optical coupling end via a plurality of wire bonds (see 221 in fig. 4B and paragraph 0036, lines 12-14).

Regarding claim 9, as it is understood in view of the above 112 problem, WU teaches the stepped profile (112, 231 in fig. 4A) of the substrate (23, fig. 4A) and the vertical surface (112, fig. 4A) defining the stepped profile (paragraph 0031, line 2) limit travel of at least one TOSA module (12, fig. 4A) along an axis (see paragraph 0030, lines 7-10, note that the stepped profile provided by bench 11, its upper surface 111, and the extended sidewall 112, limits the movement of TOSA module), and the recessed TOSA module mounting surface (1121, fig. 4B) supports the at least one TOSA module (12, fig. 4B) and limits travel of the TOSA module along an axis (note that TOSA module 12 is positioned at the center of upper surface 1121 of high flatness, thus, its movement is limited).

Regarding claim 10, WU teaches the second mounting region (11, fig. 4B) is configured to couple to and support a plurality of TOSA modules (see 121 in fig. 3A and paragraph 0031, lines 1-9).

Regarding claim 11, WU teaches the substrate is a printed circuit board (paragraph 0036, line 5), and wherein the optical subassembly (2, figs. 2, 4A, 4B) is a multi-channel optical transmitter (paragraph 0031, lines 9) or multi-channel optical transceiver capable of transmitting multiple channel wavelengths (paragraph 0031).

Regarding claim 13, WU teaches RF terminals (22, fig. 4A, 4B) disposed on the at least one component mounting surface proximate to the optical coupling end, wherein the TOSA module (12, figs. 4A, 4B) electrically couples (221, fig. 4B) with RF terminals (22, fig. 4B) via one or more wire bonds (paragraph 0036, lines 12-14).

Regarding claim 14, WU teaches the recessed TOSA mounting surface (1121, fig. 4B) is vertically offset (paragraph 0031, lines 1-3) relative to the at least one component mounting surface of the transceiver substrate by a first offset distance (see 112 in figs. 2, 4A).

Regarding claim 15, WU teaches the at least one TOSA module (12, fig. 4A, 4B) comprises a plurality of TOSA modules (paragraph 0031, line 4, the "laser chips"), and wherein each TOSA module of the plurality of TOSA modules include a submount (1121, fig. 2, 4A, 4B)

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and a laser diode driver (LDD) (the LDD of respective laser chips) coupled to the submount (1121, figs. 2, 4B).

Regarding claim 16, as it is understood in view of the above 112 problem, WU teaches each LDD (paragraph 0031, line 4, the laser diode driver circuitries of each laser chip) of the plurality of TOSA modules (paragraph 0031, line 4, "the laser chips") is disposed (see 121 in fig. 3A) proximate the at least one component mounting surface (see for example, 13 and 111 in fig. 2), and wherein an invisible line drawn at the at least one component mounting surface, and parallel thereto, intersects with each LDD of the plurality of TOSA modules (note that an invisible line can be drawn from the component mounting surface 111, or parallel thereto, to further intersect with the LDD 12 extended sidewall 112, shown in fig. 2).

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

10. Claim 7 is/are rejected under 35 U.S.C. 103 as being unpatentable over WU et al. (US Patent Application Publication No: 2014/0105612 A1) in view of Brennan et al. (US Patent Application Publication No: 2006/0043609 A1).

Regarding claim 7, WU differs from the claimed invention in that WU does not specifically disclose each of the plurality of wire bonds (221 in figs. 4A, 4B) extend from the component mounting surface of the substrate (23, fig. 4B) at an angle of less than or equal to 45 degrees. Brennan teaches the use of wire bonds (422, 424, 426, fig. 4) that extend from a mounting surface of a substrate (412, fig. 4) at an angle of less than or equal to 45 degrees (see paragraph 0031). Therefore, it would have been obvious before the effective filing date of the claimed invention to a person of ordinary skill in the art to provide and position the wire bonds 221 of WU, for example, at angles of less than or equal to 45 degrees, as it is taught by Brennan, to provide proper electrical coupling for signal transmission.

11. Claim 8 is/are rejected under 35 U.S.C. 103 as being unpatentable over WU et al. (US Patent Application Publication No: 2014/0105612 A1) in view of Brennan et al. (US Patent Application Publication No: 2006/0043609 A1) and in further view of Haba et al. (US Patent Application Publication No: 2012/0267777 A1).

Regarding claim 8, the electro-optical signal transmission device of WU modified by Brennan further differs from the claimed invention in that WU and Brennan do not specifically disclose the use of wire bonds with an overall length of less than 500 microns. Haba teaches the use of wire bonds (63 in fig. 2) with length of about 500 microns (see paragraph 0060, lines 14-17). Therefore, it would have been obvious before the effective filing date of the claimed invention to a person of ordinary skill in the art to provide wire bonds of length 500 microns, such as the ones disclosed by Haba, for the wire bonds 221 of WU, to provide a proper and efficient electrical signal coupling between electro-optical components.

Conclusion

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to M R SEDIGHIAN whose telephone number is (571)272-3034.

The examiner can normally be reached on M-W 11 AM to 7 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kenneth Vanderpuye can be reached on (571) 272-3078. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <https://ppair-my.uspto.gov/pair/PrivatePair>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MOHAMMAD R SEDIGHIAN/
Primary Examiner, Art Unit 2636

<i>Notice of References Cited</i>	Application/Control No. 16/737,438		Applicant(s)/Patent Under Reexamination LIN et al.	
	Examiner M R SEDIGHIAN		Art Unit 2636	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20140105612-A1	04-2014	WU; TSU-HSIU	H04B10/40	398/139
*	B	US-20060043609-A1	03-2006	Brennan; John M.	H01L24/49	257/784
*	C	US-20120267777-A1	10-2012	Haba; Belgacem	H05K3/303	257/737
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<i>Search Notes</i> 	Application/Control No. 16/737,438	Applicant(s)/Patent Under Reexamination LIN et al.
	Examiner M R SEDIGHIAN	Art Unit 2636

CPC - Searched*		
Symbol	Date	Examiner
H04B 10/40, 503, 801	09/26/2020	MRS
H01L 23/52	09/26/2020	MRS

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
398	135	09/26/2020	MRS

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see search history	09/26/2020	MRS

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	172	(wire adj1 bonds) with "45"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:07
S2	1	(wire adj1 bonds) with ("45" adj1 degree\$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:08
S3	1	(wire adj1 bonds) with ("45" near3 degree\$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:09
S4	1	(wire adj1 bonds) with ("45" near5 degree\$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:09
S5	1,160	(wire adj1 bonds) and ("45" near5 degree\$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:09
S6	27	(wire adj1 bonds) same ("45" near5 degree\$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:10
S7	123	(wire adj1 bonds) same ("500" near1 microns)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:20
S8	25	(wire adj1 bonds) with ("500" near1 microns)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:20
S9	25	(wire adj1 bonds) with ("500" near3 microns)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:24
S10	25	(wire adj1 bonds) with ("500" near5 microns)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/28 23:24

9/29/2020 12:52:02 AM

Bibliographic Data

Application No: 16/737,438

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged: /M R SEDIGHIAN/

Examiner's Signature

Initials

Title:

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING
TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL
TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
01/08/2020	398	2636	PAT276US
RULE			

APPLICANTS

Applied Optoelectronics, Inc., Sugar Land, TX, UNITED STATES

INVENTORS

Kai-Sheng LIN, Sugar Land, TX, UNITED STATES

Hang XIE, Missouri City, TX, UNITED STATES

Yi WANG, Katy, TX, UNITED STATES

CONTINUING DATA

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

01/29/2020

STATE OR COUNTRY

UNITED STATES

ADDRESS

APPLIED OPTOELECTRONICS, INC.

13115 JESS PIRTLE BLVD.

SUGAR LAND, TX 77478

UNITED STATES

FILING FEE RECEIVED

\$1,720

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S20	3	("20060043609").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 13:27
S21	2	("20120267777").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 14:43
S22	1	S21 and "500"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 14:51
S23	0	S21 and (wire with ("500" adj1 micron))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 14:57
S24	92	(wire with ("500" adj1 micron))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 14:57
S25	119	LIN near3 Kai near3 Sheng	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:47
S26	39	S25 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:47
S27	23	S26 and recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:47
S28	93	XIE near3 Hang	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:53
S29	1	S28 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:53
S30	28,036	WANG near3 Yi	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	OFF	2020/09/29 23:53

			JPO; DERWENT; IBM_TDB			
S31	287	S30 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:54
S32	71	S31 and recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:54
S33	4	S32 and TOSA	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/29 23:54

9/29/2020 11:56:13 PM

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EAST Search History

EAST Search History (Prior Art)

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L3	181	1 and (mount\$3 adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 15:48
L4	126	1 and (mounting adj1 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 15:48
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L7	102	6 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 16:09
L8	19	7 and recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 16:09
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L10	231	9 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 16:47
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L12	613	1 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 16:53
L13	147	12 and recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 16:53

L14	1,775	H01L23/52.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 17:53
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L16	29	15 and recess\$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 17:53
L17	2,242	398/135.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 17:55
L18	199	17 and (mount\$3 near5 surface)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2020/09/26 17:55
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9/26/2020 5:57:45 PM

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 16/737,438	
APPLICATION AS FILED - PART I							
(Column 1)		(Column 2)		SMALL ENTITY		OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(j))	16	minus 20 = *			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2	minus 3 = *				x 460 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s)) If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).							0.00
							0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
			TOTAL			TOTAL	1720
* If the difference in column 1 is less than zero, enter "0" in column 2.							
APPLICATION AS AMENDED - PART II							
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY	
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)
	Total (37 CFR 1.16(i))	*	Minus **	=	x =	OR	x =
	Independent (37 CFR 1.16(h))	*	Minus ***	=	x =	OR	x =
	Application Size Fee (37 CFR 1.16(s))					OR	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					OR	
			TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY	
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)
	Total (37 CFR 1.16(i))	*	Minus **	=	x =	OR	x =
	Independent (37 CFR 1.16(h))	*	Minus ***	=	x =	OR	x =
	Application Size Fee (37 CFR 1.16(s))					OR	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					OR	
			TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.							



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/737,438	01/08/2020	2883	1720	PAT276US	16	2

CONFIRMATION NO. 7554

FILING RECEIPT

27543
APPLIED OPTOELECTRONICS, INC.
13115 JESS PIRTLE BLVD.
SUGAR LAND, TX 77478



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Inventor(s)

Kai-Sheng LIN, Sugar Land, TX;
Hang XIE, Missouri City, TX;
Yi WANG, Katy, TX;

Applicant(s)

Applied Optoelectronics, Inc., Sugar Land, TX;

Power of Attorney: The patent practitioners associated with Customer Number 27543

Domestic Applications for which benefit is claimed - None.

