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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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CAMBRIDGE INDUSTRIES USA INC.,  
Petitioner

v.

APPLIED OPTOELECTRONICS, INC.,  
Patent Owner

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Case No. IPR2025-00436  
U.S. Patent No. 10,313,024

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**DECLARATION OF DR. ANDREW G. KIRK IN SUPPORT OF  
PETITION FOR *INTER PARTES* REVIEW OF  
U.S. PATENT NO. 10,313,024**

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## **TABLE OF EXHIBITS**

| <b>Exhibit</b> | <b>Short Name</b>                      | <b>Description</b>                                                                                                                                                                       |
|----------------|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ex. 1001       | '024 Patent                            | U.S. Patent No. 10,313,024                                                                                                                                                               |
| Ex. 1002       | '024 Patent File History               | File History of U.S. Patent No. 10,313,024                                                                                                                                               |
| Ex. 1003       | Kirk Declaration                       | Expert Declaration of Dr. Andrew G. Kirk                                                                                                                                                 |
| Ex. 1004       | Kirk CV                                | <i>Curriculum Vitae</i> of Dr. Andrew G. Kirk                                                                                                                                            |
| Ex. 1005       | Scheduling Order                       | Doc. No. 30, Scheduling Order, <i>Applied Optoelectronics, Inc. v. Cambridge Industries USA, Inc.</i> , No. 3:24-cv-01010-JD (N.D. Cal.)                                                 |
| Ex. 1006       | Mizobuchi                              | U.S. Patent No. 9,568,694                                                                                                                                                                |
| Ex. 1007       | Akashi                                 | U.S. Patent App. Pub. No. 2014/0140665 A1                                                                                                                                                |
| Ex. 1008       | Hartzell                               | U.S. Patent App. Pub. No. 2005/0175350 A1                                                                                                                                                |
| Ex. 1009       | Claim Construction Statement           | Joint Claim Construction Pre-hearing Statement, Dkt. 34, December 16, 2024, in <i>Applied Optoelectronics, Inc. v. Cambridge Industries USA, Inc.</i> , No. 3:24-cv-01010-JD (N.D. Cal.) |
| Ex. 1010       | Excerpt from Infringement Claim Charts | Excerpt from Patent Owner's L.R. 3-1 & 3-2 Disclosures, June 6, 2024, in <i>Applied Optoelectronics, Inc. v. Cambridge Industries USA, Inc.</i> , No. 3:24-cv-01010-JD (N.D. Cal.)       |

I, Andrew G. Kirk, do hereby declare and say as follows:

**I. Introduction**

1. My name is Dr. Andrew G. Kirk, and I have been retained as a technical expert by counsel for Petitioner Cambridge Industries USA Inc. (“CIG USA”) to address certain issues regarding U.S. Patent No. 10,313,024 (“the ’024 Patent”).

2. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

3. Unless otherwise stated, the matters contained in this Declaration are of my own personal knowledge and, if called as a witness, I could and would testify completely and truthfully with regard to the matters set forth herein.

4. My opinions are based on my years of education, research, and experience, as well as my study of the relevant materials. A list of materials I considered is included at the beginning of this Declaration.

5. I reserve all available rights to supplement this Declaration if further information becomes available, or if I am asked to consider additional information. This Declaration represents only those opinions I have formed to date.

6. Further, I reserve all available rights to consider and comment on any additional expert statements or testimony of Patent Owner’s expert(s) in this matter.

7. I am being compensated at my usual consulting rate of \$400 per hour for my time spent working on issues in this matter. My compensation does not

depend on the outcome of this matter or the opinions I express.

## **II. Qualifications**

8. A true and correct copy of my curriculum vitae is submitted herewith as Ex. 1004.

9. I have over 30 years of experience in communications and signal processing. I am currently a Professor in the Department of Electrical & Computer Engineering, Photonics Systems Group, at McGill University in Montreal, Canada. I graduated with Honors from University of Bristol, United Kingdom in 1989 with an B.Sc. in Physics and went on to receive a Ph.D. from King's College, London, in 1992 in Physics. The title of my thesis was "Diffractive optical elements within parallel optical systems" I conducted Post-Doctoral research in reconfigurable optical interconnects for parallel processing applications at the University of Tokyo as a JGF Research Fellow and in design, analysis, and packaging of parallel optical interconnects in an HCM Fellowship at Vrije Universiteit Belgium, Brussels.

10. In 1996, I joined McGill University as an Assistant Professor in the Department of Electrical and Computer Engineering, and in 2002, I was promoted to Associate Professor.

11. In 2006, I became Associate Dean for Research and Graduate Education, Faculty of Engineering, and in 2011 was promoted to Professor in the Department of Electrical and Computer Engineering. My teaching responsibilities

include courses in fiber-optic communications, free-space optical systems, optoelectronics, quantum optics, thermodynamics and professional engineering.

12. I was awarded a William Dawson Scholar research chair by McGill in 2000, which was renewed in 2005. In 2011, I was appointed as a James McGill Professor (term ended in 2018). I was appointed as Department Chair in 2011 and again from 2013 to 2018 and served as Dean of the Faculty of Engineering (in an Interim position from 2011-2013). I have obtained academic appointments as a Visiting Researcher at the University of Glasgow (UK), University of Sydney (Australia), Universidad Politécnica de Valencia (Spain) and Lady Davis Institute of the Jewish General Hospital, Montreal.

13. My responsibilities as a member of the Photonics Systems Group included leading a \$800,000 research program involving approximately 5 faculty members and supervising 6 doctoral and post-doctoral students.

14. In addition to the activities, education, and professional experience listed above, I have been involved in several research projects that contribute to my expertise relating to fiber-optic communications.

15. I have received numerous awards such as James McGill Professor, the William and Reah Seath Award for Engineering Innovation and the NSERC Synergy Award (as part of a team). I am a Member of the SYTACom Research Center. I have contributed to advances in the design of integrated optical

wavelength demultiplexers and switches, to microelectromechanical optical systems, optical sensor devices and signal processing for optical sensors.