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Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

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Projected Publication Date: 07/08/2021

Non-Publication Request: No

Early Publication Request: No

Title

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL
SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

Preliminary Class

385

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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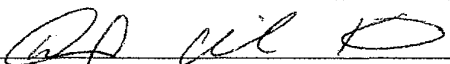
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Applied Optoelectronics, Inc.	
Applicant Name	
13115 Jess Pirtle Blvd., Sugar Land, TX 77478	
Applicant Address	
Signature 	Date 9/24/2012
Name and Title (of individual signing on behalf of assignee or obligated assignee)	
David Kuo, Assistant General Counsel	

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

ABSTRACT

The present disclosure is generally directed to a stepped profile for substrates that support “on board” optical subassembly arrangements. The stepped profile enables mounting TOSA modules to the substrate in a recessed orientation to reduce the overall distance between terminals of the substrate and associated components of the TOSA, e.g., RF terminals of the substrate and an LDD of the TOSA. In an embodiment, the stepped profile further simplifies mounting and optical alignment of TOSA modules by providing at least one mechanical stop to engage surfaces of the TOSA modules and limit travel by the same along one or more axis.

CLAIMS

What is claimed is:

1. An optical subassembly module, the optical subassembly module comprising:
a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end;
a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate;
a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface.
2. The optical subassembly module of claim 1, wherein the optical subassembly module further comprises the at least one TOSA module coupled to the second mounting region of the substrate, the at least one TOSA module having a body that includes a component mounting surface to couple to a laser arrangement and a substrate mating surface disposed opposite the component mounting surface of the body, the substrate mating surface of the body to couple to the recessed TOSA mounting surface of the optical coupling end of the substrate such that the recessed mounting TOSA mounting surface of the substrate underlies and supports at least a portion of the mating surface of the body of the TOSA module.

3. The optical subassembly module of claim 2, wherein the substrate mating surface of the body is vertically offset from the component mounting surface of the substrate by the first offset distance.

4. The optical subassembly module of claim 2, wherein the laser arrangement of the TOSA module comprises a submount and a laser diode coupled to the submount, and wherein an invisible line drawn at the component surface of the substrate, and parallel thereto, intersects with the submount and/or the laser diode of the at least one laser arrangement.

5. The optical subassembly module of claim 2, wherein the laser arrangement of the at least one TOSA module comprises a laser diode driver (LDD) disposed on the component mounting surface of the TOSA module.

6. The optical subassembly of claim 5, wherein the LDD is electrically coupled to radio frequency (RF) terminals disposed on the component mounting surface of the substrate adjacent the optical coupling end via a plurality of wire bonds.

7. The optical subassembly of claim 6, wherein each of the plurality of wire bonds extend from the component mounting surface of the substrate at an angle less than or equal to 45 degrees.

8. The optical subassembly of claim 6, wherein each of the plurality of wire bonds has an overall length of less than 500 microns.

9. The optical subassembly of claim 1, wherein the stepped profile of the substrate provides an alignment guide, whereby the vertical surface defining the stepped profile provides a mechanical stop to limit travel of the at least one TOSA module along a first axis, and the recessed TOSA module mounting surface supports the at least one TOSA module and limits travel of the TOSA module along a second axis, the second axis being different than the first axis.

10. The optical subassembly of claim 1, wherein the second mounting region is configured to couple to and support a plurality of TOSA modules.

11. The optical subassembly of claim 1, wherein the substrate is a printed circuit board, and wherein the optical subassembly is a multi-channel optical transmitter or multi-channel optical transceiver capable of transmitting multiple channel wavelengths.

12. An optical transceiver, the optical transceiver comprising:
a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end;
at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end; and
a recessed transmitter optical subassembly (TOSA) mounting surface at the optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface;
at least one TOSA module coupled to optical coupling end of the transceiver substrate; and
a receiver optical subassembly arrangement coupled to the transceiver substrate.

13. The optical transceiver of claim 12, further comprising radio frequency (RF) terminals disposed on the at least one component mounting surface proximate to the optical coupling end, wherein the at least one TOSA module electrically couples with the RF terminals via one or more wire bonds.

14. The optical transceiver of claim 12, wherein the recessed TOSA mounting surface is vertically offset relative to the at least one component mounting surface of the transceiver substrate by a first offset distance.

15. The optical transceiver of claim 12, wherein the at least one TOSA module comprises a plurality of TOSA modules, and wherein each TOSA module of the plurality of TOSA modules include a submount and a laser diode driver (LDD) coupled to the submount.

16. The optical transceiver of claim 15, wherein each LDD of the plurality of TOSA modules is disposed proximate the at least one component mounting surface, and wherein an invisible line drawn at the at least one component mounting surface, and parallel thereto, intersects with each LDD and/or submount of the plurality of TOSA modules.

SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to co-pending Application Ser. No. 16/737,414 (Atty. Docket No. PAT275US) entitled “Monitor Photodiode (MPD) Submount for Vertical Mounting and Alignment of Monitoring Photodiodes” filed concurrently herewith on January 8, 2020, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to optical communication devices, and more particularly, to a substrate with a stepped profile for simplifying mounting and alignment of transmitter optical subassemblies (TOSA) modules, e.g., via edge mounting, and to reduce the vertical offset between TOSA modules and radio frequency (RF) terminals of the substrate to allow for relatively short electrical interconnect lengths, e.g., via wire bonds.

BACKGROUND

[0003] Optical transceivers are used to transmit and receive optical signals for various application including, without limitation, internet data center, 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 has presented challenges, for example, with respect to space management and manufacturing yield.

[0004] Optical transceiver modules generally include one or more transmitter optical subassemblies (TOSAs) for transmitting optical signals and one or more receiver optical subassemblies (ROSAs) for receiving optical signals. In general, TOSAs include one or more lasers to emit one or more channel wavelengths and associated circuitry for driving the lasers and

monitoring power to ensure nominal performance. However, continued scaling and the standardization of transmission speeds of up to and exceeding 400 Gbp/s presents numerous technical challenges that complicates mounting and electrical interconnection between TOSA modules and a supporting substrate, e.g., a printed circuit board (PCB).

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0006] FIG. 1 shows a block diagram of an example multi-channel optical transceiver module in accordance with an embodiment of the present disclosure.

[0007] FIG. 2 is a perspective view of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1, in accordance with an embodiment of the present disclosure.

[0008] FIG. 3 shows an enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0009] FIG. 4 shows a top view of the enlarged portion shown in FIG. 3, in accordance with an embodiment of the present disclosure.

[0010] FIG. 5 shows another enlarged region of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment of the present disclosure.

[0011] FIG. 6A shows a front view of a monitor photodiode submount suitable for use in the multi-channel optical transceiver module of FIG. 2, in accordance with an embodiment.

[0012] FIG. 6B shows a perspective view of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0013] FIG. 6C shows another perspective view of a rear side of the monitor photodiode submount of FIG. 6A in accordance with an embodiment.

[0014] FIG. 7A shows a cross-sectional view of the multi-channel optical transceiver module of FIG. 2 in accordance with an embodiment.

[0015] FIG. 7B shows an enlarged portion of a multi-channel optical transceiver module consistent with an embodiment of the present disclosure.

[0016] FIG. 8 shows an example approach to mounting and electrical coupling of transmitter optical subassemblies (TOSA) modules on a transceiver substrate.

DETAILED DESCRIPTION

[0017] As discussed above, scaling and increased transmission speeds raise numerous challenges in optical subassembly design. One such challenge includes reducing the impact of electrical interconnection devices, e.g., wire bonds, on high frequency signals such as radio frequency (RF) signals that drive TOSA modules.

[0018] These challenges are better understood by way of illustration. FIG. 8 shows a portion of a transceiver substrate 804, e.g., a printed circuit board, that edge-mounts to a plurality of TOSA modules, e.g., TOSA module 802. In this example, the TOSA modules 802 can be at least partially formed/configured separate from the transceiver substrate 804 and then subsequently coupled “on board” the transceiver substrate 804. Such “on board” mounting of optical subassemblies can significantly simplify manufacturing and design of transceivers and other devices that transmit and/or receive optical signals.

[0019] As further shown in FIG. 8, this on-board mounting can include the laser diode driver (LDD) of each TOSA module electrically coupling with adjacent RF terminals, e.g., RF terminals 806, to receive RF driving signals to modulate an associated laser by way of wire bonds 808. However, electrical interconnects such as wire bonds 808 can introduce time of flight (ToF) issues for RF signals, as well as impedance matching issues which can significantly degrade signaling performance. Wire bonds also tend to be fragile and can easily break by inadvertent contact.

[0020] In the context of wire bonding specifically, one approach to mitigate the impact of such issues on signaling performance includes having wire bonds with relatively short overall lengths. While this solution seems relatively simple, space constraints and other factors such as component layout can complicate or otherwise prevent shortening wire bond lengths. For instance, in the context of FIG. 8, the TOSA 802 includes a submount that vertically displaces the LDD, and importantly, the electrodes of the LDD that receive RF signaling. This vertical displacement results in wire bonds 808 extending at substantially 90 degrees from the RF terminals and having an overall length of about 800-900 microns to reach corresponding LDD terminals. Such overall

wire bond lengths significantly impact signal quality, particularly high frequency RF signals, and ultimately can limit the maximum achievable transmission speeds of the TOSA module.

[0021] Continued development to achieve ever-higher optical transmission speeds, e.g., up to and beyond 400 Gbp/s, depends at least in part on optical subassembly module designs that significantly reduce the length of electrical interconnections between associated components without increasing design and manufacturing complexity. Moreover, continued development and rapid adoption of such high-speed transmission systems further depends at least in part on optical subassembly module designs that both shorten electrical interconnect lengths and allow for continued scaling without substantial redesign of existing components, such as PCBs and TOSA modules.

[0022] Thus, in accordance with an embodiment, a stepped profile for substrates that support “on board” optical subassembly arrangements is disclosed that allows for mounting of TOSA modules to the substrate in a recessed orientation to reduce the overall distance between terminals of the substrate and associated components of the TOSA, e.g., RF terminals of the substrate and an LDD of the TOSA. In an embodiment, the substrate comprises a printed circuit board PCB or PCB assembly (PCBA) that includes an electrical coupling end to electrically couple with external circuitry and an optical coupling end to couple to one or more TOSA modules. The substrate provides at least a first component mounting surface for coupling to circuitry to provide power and driving signals to the one or more TOSA modules. The substrate further defines a recessed TOSA mounting surface at the optical coupling end. The TOSA mounting surface extends substantially parallel with the first component mounting surface, and is offset from the same by a first predetermined offset distance. Thus, TOSA modules mount to the substrate via the recessed TOSA mounting surface, and components such as LDDs that would otherwise have a vertical offset relative to the supporting traces of the substrate (e.g., as shown in FIG. 8) get displaced towards the same based on the first predetermined offset distance. The TOSA module components may therefore get “countersunk” via the recessed TOSA mounting surface to allow for relatively shorter electrical interconnection with the substrate.