16. My research interests include passive and active components for fiber-optic communications systems, optical packaging techniques and optical sensor devices. I have extensive experience researching and teaching about optics and photonics, optical signal processing and packaging. I also have experience with optical transceiver modules, including pluggable-type modules.

17. To date, I have published book chapters on optical Interconnects and reviews in the area of fiber optic communications systems. In addition, I have published more than 150 papers in conference proceedings and more than 100 peer-reviewed journal papers. I am also a named inventor on three patents relating to fiber-optic components.

18. I have previously consulted for several major companies in the field of optical fiber communications technology, including Nortel, JDSU, Corning and Accelight Networks.

19. Through my work, I have earned the respect of the optical communication and electrical engineering community more broadly. I served as an Elected Member of the Board of Governors of the IEEE Photonics Society and as Chair of the IEEE Photonics Society Nanotechnology Committee. I have served as Board Member for several technical organizations including PROMPT-Quebec,

CQRDA and CRIAQ.

### **III. Scope of the Engagement**

20. I have been retained by Eversheds Sutherland (US) LLP on behalf of CIG USA to provide various analyses and opinions. Among other tasks, I have been asked to address the technology claimed in the '024 Patent and to evaluate whether certain claims of the '024 Patent would have been regarded as lacking novelty or would have been obvious to a person of ordinary skill in the art.

21. All of the opinions I express in this Declaration have been made from the standpoint of a person of ordinary skill in the relevant art at the time of the invention of the '024 Patent, which I am informed is, for purposes of the '024 Patent, April 26, 2018.

22. I have been asked to identify the level of skill in the art pertinent to the '024 Patent. It is my opinion that a person of ordinary skill in the art pertinent to the '024 Patent would have had at least a bachelor's degree in electrical engineering, computer engineering, networking, or similar discipline and approximately two years of experience with optical data communications and networks or a similar field of work. Additional graduate education might substitute for experience. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background. Such a POSITA would have had knowledge of

design considerations known in the optical industry and would have been familiar with then-existing products and solutions and would have understood how to search available literature for relevant publications.

23. A POSITA in April 2018 would have been familiar with MSA optical modules, including SFP and XFP formats. The '024 Patent concerns itself with communications and networking in optical systems, and the technologies that enable them, as well as the miniaturization of those technologies into what are commonly known as Small Form-Factor Pluggable (SFP) module. Thus, a POSITA in April 2018 would have been familiar with both communications networking technology as well as optoelectronic devices.

24. I consider myself a person of ordinary skill in the art as of at least the earliest claimed priority date (April 26, 2018), and for at least a decade before that.

25. My opinions regarding the level of ordinary skill in the art are based on, among other things, my more than 30 years of experience in optical networks and components therefor, my understanding of the basic qualifications that would be relevant to an engineer or scientist tasked with investigating optical networks and components therefor, my knowledge and experience with the capabilities of such systems by 2018, and my familiarity with the backgrounds of colleagues, both past and present. Although my qualifications and experience exceed those of the hypothetical person having ordinary skill in the art defined above, my analysis and

opinions regarding the '024 Patent have been based on the perspective of a person of ordinary skill in the art as of around April 2018. I am able to take on that perspective based on my experience as I have worked with individuals who had this level of experience in the 2018-time frame and am familiar with their level of knowledge.

26. My opinions are also based on the information I have reviewed as of the date of this Declaration. In connection with my analysis, I have reviewed the exhibits listed in the above list of exhibits, as well as each of the items referenced herein. I attest that the foregoing exhibits are true and accurate copies that I downloaded. My opinions directed to the invalidity of the challenged claims are based, at least in part, on the following patents and publications:

- **“Mizobuchi”** Ex. 1006, which is U.S. Patent No. 9,568,694, filed on March 18, 2016, and issued on February 14, 2017, claiming priority to Japanese Patent Application 2015-076138, filed April 2, 2015.
- **“Akashi”** Ex. 1007, which is U.S. Patent Application Publication No. 2014/0140665 A1, filed on November 4, 2013, and published May 22, 2014.
- **“Hartzell”** Ex. 1008, which is U.S. Patent Application Publication No. 2005/0175350 A1, filed on January 26, 2004, and published August 11, 2005. I rely on this reference, which was cited during prosecution of the '024 Patent, solely as demonstrating that it was well known in the field of optical

communications, many years before the application for the '024 Patent was filed, to separate power and RF signals on circuit boards to reduce signal noise.

#### **IV. Legal Standards**

27. For purposes of this Declaration, counsel for CIG USA have instructed me to make the following assumptions:

28. Claims are construed from the perspective of a person of ordinary skill in the art (“POSITA”) as of the effective filing date of the patent application. Persons of ordinary skill in the art are deemed to read the claims in the context of the entire patent, including the specification and prosecution history. In other words, the terms are not considered in a vacuum.

29. It is my understanding that information that satisfies one of the categories of prior art set forth in 35 U.S.C. § 102 may be used in an invalidity analysis under §§ 102 or 103. If information is not properly classified as prior art under one of the subsections of § 102 of the Patent Act, then it may not form the basis of an anticipation or obviousness determination. It is also my understanding that, for *inter partes* review, applicable prior art is limited to patents and printed publications.

30. I am informed and understand that a patent claim is invalid under 35 U.S.C. § 102 if a single item of prior art discloses all of the limitations set forth in a patent claim, arranged as set forth in the claim. I understand that a POSITA may

take into account technical knowledge that would have been well known to those of skill in the relevant art when considering the disclosures of a patent and that applying such knowledge to the disclosure of a reference still qualifies as anticipation. I understand from counsel that this is sometimes referred to as “single reference obviousness,” but in this case the motivation to combine comes from the single reference itself when properly interpreted by those of skill in the art.

31. I am also informed that a patent claim is invalid under 35 U.S.C. § 103 if the differences between the claimed invention and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a POSITA to which the subject matter pertains. Obviousness, I am informed, is determined based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and secondary indications of non-obviousness to the extent they exist.