[0023] Substrates having stepped profiles consistent with the present disclosure advantageously utilize the recessed TOSA mounting surface to allow for mounting of TOSA modules in a manner that maintains the advantages and simplicity of “on board” TOSA arrangements while also significantly reducing the overall length of electrical interconnections to

provide RF and/or power signals to the same. In an embodiment, the stepped profile reduces electrical interconnection lengths by up to and exceeding 50% relative to approaches that do not feature substrates with stepped profiles (e.g., compare FIG. 8 with FIG. 7B), and as a result, the stepped profile significantly reduces the introduction of signal degradation when utilizing relatively longer electrical interconnections.

[0024] 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 dense wavelength division multiplexing (DWDM) grid. This disclosure is equally applicable to coarse wavelength division multiplexing (CWDM). In one specific example embodiment, the channel wavelengths are implemented in accordance with local area network (LAN) wavelength division multiplexing (WDM), which may also be referred to as LWDM. 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.

[0025] The term substantially, as generally referred to herein, refers to a degree of precision within acceptable tolerance that accounts for and reflects minor real-world variation due to material composition, material defects, and/or limitations/peculiarities in manufacturing processes. Such variation may therefore be said to achieve largely, but not necessarily wholly, the stated characteristic. To provide one non-limiting numerical example to quantify “substantially,” minor variation may cause a deviation of up to and including $\pm 5\%$ from a particular stated quality/characteristic unless otherwise provided by the present disclosure.

[0026] Referring to the Figures, FIG. 1 illustrates an optical transceiver module 100, consistent with embodiments of the present disclosure. The optical transceiver module 100 is shown in a highly simplified form for clarity and ease of explanation and not for purposes of limitation. In this embodiment, the optical transceiver module 100 can be pluggable (e.g., conforms with pluggable small form factor (SFFP) standards) and transmits and receives four (4) channels using four different channel wavelengths ($\lambda_1, \lambda_2, \lambda_3, \lambda_4$) and may be capable of transmission rates of at least about 25 Gbps per channel. In one example, the channel wavelengths $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ may be within a ± 13 nm range and have respective channel wavelengths of 1270 nm, 1290 nm, 1310 nm,

and 1330 nm, respectively. Other channel wavelengths and configurations are within the scope of this disclosure including those associated with local area network (LAN) wavelength division multiplexing (WDM). For instance, the optical transceiver module 100 can include up to eight (8) or more channels and provide transmission rates of at least 25 Gbps per channel.

[0001] The optical transceiver module 100 may also be capable of transmission distances of 2 km to at least about 10 km. The optical transceiver module 100 may be used, for example, in internet data center applications or fiber to the home (FTTH) applications.

[0002] In an embodiment, the optical transceiver module 100 is disposed in a transceiver housing 103. The transceiver housing 103 can be configured with one or more cavities to receive one or more optical transceiver modules, depending on a desired configuration.

[0003] The optical transceiver module 100 may include a number of components to support transceiver operations. The optical transceiver module 100 may include an optical transceiver substrate 102, a plurality of transmitter optical subassemblies (TOSA) modules 104 for transmitting optical signals having different channel wavelengths, transmit connecting circuit 106, a multi-channel receiver optical subassembly (ROSA) arrangement 108 for receiving optical signals on different channel wavelengths, an optical fiber receptacle 110 to receive and align a fiber connector (e.g., a ferrule) with the ROSA, and a receiver connecting circuit 112.

[0004] The optical transceiver substrate 102 includes traces, connector pads, and other circuitry to support transceiver operations. The optical transceiver substrate 102 may include TOSA connector pads 114 (or terminals 114) that enable each of the TOSA modules 104 to mount and electrically couple to the optical transceiver substrate 102. The TOSA connector pads 114 may also be referred to herein as a simply connector pads. The optical transceiver substrate 102 may include traces 116 that couple the TOSA connector pads 114 to the transmit connecting circuit 106. As discussed in greater detail below, monitor photodiode (PD) submounts/modules may be disposed on (e.g., directly) the traces 116 and/or the TOSA connector pads 114.

[0005] The optical transceiver substrate 102 may include traces 118 that electrically couple the ROSA arrangement 108 to the receiver connecting circuit 112. The optical transceiver substrate 102 may provide an optical transceiver module that may be “plugged” into an optical transceiver cage. Therefore, the transmit connecting circuit 106 and the receiver connecting circuit 112 may electrically couple to external circuitry of the optical transceiver cage. The optical

transceiver substrate 102 may be manufactured from a multi-layer printed circuitry board (PCB), although other types of substrates may be utilized and are within the scope of this disclosure.

[0006] Each of the TOSA modules 104 may be configured to receive driving electrical signals (TX_D1 to TX_D4), convert the electrical signals to a multiplexed optical signal (e.g., a signal with channel wavelengths $\lambda_1.. \lambda_n$) and output the same to a multiplexer (not shown). Each of the TOSA modules 104 may be electrically coupled to the TOSA connector pads 114 and to the traces 116 through TOSA module connector pads 120. Each of the TOSA modules 104 may include a laser diode device and supporting circuitry. The laser diode devices of the TOSA modules 104 may include distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. In an embodiment, monitor photodiodes 131 may be used to monitor the lasers' output power, as discussed below.

[0007] Referring to FIG. 2, an example embodiment of a multi-channel optical transceiver module for use in the multi-channel optical transceiver of FIG. 1 is shown. As shown, the multi-channel optical transceiver module 200 includes an optical transceiver substrate 202 coupled to a TOSA arrangement 206. The optical transceiver substrate 202 may also be referred to herein as a substrate. The optical transceiver substrate 202 may be manufactured from a multi-layer printed circuitry board, although other types of substrates may be utilized and are within the scope of this disclosure.

[0008] The optical transceiver substrate 202 includes a first end 203 that extends to a second end 207 along a longitudinal axis 250. The first end 203 couples to one or more TOSA modules, such as shown, for launching channel wavelengths onto transmit waveguides, e.g., optical fibers 209. The second end 207 includes terminals/pads for electrical coupling with external circuitry to receive power and data signals. Accordingly, the first end 203 may also be referred to herein as an optical coupling end, and the second end 207 may be referred to as an electrical coupling end.

[0009] The transceiver substrate 202 further includes at least a first mounting surface 245 disposed opposite a second mounting surface 246 for supporting passive and/or active optical components. The first and second mounting surfaces 245, 246 may also be referred to as first and second component mounting surfaces. Although not shown in the embodiment of FIG. 2, the optical transceiver substrate 202 can include a multi-channel ROSA arrangement mounted to and supported by the first and/or second mounting surfaces 245, 246.

[0010] Continuing on, the TOSA arrangement 206 includes a plurality of TOSA modules 205-1 to 205-4. Each TOSA module of the plurality of TOSA modules 205-1 to 205-4 includes a base/body portion, and in the particular embodiment illustrated in FIG. 2, cuboid-type base portions. The plurality of TOSA modules 205-1 to 205-4 each support and align an associated laser arrangement with optical coupling ports 204-1 to 204-4, respectively. Thus, channel wavelengths generated by the laser arrangements get launched on to associated optical fibers 209 by way of optical coupling receptacles 204-1 to 204-5. Each laser arrangement may be configured to emit a different channel wavelength and can be monitored by an associated MPD module of an array of MPD modules to ensure nominal optical power, as will be discussed in greater detail below.

[0011] Continuing on, each of the plurality of TOSA modules 205-1 to 205-4 mount, e.g., edge mount, to the first end 203 of the substrate. The transceiver substrate 202 further includes a stepped profile, with the stepped profile being at least partially defined by a step/shoulder 211 proximate the first end 203. Additional aspects of the stepped profile are discussed below with reference to FIGs. 7A-7B. Each of the TOSA modules 205-1 to 205-4 can include a base with a plurality of sidewalls that define a generally L-shaped profile that corresponds with the step 211. The profile of the base may therefore advantageously align along at least two axis, e.g., the X and Z axis, by simply engaging/bottoming out against surfaces of the step 211, e.g., vertical surface 704 shown and discussed below with reference to FIG. 7A, that operate as an alignment guide by providing mechanical stops/limits to limit travel along at least one axis. Alignment along the remaining axis, e.g., the Y axis, may therefore be performed by relatively simply lateral movement (e.g., along the X axis) of each TOSA module 205-1 to 205-4.

[0012] Once aligned, each of the plurality of TOSA modules electrically couple to the transceiver substrate 202, and more particularly TOSA module connector pads disposed proximate the first end 203 of the transceiver substrate 202, which is shown more clearly in FIGs. 3 and 4. The TOSA module connector pads allow each of the TOSA modules 204-1 to 204-5 to receive driving signals and power from transmit connecting circuitry, e.g., via traces 116 and TX connecting circuit 106 (See FIG. 1).

[0013] Referring to FIGs. 3-4, an enlarged region of the multi-channel optical transceiver module of FIG. 2 is shown in accordance with embodiments of the present disclosure. As shown, each TOSA module of the TOSA arrangement 206 includes a laser arrangement having, for

example, a filtering capacitor 401, laser diode (LD) 402, and focusing lens 403. One such laser arrangement 712 is shown in further detail in FIGs. 7A. The components of the TOSA arrangement 206, such as LD 402, can directly mount to the body of the associated TOSA module, or indirectly via an LD submount 404, such as shown. The LD submount 404 can support components of each laser arrangement and provide electrical traces and other circuitry to support TOSA operations. Note the LD submount 404 may also couple directly to the body of the TOSA module, or indirectly by way of one or more baseplates, such as base plate 709 shown more clearly in FIG. 7A.

[0014] The LD 402 can be implemented as a distributed feedback lasers (DFBs), Vertical External-cavity Surface-emitting lasers (VECSEL) or other suitable laser devices. Preferably, the LD 402 is implemented as an electro-absorption modulator laser (EML). In an embodiment, the LD 402 can be uncooled (e.g., operate without an associated thermoelectric cooler). Instead, the LD 402 is in thermal communication with the body of the TOSA module to dissipate heat. In addition, the body of the TOSA module may also be in thermal communication with the transceiver substrate 202 via the step 211 to further increase heat dissipation. Accordingly, in an embodiment each TOSA module can provide a thermal communication path 311 that extends between each LD and the transceiver substrate 202 by way of an associated LD submount, TOSA body, and the step 211 of the transceiver substrate 202.

[0015] Continuing with reference to FIGs. 3-5, the components of each laser arrangement may be disposed coaxially, or substantially coaxially and be aligned with a longitudinal center line of a corresponding optical coupling receptacle (See FIG. 2). Each TOSA module of the TOSA arrangement 206 may therefore also be referred to as cuboid-type coaxial TOSA assemblies, or simply coaxial TOSA assemblies. Notably, cuboid-type TOSA bases allow for each laser assembly to be mounted in close proximity with adjacent cuboid-type TOSAs, e.g., directly contacting each other in a side-by-side relationship. Alternatively, spacing between the cuboid-type TOSA bases can provide for thermal isolation between adjacent TOSA modules (e.g., based on an air gap) while ensuring a relatively small overall footprint for the TOSA arrangement 206.

[0016] In operation, each TOSA module 205-1 to 205-4 of the TOSA arrangement 206 can emit associated channel wavelengths and launch the same along optical fibers 209, for example. Associated MPDs monitor and ensure nominal power for each of the TOSA modules 205-1, 205-4. As discussed above, each of the TOSA modules includes at least a LD, e.g., LD 402, and at

least one corresponding monitor photodiode (MPD), e.g., provided by MPD module 252, to monitor the optical output power. As shown in FIG. 3, for example, the MPD module 252 optically aligns with a back surface of the LD 402 to receive and measure a small percentage of light emitted therefrom, e.g., 1-3%. Laser threshold current and slope efficiency are both functions of temperature and aging time. To maintain nominal optical output power, the electrical bias current and modulation current applied to the laser may be varied to compensate the change brought about by the variations in temperature and/or aging time. The optical transceiver module 200 can vary the current applied to the LD 402 based on the measured light to, for instance, maintain a stable output power based on an average output current of the MPD module 252.

[0017] Referring to FIGs. 6A-6C, an example monitor photodiode submount 610 suitable for use with the MPD module 252 is shown in accordance with an embodiment. The monitor photodiode (MPD) submount 610 is configured to couple to and align a MPD 251 with an associated laser diode, as discussed above. The MPD submount 610 comprises a base 617 having a plurality of sidewalls to provide at least one mounting surface for supporting an MPD and supporting circuitry and at least one mating surface for coupling to an associated transceiver substrate. The base 617 can comprise, for instance, Silicon (Si), or any other non-conductive suitably rigid material. The base 617 may be formed monolithically from a single piece of material or from multiple pieces. While the following discussion includes reference to disposing/patterning metallic material on to a non-conductive base, e.g., formed from Si to provide electrically conductive paths, the base 617 may be at least partially formed from a conductive material such as a metal to provide integrated traces. In this instance, multiple independent electrical traces/paths may be provided by disposing an electrical insulating layer therebetween.

[0018] Continuing on, at least one sidewall defining the base 617 of the submount 610 provides a mounting surface 609 for coupling to and supporting MPD 251, such as shown. At least one sidewall defining the base 617 of the submount 610 further provides mating surface 614 for mounting to and being supported by TOSA connecting pads, as will be discussed in greater detail below. As shown, the mounting surface 609 extends substantially transverse relative to the mating surface 614 to provide a vertical mounting orientation for the MPD 251.

[0019] The base 617 further provides at least first and second electrically conductive paths 611, 613 disposed along multiple sidewalls of the base 617 using a plurality of conductive traces disposed/patterned thereon. In particular, the first electrically conductive path 611 is collectively

provided by at least first and second conductive traces 612-1, 612-2 (or conductive segments) disposed on the base 617. Likewise, the second electrically conductive path 613 is collectively provided by at least third and fourth conductive traces 612-3 and 612-4 (or conductive segments) disposed on the base 617. Patterning of the conductive traces 612-1 to 612-4 can comprise deposition of one or more layers of metallic material such as copper, silver, or other suitable material on to sidewalls of the base 617.

[0020] At least a portion of the first conductive trace 612-1 defines the mounting surface 609 for both physically and electrically coupling to the MPD 251. Further, the first conductive trace 612-1 includes a region with a relatively rectangular profile having a width that is about 1.2x to 1.3x the width of the MPD 251. This rectangular profile may be dimensioned such that corner(s) of the same get disposed at substantially a center of the mounting surface 609. Alignment of the MPD 251 relative to the base 617, and more importantly relative to an associated laser diode, may therefore be initially accomplished along the X, Y and Z axis by ensuring that the edges 619-1 and 619-2 of MPD 251 mount substantially flush with a far edge of rectangular pad provided by the first conductive trace 612-1. Stated differently, alignment of MPD 251 can include mounting the same at a predetermined position on the first conductive trace 612-1 such that edges 619-1 and 612-2 extend parallel with the edges defining the rectangular pad and include a relatively uniform gap therebetween measuring about 0 to 100 microns. The first conductive trace 612-1 may therefore provide a visual alignment indicator, e.g., in the form of a rectangular pad or other regular or non-regular geometric shape, to provide a visual representation of a predefined mounting location for the MPD to simplify mounting and alignment of the same.

[0021] The above-discussed mounting and alignment of MPD 251 on to the MPD submount 610 can occur prior to attachment to the transceiver substrate 202 (FIG. 2). The MPD submount 610 may therefore get mounted to the transceiver substrate 202 with the MPD 251 being aligned along at least the X and Z axis with the associated laser diode. Alignment along the Y axis can include simply shifting the MPD submount 610 laterally until nominal optical coupling with an associated laser diode gets achieved.

[0022] Continuing on, the first conductive trace 612-1 extends towards the transceiver substrate 202 when the MPD submount is coupled thereto. The first conductive trace 612-1 also extends substantially transverse relative to the first mounting surface 245 of substrate 202 when coupled thereto (See FIG. 3). The first conductive trace 612-1 then transitions to the second

conductive trace 612-2 based on an edge/intersection between associated sidewalls of the base 617. The second conductive trace 612-2 extends substantially transverse relative to the mounting surface 609, and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202 when coupled thereto (See e.g., FIGs. 3-5).

[0023] As further shown, third and fourth conductive traces 612-3 and 612-4 are disposed on the base 617 to collectively define a second electrically conductive path to electrically couple the MPD 251 to the transceiver substrate 202. The third conductive trace 612-3 is disposed on the mounting surface 609 and is configured to electrically couple to the MPD 251 via, for instance, wire bonding such as shown. The third conductive trace 612-3 extends towards the transceiver substrate 202 when the MPD submount 610 is coupled thereto. The third conductive trace 612-3 transitions to the fourth conductive trace 612-4 at an edge/intersection between sidewalls of the base 617. The fourth conductive trace 612-4 extends substantially transverse relative to the mounting surface 609 and substantially parallel relative to the first mounting surface 245 of the transceiver substrate 202.

[0024] The first and second conductive paths 611, 613 therefore include at least one region/segment that extend substantially in parallel, and proximate, to an interface formed between the mating surface 614 and the first mounting surface 245 of the transceiver substrate 202 when the MPD submount 610 is coupled thereto. As discussed in greater detail below, the first and second conductive paths 611, 613 can be electrically coupled to the transceiver substrate 202 utilizing a conductive epoxy or other conductive material that can be disposed around MPD submount 610.

[0025] The MPD 251 can comprise a surface MPD having a detecting surface/region 603 having a receiving area 602 that is configured to be optically coupled with an associated laser diode by being aligned along the X, Y and Z axis. In particular, alignment includes the receiving area being disposed at a position that intersects with an optical path extending from a back surface of the associated laser diode towards the MPD. An anode 604 is disposed on the detecting surface 603. A cathode (not shown) of the MPD 251 is provided on a surface opposite the detecting surface 603. The MPD 251 mounts (e.g., directly) on the first conductive trace 612-1, with the associated cathode electrically connected to the first conductive path 611. The anode 604 electrically couples to the second conductive path 613 by wire bonding, for instance.

[0026] As shown in FIGs. 6A-6C, the body 617 of the MPD submount 610 can include channels/notches 631-1, 631-2. The channels 631-1, 631-2 extend substantially transverse relative to mounting surface 609 and include a curved/arcuate profile (such as shown). Other shapes and configurations for the channels 631-1, 631-2 are within the scope of this disclosure. As further shown, the second conductive trace 612-2 and the fourth conductive trace 612-4 are at least partially disposed on the channels 631-1, 631-2. The channels 631-1, 631-2 can advantageously facilitate flow and adhesion of a layer of epoxy 509 (FIG. 5) to securely attach the MPD submount 610 to an associated transceiver substrate, e.g., transceiver substrate 202. In addition, the channels 631-1, 631-2 reduce the overall footprint of the mating surface 614 by providing a taper, and by extension, reducing the overall footprint of the MPD submount 610 when coupled to the transceiver substrate 202 (See FIG. 5). The channels 631-1, 631-2, may thus define a tapered region that at least partially defines the mating surface 614.

[0027] When the MPD submount 610 mounts to the transceiver substrate 202 via mating surface 614, conductive epoxy 509 can flow into the channels 631-1, 631-2 to securely attached the MPD submount 610 at a predetermined position, as discussed further below. The rounded profile/shape of the channels 631-1, 631-2 can encourage increased adhesion and allow for a relatively larger amount of conductive epoxy to be utilized and substantially confined without the same inadvertently contacting adjacent conductive pads/traces. Note that while the embodiment of FIGs. 6A-6C show two channels 631-1, 631-2, this disclosure is not limited in this regard. An MPD submount consistent with the present disclosure can have a single channel, or a plurality of channels (as shown), or no channels depending on a desired configuration.

[0028] As shown in FIG. 6C, the first and second conductive paths 611, 613 can also include fifth and sixth conductive traces 612-5, 612-6, respectively. The fifth and sixth conductive traces 612-5, 612-6 can be disposed on back surface 616, with back surface 616 being disposed opposite the mounting surface 609. In this embodiment, the fifth and sixth conductive traces 612-5, 612-6 can further increase electrical conductivity via the conductive epoxy and can balance bonding stresses applied to the MPD submount 610.

[0029] Referring back to FIGs. 3-5, with additional reference to FIGs. 6A-6C, the MPD submount 610 is shown implemented as MPD module 252. These MPD module 252 is configured to be disposed on the TOSA connector pads 423, 424, and when coupled thereto, an interface 504 gets formed between the MPD module 252 and the surfaces defining the transceiver substrate 202

(See FIG. 5). A layer of conductive epoxy 509, e.g., silver epoxy, may be disposed along the interface 504 between MPD module 252 and surfaces defining the transceiver substrate 202, and in particular, the connector pads 423, 424.

[0030] Therefore, the first and the second conductive paths 611, 613 (FIG. 6A) electrically couple to a pad/trace of the transceiver substrate based at least in part on the layer of conductive epoxy 509. Minor adjustment to MPD orientation along the Y axis, e.g., relative to an associated laser diode, can be achieved while the layer of conductive epoxy 509 cures, thus allowing for greater tolerances and multiple manufacturing phases to occur at potentially the same time. To avoid or otherwise reduce reflection losses, the receiving area 602 may be disposed at an angle with respect to the light path of the laser diode. The angle may be, for example, 0-15°, and preferably about 8° relative to normal.

Stepped Profile Architecture

[0031] Turning to FIGs. 7A an enlarged cross-sectional view of the substrate 202 is shown in accordance with an embodiment. Note, the embodiment of FIG. 7A shows a laser arrangement having a vertically-mounted monitored photodiode, as discussed above. However, the stepped profile is equally applicable to other TOSA configurations including designs where an MPD is mounted to the TOSA body (e.g., See FIG. 7B).