32. I understand that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a POSITA at the time of the invention. A POSITA is a hypothetical person who is presumed to be aware of all of the relevant art at the time of the invention. The POSITA is not an automaton and may be able to fit together the teachings of multiple patents (or other printed publications) by employing ordinary creativity and the common sense that familiar items may have obvious uses in another context or beyond their

primary purposes.

33. In analyzing the relevance of the differences between the claimed invention and the prior art, I understand that I must consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The POSITA faced with a problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

34. I understand that an invention would have been obvious if a POSITA, facing the wide range of needs created by developments in the field, would have seen an obvious benefit to the solutions tried by the patent applicant. When there is a design need or market pressure to solve a problem and there are a finite number of identified predictable solutions, it would have been obvious to a POSITA to try the known options. If a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

35. I understand that I do not need to look for precise teachings in the prior art directed to the subject matter of the claimed invention. I understand that I may consider the inferences and creative steps that a POSITA would have employed in reviewing the prior art at the time of the invention. For example, if the claimed invention combines elements that were known in the prior art and if the combination

yields results that were predictable to a POSITA at the time of the invention, then this would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yields unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this would make it more likely that the claim that successfully combined those elements was not obvious. I understand that hindsight must not be used when comparing the prior art to the invention during an obviousness analysis.

36. I understand that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a POSITA to combine the invalidating references. I also understand that this suggestion or motivation may come from sources such as explicit statements in the prior art, or from the knowledge of a POSITA. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I also understand that when there is a design need or market pressure, and there are a finite number of predictable solutions, persons of ordinary skill may be motivated to apply both their skill and common sense in trying to combine the known

options in order to solve the problem.

37. I understand that absent evidence of an invention date prior to the filing date of a patent, the invention date of the patent is presumed to be its filing date. A prior invention requires a complete conception of the invention and a reduction to practice of that invention. The patent owner has the burden of establishing by clear and convincing evidence a date of conception earlier than the filing date of the patent.

## **V. Technical Background**

38. In this technical background, I describe the pertinent technology as it existed as of April 2018, the earliest alleged priority date of the '024 Patent.

39. The '024 Patent generally relates to an optical transceiver module that includes a transceiver optical subassembly ("TOSA"). A TOSA by 2018 generally would have been understood by a POSITA in 2018 to include a number of lasers disposed within a hermetically sealed cavity, which generate separate channel wavelength optical signals that encode data. As described in the '024 Patent, the hermetically sealed cavity and contents is referred to as "a light engine." The hermetically sealed cavity typically is filled with an inert gas to prevent environmental factors from affecting laser performance.

40. The lasers are driven by circuitry located on a substrate outside of the hermetically sealed cavity that provides RF and power signals to the lasers (this

circuitry is referred to in the '024 Patent as a “light engine driving circuit”). Information encoded via the RF and power signals that are provided to the light engine driving circuit arises from a transmit connect circuit. *See, e.g.*, TX circuit 104 in FIG. 1A of the '024 Patent, a standard design for a TOSA in 2018. Light emitted from the lasers is combined into a single multiwavelength optical signal that exits the hermetically sealed cavity via an optical output, e.g., an optical fiber.

41. The substrate on which the lasers are disposed within hermetically sealed cavity extends through an opening in the wall of the hermetically sealed cavity and includes a region for electrically coupling to the laser driving circuitry and transmit circuit via a connector. In the lexicon of the '024 Patent, this connector is referred to as a “feedthrough device,” because it electrically couples the lasers within the light engine to the rest of the optical module electronics, and specifically the light driving circuitry and transmit circuitry.

42. It was well known in April 2018, and indeed decades earlier, that multiple design alternatives existed to reduce interference between RF signals and power signals by physically spacing the circuit traces carrying such signal apart from one another, or interleaving ground traces between the RF signals.

43. For example, Hartzell, U.S. Patent App. Pub. No. 2005/0175350 A1, Ex. 1008, describes a common practice of placing RF signal traces on one layer or surface of a circuit board, and the power traces on a separate surface or layer of the

circuit board. *See, e.g.*, Ex. 1008, Abstract, ¶¶ [0006], [0028]-[0029]. Such an arrangement physically separates the different traces. Alternatively, a POSITA would have understood that physical characteristics of the substrate could be altered to enhance shielding, for example, by increasing the thickness of the substrate or embedding a ground plane in substrate. *See id.*, ¶ [0032] (describing copper ground plane to provide electrical isolation).

44. As described in Hartzell, Ex. 1008, and other prior art cited during prosecution of the '024 Patent (discussed, *infra*), it was well known to separate RF and power signals on the circuit boards of optical transceivers, including the TOSA component. The alleged innovation provided by the '024 Patent was to extend the physical separation on the circuit traces on the substrate and connector that carry signals from the light engine driving circuitry to light engine, and so that the surfaces of the feedthrough device extend substantially parallel to the first and second surfaces of the substrate. In other words, the alleged invention of the '024 Patent is to replicate the arrangement of the RF and power signals on the circuit board to the “feedthrough device.”

45. It also was known to a POSITA in 2018 that there were numerous methods of interconnecting circuit boards, some of which are particularly well suited for RF electronics, and others that are more suitable for transmitting power. A POSITA in the field of optical communications would have known, for example,

that a simple mechanical connector could be used for power transmission, without deleterious effects arising from resistive heating that could be caused by an RF signal. Such a POSITA also would have understood that a DC busbar could be used for power transmission, particularly if multiple power connections are desired where space limitations are a concern. A POSITA likewise would have understood that soldering or wire bonding would be the preferred alternative for coupling RF electronics to provide a robust connection not susceptible to resistive heating.

46. As I will demonstrate below, the standard electronics design choices on which the '024 Patent obtained a patent were well known to a POSITA at the time of the alleged invention of that patent.

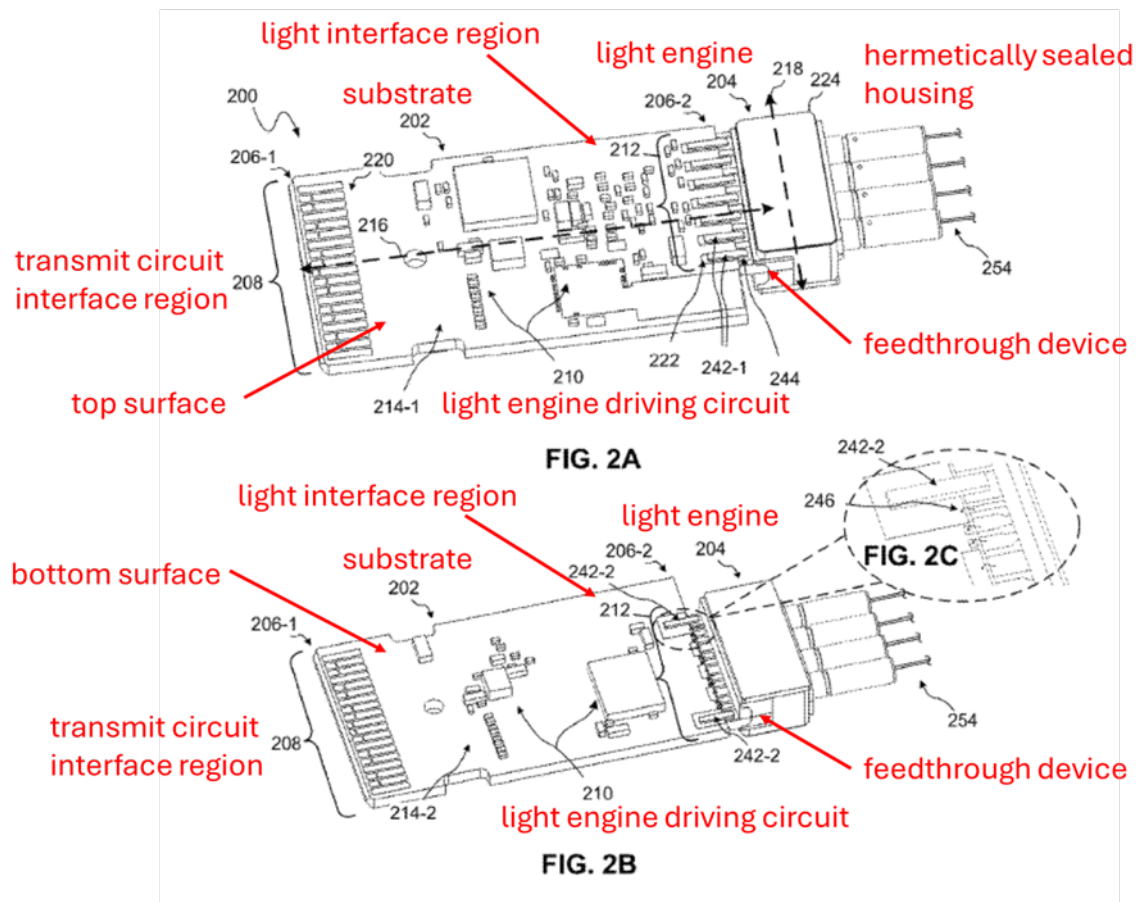
## **VI. The '024 Patent**

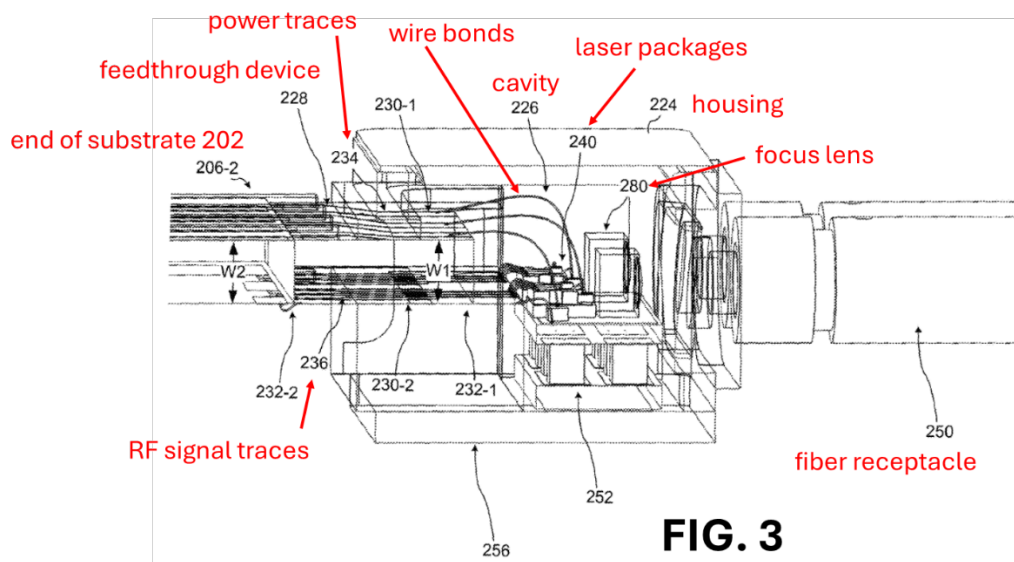
47. The '024 Patent is generally directed towards a TOSA and an optical transceiver including a TOSA in which a hermetically sealed light engine (containing laser packages) is coupled to a substrate having light engine driving circuit by a “feedthrough device” – a connector. As specifically described in the '024 Patent, the substrate carrying the light engine driving circuit has RF signal and power signals arranged on opposite sides (in “opposing arrangement”). That arrangement of RF and power signal traces was a well-known design technique in April 2018 for such circuitry, as demonstrated by Hartzell, Ex. 1008 (which was used to reject this feature, without traverse, as recited in as-filed application claim

1 filed in the application that matured as the '024 Patent).

48. Patent Owner amended its application claims to recite that the feedthrough device, the connector that couples the substrate to the light engine, replicates the arrangement of the RF and power signals on the substrate to reduce interference and to maintain the components substantially parallel.

49. I have reproduced and annotated below and on the following page FIGS. 2A, 2B and 3 from the '024 Patent, Ex. 1001, to provide a ready reference illustrating how the claim terms apply to the embodiment disclosed in the patent.