[0032] As shown in FIG. 7A, the first component mounting surface 245 defines at least a portion of a first mounting region to allow for mounting of components and to provide traces for electrical interconnection with external circuitry. The first mounting region can therefore extend from the electrical coupling end 207 to a second mounting region disposed at the optical coupling end 203.

[0033] The second mounting region is defined at least in part by the step 211. The step 211 defines at least a portion of the stepped profile which can simplify alignment and coupling processes for TOSA modules, as discussed above. The stepped profile, and in particular, step 211 is defined at least in part by a recessed TOSA mounting surface 702, which may be referred to herein as simply a recessed mounting surface. The recessed mounting surface 702 is offset/recessed from the first component mounting surface 245 by a first offset distance (OD1). The offset distance OD1 measures between 10 and 50 microns, and preferably, 10-20 microns

[0034] The stepped profile may therefore be provided by the recessed TOSA mounting surface 702 extending substantially parallel with the first component mounting surface 245 and

substantially transverse relative to vertical surface 704, with the vertical surface 704 adjoining the recessed mounting surface 702 and the first component mounting surface 245. The overall height of vertical surface 704 can be predetermined to establish the first offset distance OD1. As shown in FIGs. 2 and 7A, the first mounting region is shown as the portion of the substrate 202 having a first overall width W1. The first mounting region preferably includes a uniform width, or may vary along the longitudinal axis 250 (See FIG. 2) up to a maximum width equal to W1. On the other hand, the second mounting region is shown as the portion of the substrate 202 having a second overall width W2, with the second overall width W2 being less than the first overall width. The second mounting region also includes, preferably, a uniform width although this disclosure is not limited in this regard and the second overall width W2 can vary along the longitudinal axis up to a maximum width equal to W2.

[0035] As further shown in FIG. 7A, the first TOSA module 205-1 includes a body 706 (or base) configured to securely mount, e.g., edge mount, to the second mounting region of the substrate 202. The body 706 includes a plurality of sidewalls that provide a substrate mating surface 708-1 and a component mounting surface 708-2. The substrate mating surface 708-1 is disposed opposite the component mounting surface 708-2, and in the embodiment shown in FIGs. 7A-7B, the component mounting surface is accessible via an opening 710 defined by sidewalls of the body 706 that extend substantially transverse from the component mounting surface 708-2.

[0036] Thus, the recessed TOSA mounting surface 702 underlies and supports at least a portion of the substrate mating surface 708-1, and thus by extension, the body 706 of the at least one TOSA module 205-1. In an embodiment, epoxy or other adhesive material may be disposed between the recessed TOSA mounting surface 702 and the substrate mating surface 708-1 to securely attach the body 706 to the substrate 202, although other attachment methods are within the scope of this disclosure such as welding. In this embodiment, the stepped profile operates, in a general sense, as a dam to prevent epoxy from contacting other surfaces such as the substrate mating surface 708-1. Accordingly, the stepped profile also aids in containing and confining epoxy during manufacturing, which can reduce component failure and the time required for post-processing stages to remove excess epoxy.

[0037] The recessed TOSA mounting surface 702 can include one or more layers of metallic material disposed thereon (See FIG. 7B), e.g., such as Gold (Au) or Copper (Cu), to increase

thermal communication between the TOSA module 205-1 and the substrate 202 and/or to allow for attachment via welding/soldering.

[0038] Turning to FIG. 7B, with additional reference to FIG. 7A, the body 706 includes at least one laser arrangement 712 mounted to the component mounting surface 708-2 of the body 706. As shown, the laser arrangement 712 includes a laser diode driver 714, a laser diode 716, a monitor photodiode 718 and a focus lens 720. The laser arrangement 712 may include more or fewer active and/or passive optical components depending on a desired configuration, and the embodiment shown in FIG. 7B is not intended to be limiting.

[0039] As further shown, the at least one laser arrangement 712 mounts to the body 706, and more particularly, the component mounting surface 708-2 by way of a submount 722 and optional base plate 709. The submount 722 can provide traces/terminals for electrical connectivity with components of the at least one laser arrangement 712. The overall height H1 of the submount 722 (e.g., including the base plate 709) may therefore measure substantially equal to or greater than the first offset distance OD1. Accordingly, an invisible line drawn at the first component mounting surface 245, and parallel thereto, can intersect with the submount 722 and/or at least one component of the at least one laser arrangement 712 such as the LDD 714 and LD 716.

[0040] Stated differently, the submount 722 vertically displaces the components of the at least one laser arrangement 712 relative to the component mounting surface 708-2 of the body 706, e.g., by overall height H1, but the vertical displacement gets 'offset' based on stepped profile of the substrate 202, and more particularly, the first offset distance (OD1) of the recessed TOSA mounting surface 702 relative to the first component mounting surface 245 of the substrate 202. Stated simply, the recessed TOSA mounting surface 702 gets countersunk relative to the first component mounting surface 245. The overall height H2 between the first component mounting surface 245 and a top surface of the submount 722 that supports the optical components of the at least one laser arrangement 712 is less than 400 microns, and preferably, less than 200 microns.

[0041] Accordingly, relatively short electrical interconnects, e.g., wire bonds 724, electrically couple the LDD 714 to RF terminals/traces 726 disposed on the first component mounting surface 245. In the shown embodiment, the overall length of each of the wire bonds 724 measures between 400 and 500 microns, and preferably, less than 400 microns. In addition, each of the wire bonds 724 extend at an angle θ relative to the first component surface 245, with angle θ being less than or equal to 45 degrees.

[0042] Substrates having stepped profiles consistent with the present disclosure advantageously position components such as LDDs in close proximity with supporting terminals of the substrate 202. By way of contrast, consider the embodiment of FIG. 8 which shows a substrate and TOSA modules with a substantially similar size and dimension to that of the embodiments shown in FIGs. 7A-7B. However, the stepped profile of the substrate 202 shown in FIGs. 7A and 7B allows for wire bonds 724 to be shortened/reduced in length by up to and exceeding 50% relative to wire bonds 808 of FIG. 8. Moreover, the wire bonds 724 extend at a relatively acute angle θ to provide a low-profile implementation. On the other hand, the wire bonds 808 shown in FIG. 8 extend from substrate 804 at roughly a 90 degree angle, which increases the risk of inadvertent contact and damage. In any event, this reduction in wire bond length translates directly to improved signal quality, and in addition, enables maximum transmission speeds otherwise unachievable with longer electrical interconnections.

[0043] In accordance with an aspect of the present disclosure an optical subassembly module is disclosed. The optical subassembly module comprising a substrate having an electrical coupling end for electrically coupling to external circuitry and an optical coupling end for launching at least one channel wavelength on a waveguide, the electrical coupling end disposed opposite the optical coupling end, a first mounting region at the electrical coupling end of the substrate to provide traces for electrical interconnection with the external circuitry, the first mounting region defined at least in part by a component mounting surface provided by a sidewall of the substrate, a second mounting region at the optical coupling end of the substrate to couple to and support at least one transmitter optical subassembly (TOSA) module via a recessed TOSA mounting surface, the recessed TOSA mounting surface being disposed offset from the component mounting surface by first offset distance (OD1) based on a stepped profile, the stepped profile defined at least in part by the recessed TOSA mounting surface extending substantially parallel with the component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the component mounting surface.

[0044] In accordance with another aspect of the present disclosure an optical transceiver is disclosed. The optical transceiver comprising a transceiver substrate having an optical coupling end disposed opposite an electrical coupling end, at least one component mounting surface provided by the transceiver substrate extending between the optical coupling end and the electrical coupling end, and a recessed transmitter optical subassembly (TOSA) mounting surface at the

optical coupling end of the substrate for coupling to and supporting at least one TOSA module, and wherein the recessed TOSA mounting surface extends substantially parallel with the at least one component mounting surface and substantially transverse relative to a vertical surface adjoining the recessed TOSA mounting surface and the at least one component mounting surface, at least one TOSA module coupled to optical coupling end of the transceiver substrate, and a receiver optical subassembly arrangement coupled to the transceiver substrate.

[0045] 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.

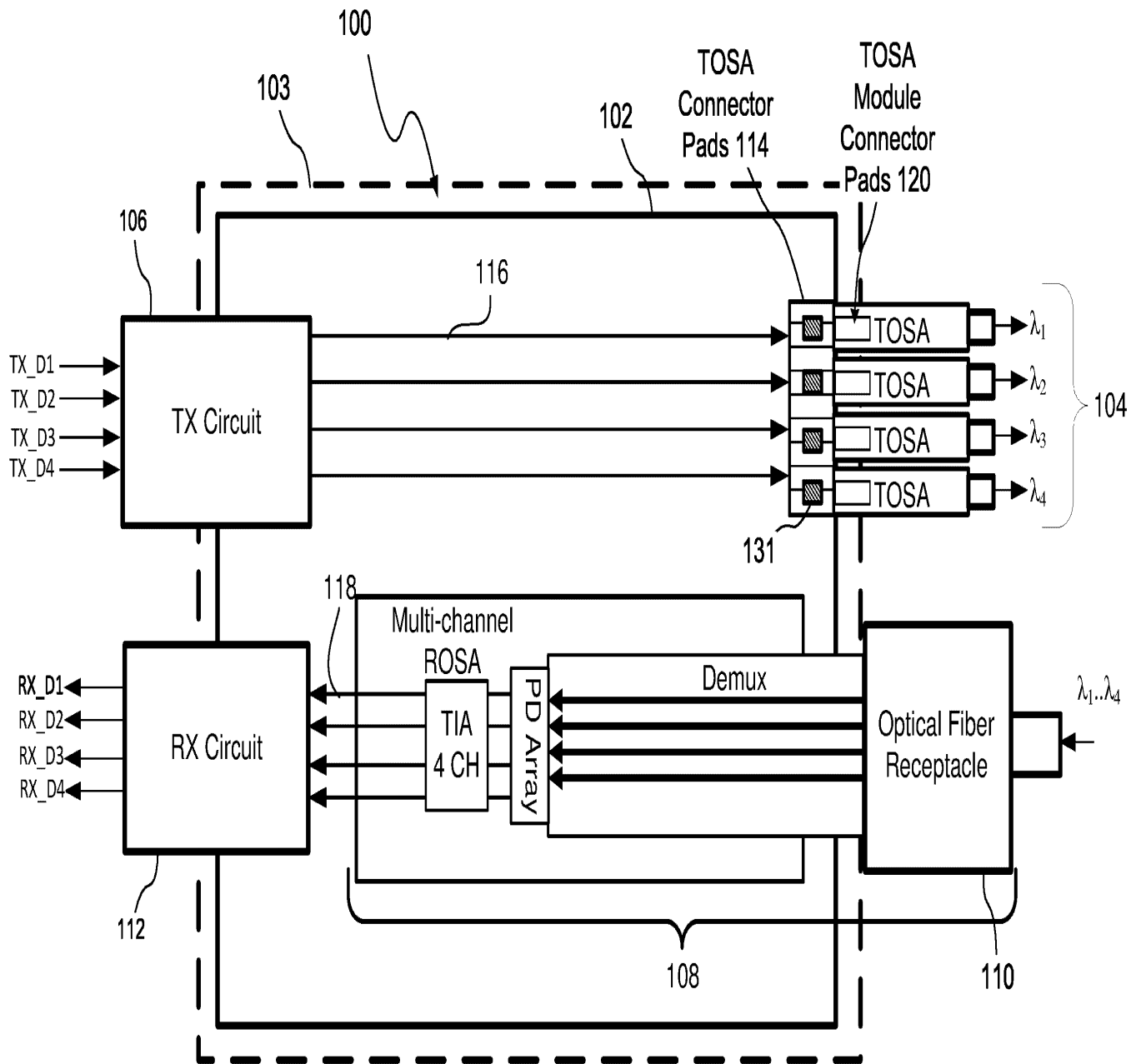
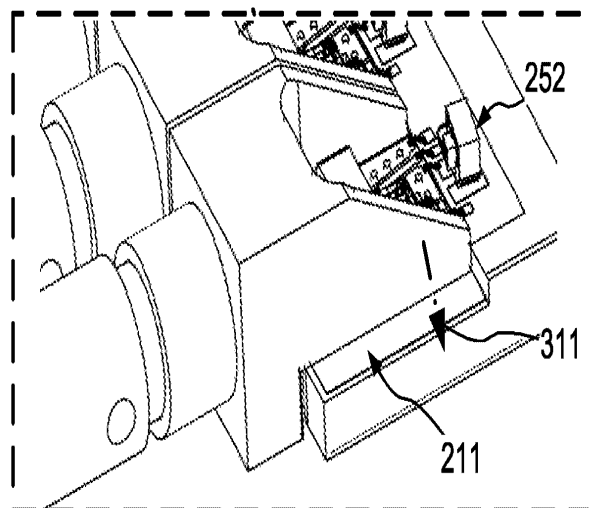
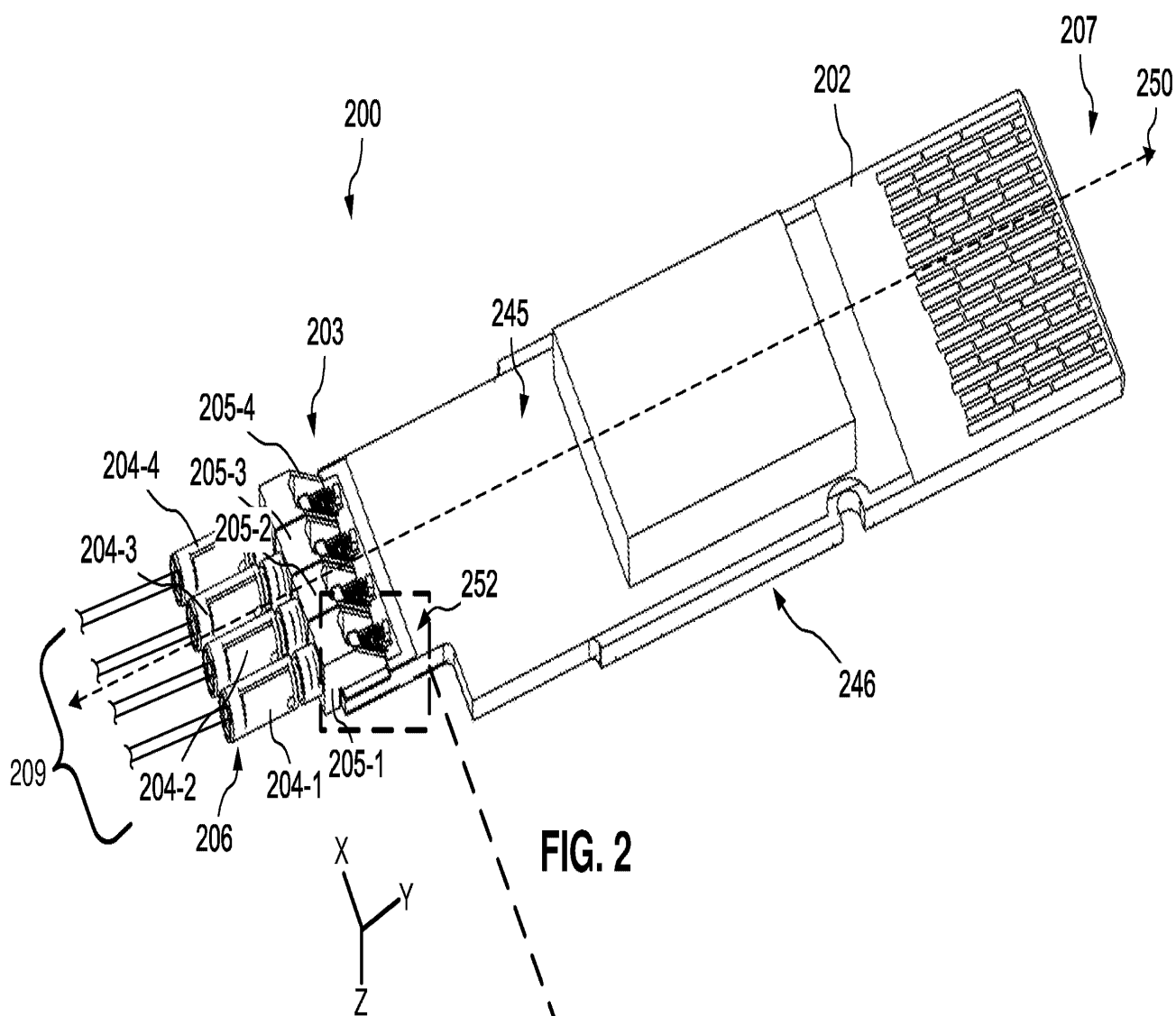