50. I have been asked to evaluate Claims 1-17 of the '024 Patent. I have reproduced these challenged claims below:

| Claim | Recitation                                                                                                                                                                                                                                                                                                 |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1a]  | A transmitter optical subassembly (TOSA) module comprising:                                                                                                                                                                                                                                                |
| [1b]  | a hermetically sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;                                                                                           |
| [1c]  | a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically sealed light engine; |
| [1d]  | a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically sealed light engine to output one or more channel wavelengths;                                                                                              |

| <b>Claim</b> | <b>Recitation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1e]         | wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal                                                                                                                                        |
| [1f]         | a feedthrough device to electrically couple the at least one laser package to the light engine driving circuit; and                                                                                                                                                                                                                                                                                                                                                                                                            |
| [1g]         | wherein the feedthrough device is defined by at least a first surface disposed opposite a second surface, and wherein the first and second surfaces extend substantially parallel with the first and second surfaces of the substrate.                                                                                                                                                                                                                                                                                         |
| 2            | The TOSA module of claim 1, further comprising at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different. |
| 3            | The TOSA module of claim 2, wherein the first type of interconnect device is a DC bus bar interconnect.                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4            | The TOSA module of claim 2, wherein the second type of interconnect device is a wire bond.                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 5            | The TOSA module of claim 1, further comprising at least one ground trace disposed on the second surface adjacent the second trace.                                                                                                                                                                                                                                                                                                                                                                                             |
| 6            | The TOSA module of claim 5, further comprising a DC bus bar interconnect device electrically coupled to the at least one ground trace and a wire bond electrically coupled to the second trace.                                                                                                                                                                                                                                                                                                                                |
| 7            | The TOSA module of claim 1, wherein the electrical isolation is provided at least in part by a width of the substrate and/or material properties of a material that forms the substrate.                                                                                                                                                                                                                                                                                                                                       |

| <b>Claim</b> | <b>Recitation</b>                                                                                                                                                                                                                                                                                                |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8            | The TOSA module of claim 1, further comprising a plurality of electrical interconnects that brace the substrate to the housing of the hermetically sealed light engine.                                                                                                                                          |
| 9            | The TOSA module of claim 1, wherein the feedthrough device is configured to directly couple to the substrate with an end-to-end connection.                                                                                                                                                                      |
| 10           | The TOSA module of claim 1, wherein the first and second surfaces of the feedthrough device are substantially coplanar with the first and second surfaces of the substrate when the feedthrough device and substrate are coupled together.                                                                       |
| 11           | The TOSA module of claim 1, further comprising at least one trace for receiving the power signal from the light engine driving circuit disposed on the first surface of the feedthrough and at least one trace for receiving the RF signal from the light engine driving circuit disposed on the second surface. |
| [12a]        | An optical transceiver comprising:                                                                                                                                                                                                                                                                               |
| [12b]        | a housing;                                                                                                                                                                                                                                                                                                       |
| [12c]        | a transmitter optical subassembly (TOSA) module disposed in the housing, the TOSA module comprising:                                                                                                                                                                                                             |
| [12d]        | a hermetically sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package disposed within the hermetic-sealed cavity;                                                                                                                                               |
| [12e]        | a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically sealed light engine;       |
| [12f]        | a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically sealed light engine to output one or more channel wavelengths; and                                                                                                |

| <b>Claim</b> | <b>Recitation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [12g]        | wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal, and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal;                                                                       |
| [12h]        | at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically sealed light engine to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically sealed light engine to provide the RF signal, the first and second types of interconnect devices being different; |
| [12i]        | a receive optical subassembly (ROSA) module disposed in the housing.                                                                                                                                                                                                                                                                                                                                                                                            |
| 13           | The optical transceiver of claim 12, wherein the first type of interconnect device comprises a DC bus bar disposed on the first and second surfaces of the substrate.                                                                                                                                                                                                                                                                                           |
| 14           | The optical transceiver of claim 12, wherein the second type of interconnect device is a wire bonds.                                                                                                                                                                                                                                                                                                                                                            |
| [15a]        | A transmitter optical subassembly (TOSA) module comprising:                                                                                                                                                                                                                                                                                                                                                                                                     |
| [15b]        | a hermetically sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;                                                                                                                                                                                                                                                |
| [15c]        | a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically sealed light engine;                                                                                                                                                      |
| [15d]        | a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically sealed light engine to output one or more channel wavelengths;                                                                                                                                                                                                                                                   |

| <b>Claim</b> | <b>Recitation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15e]        | wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal; and                                                                                    |
| [15f]        | at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different. |
| 16           | The TOSA module of claim 15, wherein the first type of interconnect device is a DC bus bar interconnect.                                                                                                                                                                                                                                                                                                                                                                        |
| 17           | The TOSA module of claim 15, wherein the second type of interconnect device is a wire bond.                                                                                                                                                                                                                                                                                                                                                                                     |

## **VII. Prosecution History**

51. Patent Owner filed Application No. 15/963,246 (the “’246 Application”) on April 26, 2018. The ’246 Application issued as the ’024 Patent on June 4, 2019. Exhibit 1002, p. 1.

52. In a Non-final Office action mailed November 19, 2018, the Patent Examiner rejected application claims 1, 5, 7, 8, 14 and 15 as obvious over Hartzell (US 2005/0175350) [Ex. 1008] in view of Grebenkemper (US 2005/0225955) and further in view of Daiber (US 2015/0162990). Exhibit 1002, pp. 37, 40-45. Specifically, the Examiner stated that the TOSA in Hartzell included a substrate

with RF and power traces in opposing arrangement, but “doesn’t clearly state that the traces for power and rf signals are placed in separate layers opposing each other” and moreover “Hartzell doesn’t explicitly state that the TOSA comprises a hermetically sealed light engine.” *Id.*, p. 41. Grebenkemper also was cited as teaching isolation of the power from RF traces. *Id.*

53. The November 19, 2018, Office action included the following additional rejections over the foregoing collection of references, further in view of additional references:

- Application claim 6 was rejected further in view of Romas (US 2014/0152373);
- Application claims 9 and 10 were rejected further in view of Edwards (US 2012/0301152);
- Application claim 16 was rejected further in view of Jack (US 2016/0139477); and
- Application claim 17 was rejected further in view of Firth (US 2013/0114629). Exhibit 1002, pp. 45-48.

54. Claims 2-4 and 11-13 were indicated to contain allowable subject matter if rewritten in independent form including all limitations of the base claim and any intervening claims. Ex. 1002, p. 39.

55. Patent Owner filed a Response on February 19, 2019, in which independent application claim 1 was amended to include the limitations of application claims 9 and 11, independent application claim 14 was amended to include the limitations of dependent application claim 2, and new independent claim 18 was added. *Id.*, pp. 29-33. The Amendments generally specified that the feedthrough device had its RF and power traces disposed on opposite sides of the single substrate depicted in FIGS. 2A and 2B, i.e., in “opposing arrangement.”

56. A Notice of Allowance was mailed on March 26, 2019, and included a Notice of Allowability. Exhibit 1002, pp. 7-11. The Notice of Allowability referred to the February 19, 2019, Response, but did not include any Examiner’s Amendment or Comment explaining the reasons for allowance. *Id.*, p. 11. The Issue Fee was submitted on April 18, 2019, and the ’024 Patent issued on June 4, 2019. *Id.*, pp. 1-2.

### **VIII. Claim Construction**

57. I am informed by counsel for CIG USA that in an *Inter Partes Review*, claims should be construed “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. §282(b).” 37 C.F.R. §42.100(b) (Nov. 13, 2018). And unless otherwise specified in the patent under review, the terms should receive their respective plain and ordinary meaning as understood by a person of ordinary skill in the art under *Phillips v. AWH Corp.*, 415

F.3d 1303 (Fed. Cir. 2005).

58. In deciding this Petition, in view of the arguments made to the Patent Examiner to secure allowance of Claims 1-17 of the '024 Patent, it is my opinion that the Board will need to construe the terms “feedthrough device” “interconnect device,” and “opposing arrangement” as used in those claims.

59. As described in the '024 Patent, the feedthrough device (also referred to in the Claims 12-17 as an “interconnect device”) is formed by “patterns/traces that propagate signals from external circuitry to components within the hermetic sealed package.” Ex. 1001, 2:7-12. By comparison, Patent Owner contends in the District Court litigation that a plain and ordinary meaning of “a device designed to transmit electrical signals or power from one region to another region” should be applied. Ex. 1009, p. 2. In my opinion, Patent Owner’s proposed construction improperly omits reference to the hermetically sealed package and thus cannot be correct.

60. Similarly, the term “opposing arrangement” is used interchangeably with the phrase “first and second surfaces disposed opposite each other.” Ex. 1001, 2:18-24 (with respect to “feedthrough device” this “electrically isolates RF traces from power-related traces (e.g., DC traces, ground traces) by disposing power and RF traces on opposite sides. This configuration of power and RF traces may also be referred to as an opposing arrangement”); *id.*, 2:39-47 (“A first side of the

feedthrough device may include traces configured to propagate power signals, e.g., DC signals, from circuitry of the substrate to components within the hermetically-sealed cavity. On the other hand, a second side of the feedthrough device, opposite the first side, may include traces configured to propagate RF signals from circuitry of the substrate to components within the hermetically-sealed cavity”); *id.*, 2:48-52 (“Therefore, the RF and power signal traces of the feedthrough device may be electrically isolated from each other based on the distance therebetween, e.g., provided by the width of the feedthrough device, and/or the material properties of the feedthrough device.”). All of the above citations identify the only described embodiment on the ’024 Patent, which is directed to a single circuit board that has power traces on a top surface of the board and RF traces on the bottom surface of the *single* circuit board.

61. Patent Owner contends in the pending litigation that its “plain and ordinary meaning” of “arranged on top and bottom sides of the substrate” applies not just to a single substrate but is infringed under a doctrine of equivalents theory by an embodiment in which RF and power traces are located on separate main and daughter circuit boards that are disposed adjacent to one another. Ex. 1009, p. 1, Ex. 1010, pp. 2, 4-5, 10, 13-14. As discussed below, in my opinion, separate main and daughter boards cannot validly fall within the scope of the claimed “opposing arrangement.”

62. However, because I understand that a claim term should have the same meaning for purposes of invalidity as for infringement, I adopt, for purposes of my unpatentability analyses herein, the plain and ordinary meaning for the term “opposing arrangement” urged by the Patent Owner in its district court litigation against the Petitioner.

## **IX. Prior Art References**

### **a. Mizobuchi Overview**

63. Mizobuchi, U.S. Patent No. 9,568,694, Ex. 1006, was filed on March 18, 2016, and issued on February 14, 2017. I understand that Mizobuchi qualifies as prior art under at least AIA 35 U.S.C. § 102(a)(1) and was neither cited nor considered during prosecution of the '024 Patent.

64. Mizobuchi teaches an optical module, including “a first circuit board, an optical sub-assembly, a first flexible printed circuit and a second flexible printed circuit,” wherein “[a] high-speed electrical signal . . . is transmitted between both the circuit boards through the first flexible printed circuit, and a power source signal and a low-speed electrical signal . . . are transmitted between both the circuit boards through the second flexible printed circuit.” Ex. 1006, Abstract.