FIG. 1



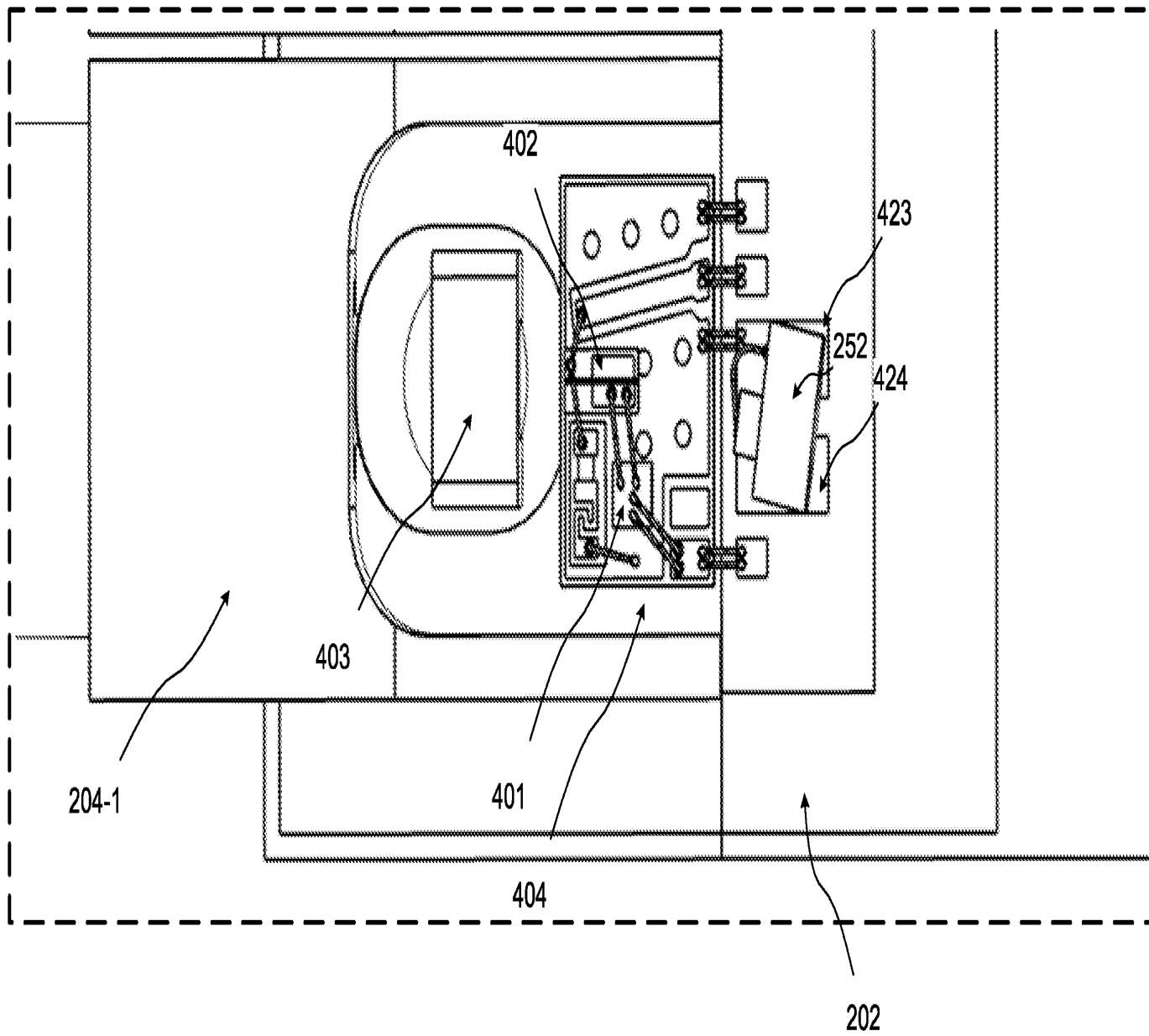


FIG. 4

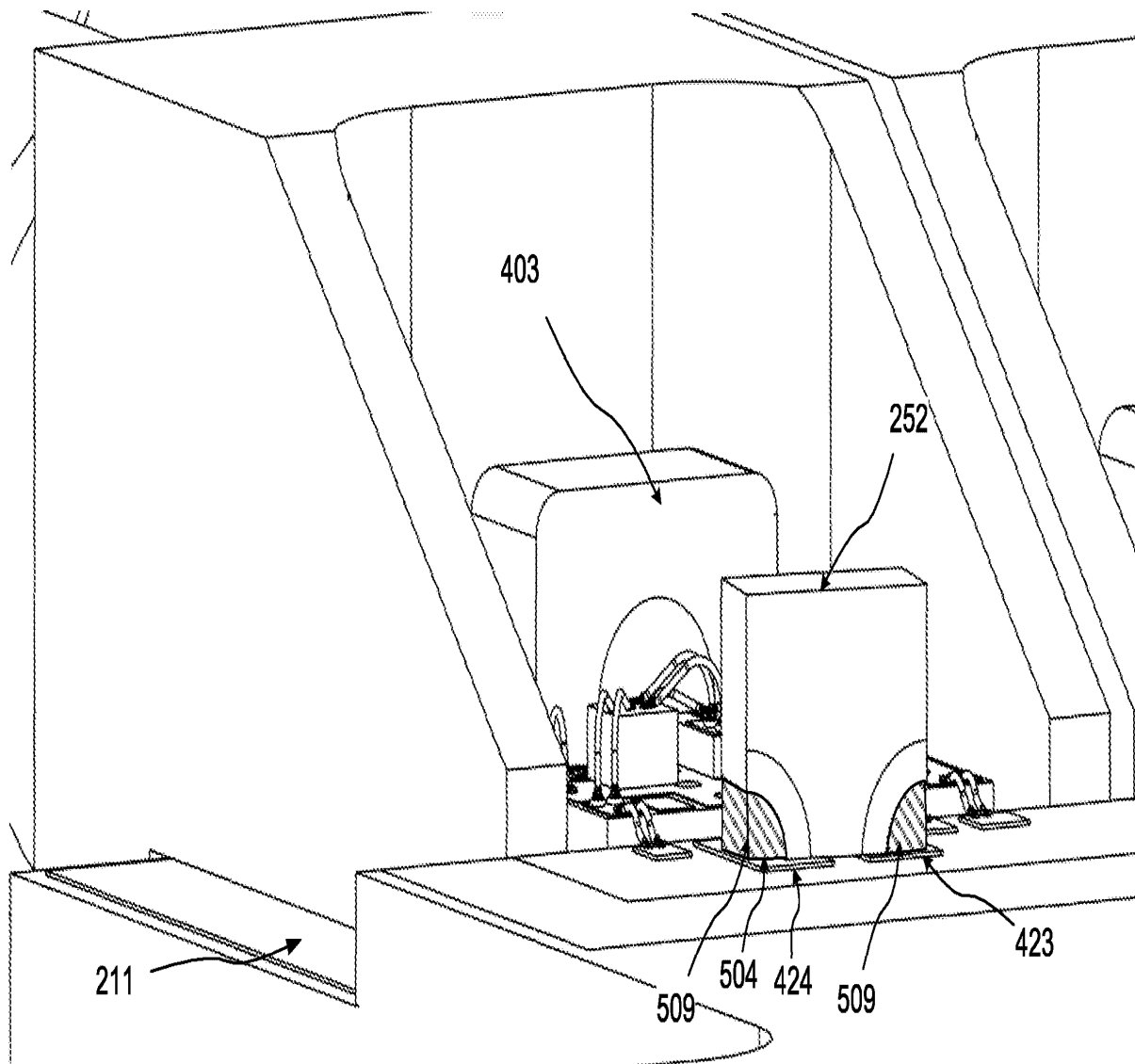


FIG. 5

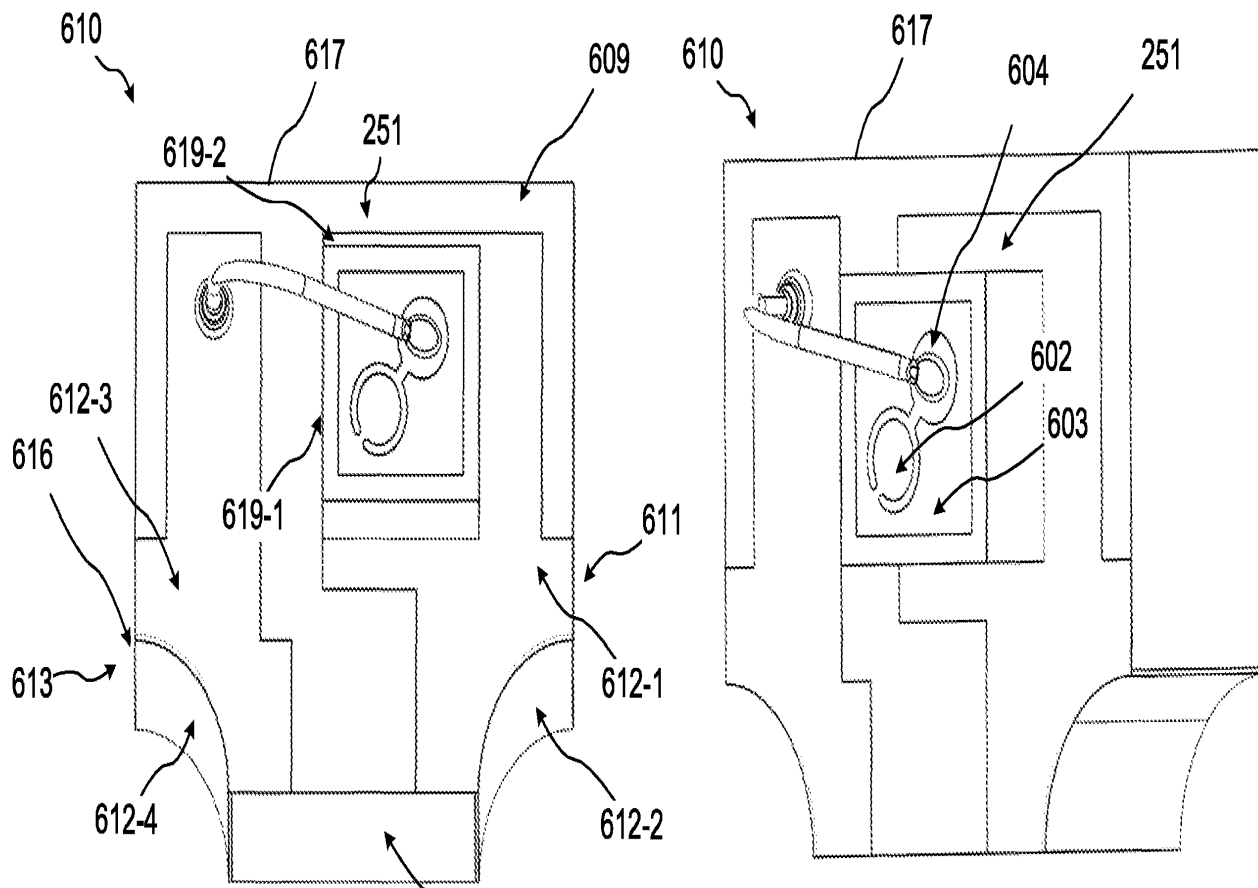


FIG. 6A

FIG. 6B

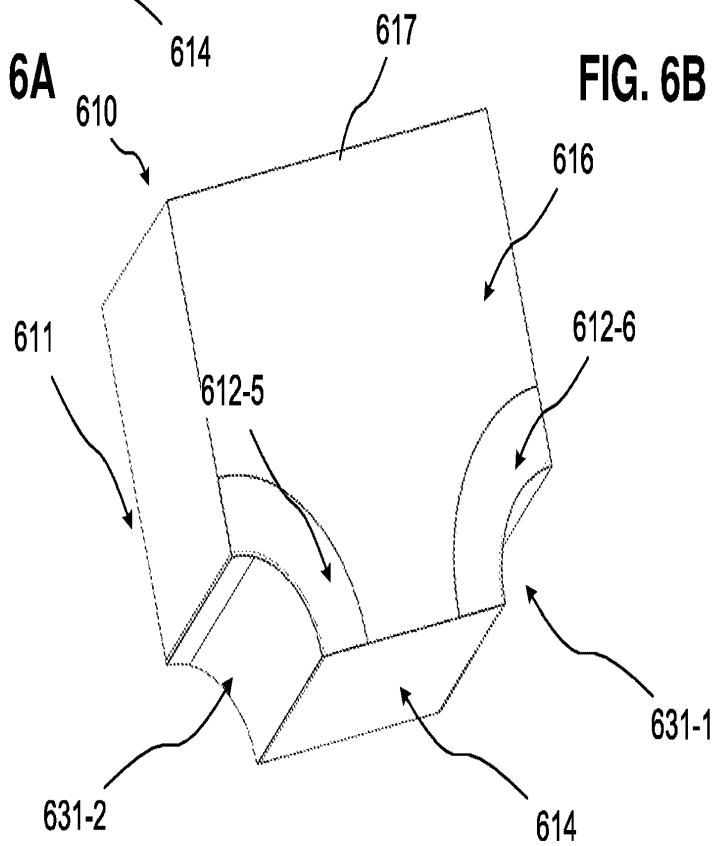


FIG. 6C

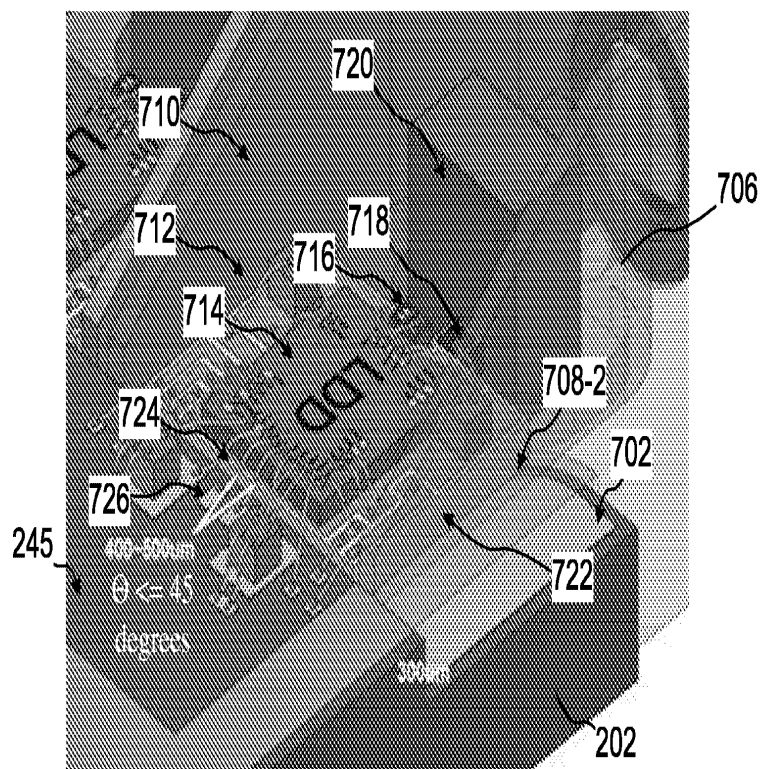
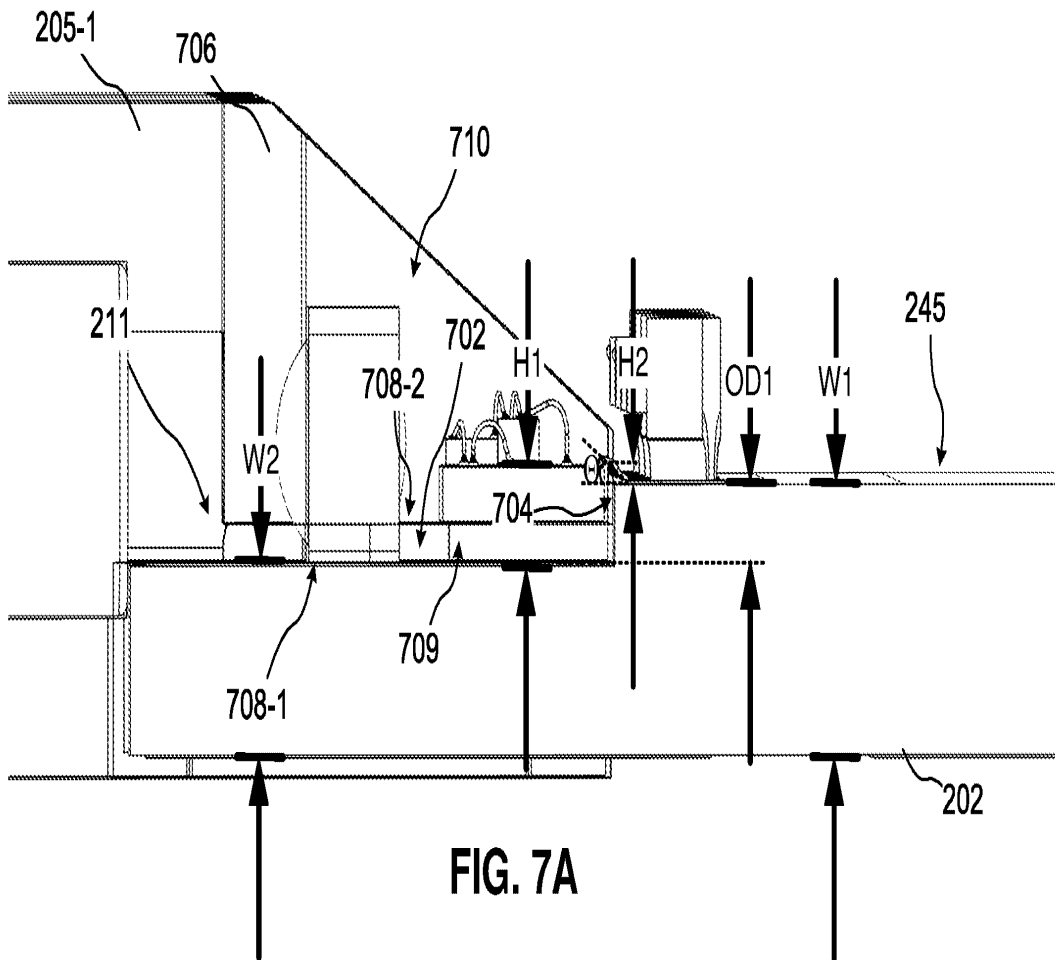