65. Mizobuchi discloses an optical transceiver including a transmitter optical subassembly (“TOSA”). *See* Ex. 1006, FIGS. 1A, 1B, 3A, 1:26-43, 12:42-58. The TOSA includes a hermetically sealed light engine. *Id.*, FIG. 3A, 5:43-50,

7:15–21, 12:46–48. A first circuit board has first and second surfaces located opposite each other and defines a substrate. *Id.*, FIGS. 2, 3A, 4:22–5:34, 6:32–60. The first circuit board is connected to a second circuit board. *Id.* The substrate defined by the first circuit board includes regions configured to electrically couple with a transmit connecting circuit and with the hermetically sealed light engine via the second circuit board. *Id.*

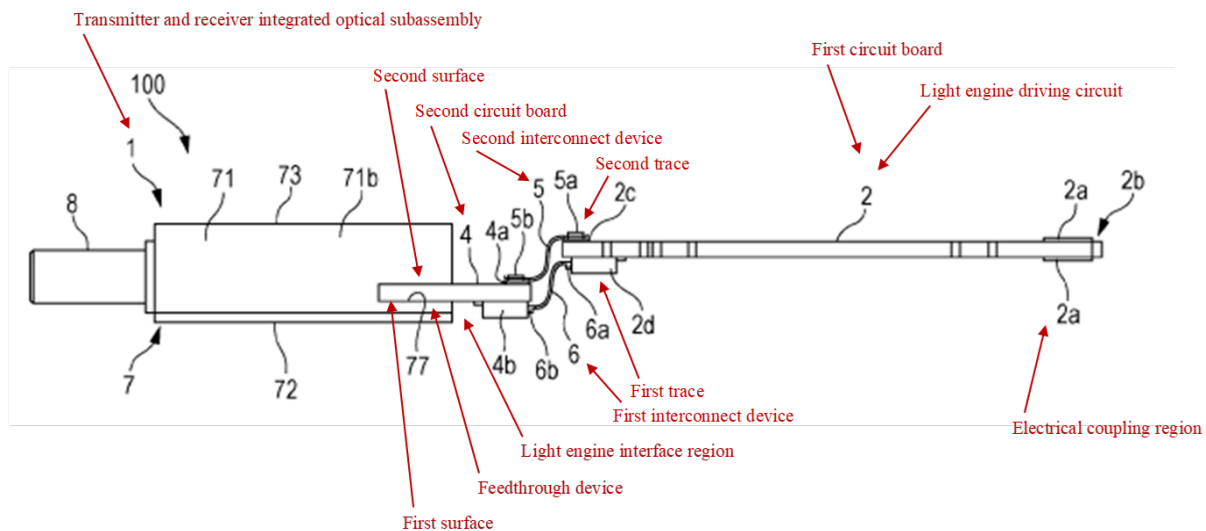


FIG. 2 (Mizobuchi)

66. A light engine driving circuit, located on the substrate, provides RF and power signals to drive the hermetically sealed light engine to output one or more channel wavelengths. *Id.*, FIGS. 2, 3A, 3:57–64, 12:27–41. The substrate includes first and second traces (located, respectively, on the substrate's first and second surfaces) for providing the power and RF signals, respectively. *Id.*, FIG. 2, 4:22–5:34, 6:48–60. The first and second traces are disposed in an opposing arrangement to provide electrical isolation and thereby reduce electrical

interference between the power and RF signals. *Id.*

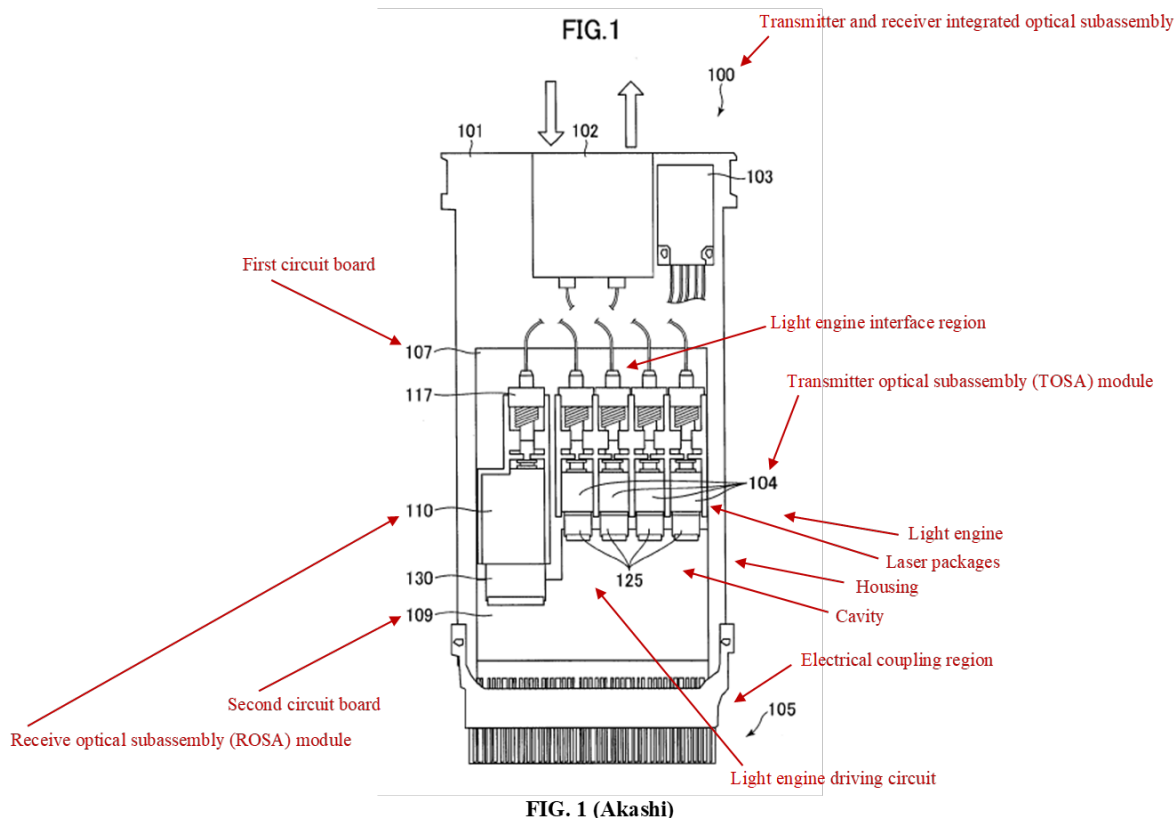
67. Mizobuchi discloses a feedthrough device in the form of flexible printed circuits that couple to a second circuit board that extends into the hermetic cavity. The flexible printed circuits (and second circuit board) have first and second surfaces, which are located opposite each other and are substantially parallel with, the first and second surfaces of the substrate that electrically couple the light engine driving circuit to the laser packages of the TOSA. *Id.*, FIGS. 2, 3A, 6:32–7:64. The opposite sides of the flexible printed circuits of Mizobuchi separately carry power and RF signals and include different types of connectors.