FIG. 7B

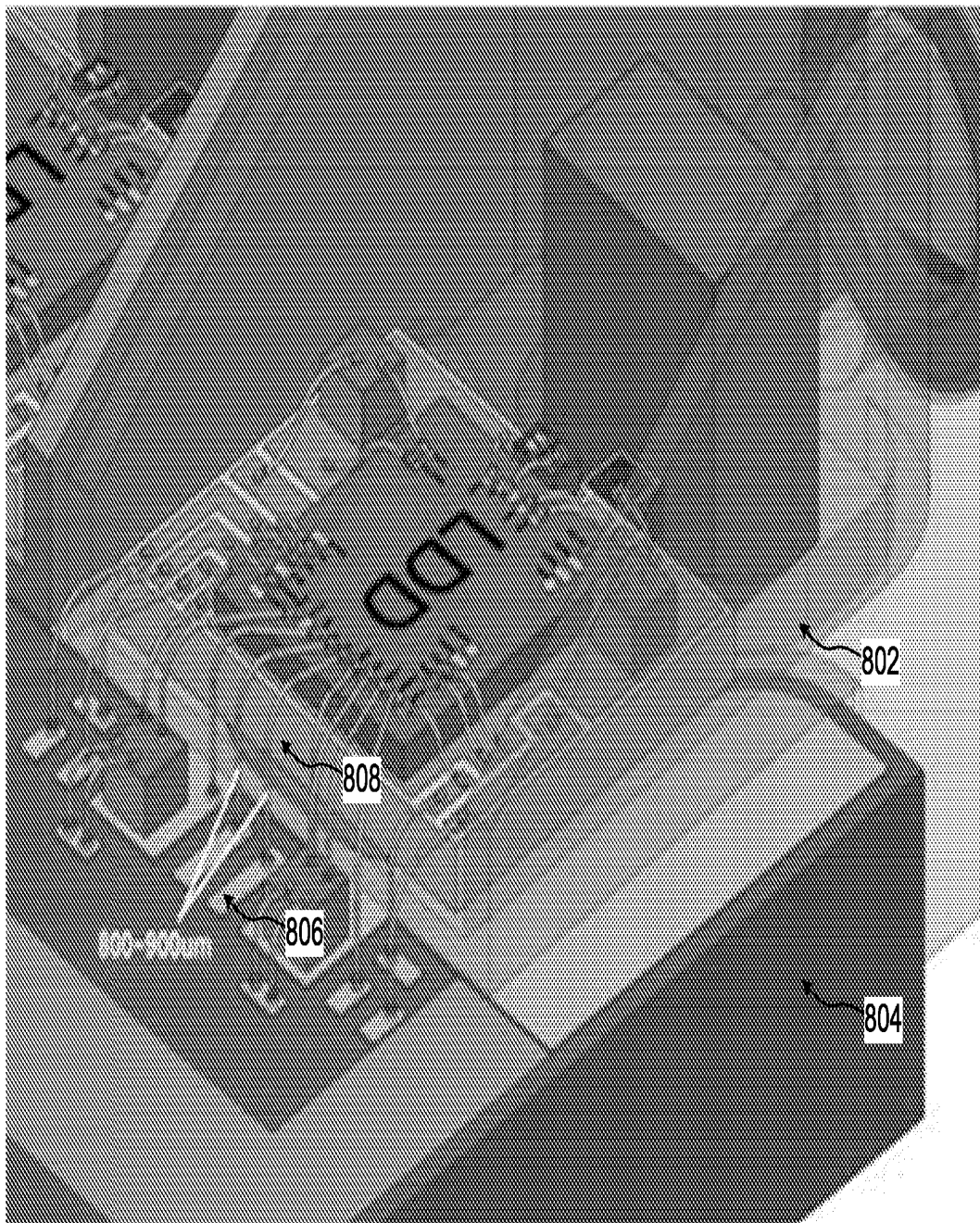


FIG. 8

Electronic Patent Application Fee Transmittal

Application Number:				
Filing Date:				
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME			
First Named Inventor/Applicant Name:	Kai-Sheng LIN			
Filer:	Kenneth M. Thompson/April Davis			
Attorney Docket Number:	PAT276US			
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1720

Electronic Acknowledgement Receipt

EFS ID:	38240371
Application Number:	16737438
International Application Number:	
Confirmation Number:	7554
Title of Invention:	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME
First Named Inventor/Applicant Name:	Kai-Sheng LIN
Customer Number:	27543
Filer:	Kenneth M. Thompson/April Davis
Filer Authorized By:	Kenneth M. Thompson
Attorney Docket Number:	PAT276US
Receipt Date:	08-JAN-2020
Filing Date:	
Time Stamp:	15:56:20
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 1720
RAM confirmation Number	E202018F56468857
Deposit Account	501705
Authorized User	April Davis

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
37 CFR 1.20 (Post Issuance fees)
37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	PAT276US_ADS.pdf	1822436	no	9
			ef0bf2efa64a6d939456ccadf42608befb388b8e		
Warnings:					
Information:					
2	Oath or Declaration filed	PAT276US_DECLARATION_Executed.pdf	700413	no	2
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Warnings:					
Information:					
3	Power of Attorney	AOI_GENERAL_POA.pdf	37470	no	1
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4		PAT276US_Application_asfiled.pdf	141197	yes	23
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	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Abstract		23	23	
	Claims		19	22	
	Specification		1	18	
Warnings:					
Information:					
5	Drawings-only black and white line drawings	PAT276US_Drawings_asfiled.pdf	905573	no	7
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Information:					
Total Files Size (in bytes):			3642104		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Kai-Sheng		LIN		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Sugar Land	State/Province	TX	Country of Residence	US

Mailing Address of Inventor:

Address 1	1306 Leigh Gardens Drive				
Address 2					
City	Sugar Land	State/Province	TX		
Postal Code	77479	Country i	US		

Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Hang		XIE		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Missouri City	State/Province	TX	Country of Residence	US

Mailing Address of Inventor:

Address 1	2914 Town Gate Ct.				
Address 2					
City	Missouri City	State/Province	TX		
Postal Code	77459	Country i	US		

Inventor	3				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Yi		WANG		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number		PAT276US	
		Application Number			
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME				
City	Katy	State/Province	TX	Country of Residence	US
Mailing Address of Inventor:					
Address 1	22126 Shady Heath Lane				
Address 2					
City	Katy	State/Province	TX		
Postal Code	77494	Country	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence information of this application.			
Customer Number	27543		
Email Address	kcarroll@gtp.com	Add Email	Remove Email

Application Information:

Title of the Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		
Attorney Docket Number	PAT276US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	27543		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			Add

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.	
--	--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section. Clear		
☒ Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:		
Name of the Deceased or Legally Incapacitated Inventor:		
If the Applicant is an Organization check here. ☒		
Organization Name	Applied Optoelectronics, Inc.	
Mailing Address Information For Applicant:		
Address 1	13139 Jess Pirtle Blvd.	
Address 2		
City	Sugar Land	State/Province TX
Country	US	Postal Code 77478
Phone Number		Fax Number
Email Address		
Additional Applicant Data may be generated within this form by selecting the Add button. Add		

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
Remove				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country ⁱ		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add				

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Kenneth M. Thompson/		Date (YYYY-MM-DD)	2020-01-08
First Name	Kenneth M.	Last Name	Thompson	Registration Number
				72001
Additional Signature may be generated within this form by selecting the Add button. Add				

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PAT276US
		Application Number	
Title of Invention	SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

- 1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
- 2 A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
- 3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
- 4 A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
- 5 A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
- 6 A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
- 7 A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
- 8 A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
- 9 A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Declaration for United States Patent Application

TITLE OF APPLICATION: SUBSTRATE WITH STEPPED PROFILE FOR MOUNTING TRANSMITTER OPTICAL SUBASSEMBLIES AND AN OPTICAL TRANSMITTER OR TRANSCEIVER IMPLEMENTING SAME

As a below named inventor, I hereby declare that:

This declaration is directed to:

☒ the attached application, or

☐ United States Application No. or PCT Application No. _____ filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the application, including the claims, and I am aware of the duty to disclose to the Office all information known to the person to be material to patentability as defined in 37 C.F.R. § 1.56 (attached hereto).

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Kai-Sheng LIN

Full name of sole or first inventor

Sole or first inventor's signature

Date

12/19/2019

Hang XIE

Full name of additional inventor, if any

Additional inventor's signature

Date

12/19/2019

YI WANG

Full name of additional inventor, if any

Additional inventor's signature

Date

12/19/2019

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.