**b. Akashi Overview**

68. Akashi, U.S. Patent Application Publication No. 2014/0140665 A1, Ex. 1007, was filed on November 4, 2013, claiming priority to a Japanese application, JP 2012-251987, filed November 16, 2012. Akashi published on May 22, 2014. I understand that it qualifies as prior art under at least AIA 35 U.S.C. § 102(a)(1) and was not cited or considered during prosecution of the '024 Patent.

69. Akashi teaches an optical module including a main body that includes “an optical connector to which a communication cable transferring optical signal is connected, and a terminal portion on which a plurality of terminal pads for transmitting and receiving an electrical signal for communication using the optical signal are arranged,” a lead array electrically connected to the terminal pads, and a

flexible printed circuit with “wires electrically connected to the metal leads” of the lead array. Ex. 1007, Abstract.



70. Akashi discloses a transmitter and receiver integrated optical subassembly that includes for transmitter optical subassemblies (TOSA) 104. Ex. 1007, FIG. 1, ¶¶ [0025]-[0026]. Each TOSA includes a hermetically sealed light engine, as was routine for such devices. *Id.*, FIG. 1, ¶¶ [0010], [0026], [0027]. The channel wavelength optical signals output by the TOSAs are combined into a single outgoing multiwavelength optical signal. *Id.*, FIG. 1, ¶ [0025]. A first circuit board (107) has first and second surfaces located opposite each other and defines a substrate. *Id.*, FIG. 1, ¶ [0026]. The first circuit board is connected to a second

circuit board that carries a transmit connecting circuit. *Id.* The substrate of the first circuit board is electrically coupled to the light engine. *Id.*

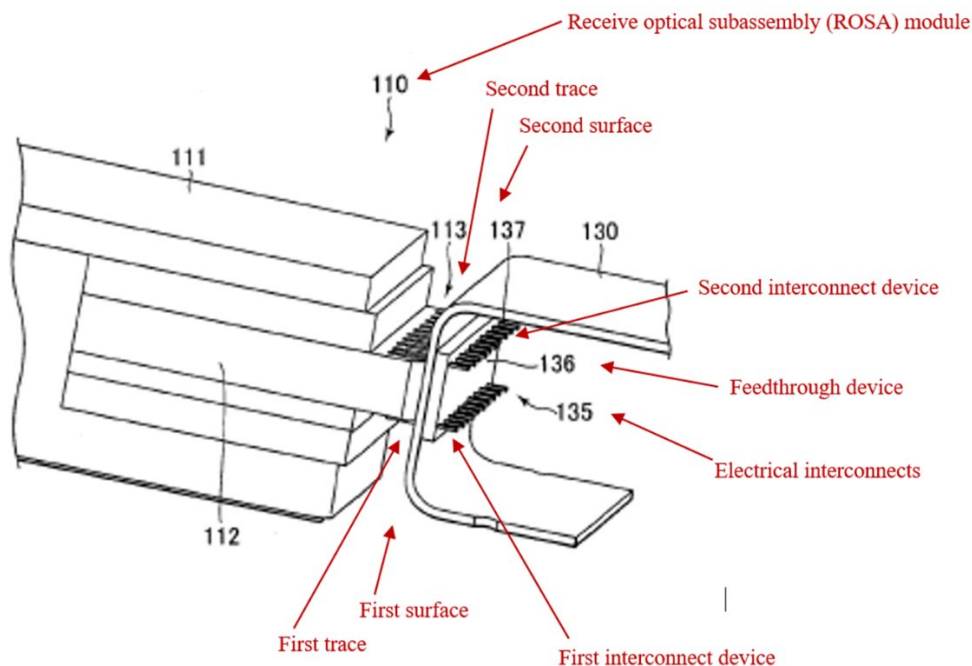


FIG. 2 (Akashi)

71. A light engine driving circuit, located on the substrate, provides RF and power signals to drive the hermetically sealed light engine to drive TOSAs 104. *Id.* The substrate includes first and second traces for providing the power and RF signals, respectively. *Id.*, FIGS. 1, 2, 6, ¶¶ [0010], [0015], [0030], [0033], [0038]. As would have been understood by a POSITA based both on knowledge of skill in the art (e.g., Hartzell, Ex. 1008), as well as the configuration of the feedthrough device coupling the substrate to the TOSAs, discussed *infra*, the first and second traces of the substrate are located in an opposing arrangement to provide electrical isolation and thereby reduce interference between the power and RF signals. *Id.*

72. The feedthrough device described in Akashi is a flexible printed circuit having power and RF signal traces on its first and second surfaces that extend substantially parallel with the respective opposing surfaces of the substrate. *Id.*, FIGS. 1, 2, ¶¶ [0015]. The feedthrough device electrically couples the laser packages of the TOSAs to the light engine driving circuit on the first circuit (107). *Id.*, FIGS. 1, 2, ¶¶ [0010]-[0012], [0015], [0038].

## **X. Grounds**

| <b>Ground</b> | <b>Reference</b> | <b>Claims</b> |
|---------------|------------------|---------------|
| Ground 1      | Mizobuchi        | 1-17          |
| Ground 2      | Akashi           | 1-17          |

### **a. Ground 1: Mizobuchi Anticipates Claims 1-17.**

#### **i. Claim 1: [1a] A transmitter optical subassembly (TOSA) module comprising:**

73. Mizobuchi discloses a transmitter and receiver integrated optical subassembly that includes a TOSA. *See* Ex. 1006, FIGS. 1B, 3A, 3:26-43, 12:42-58 and annotated FIGS. 1B and 3A reproduced on the following page.

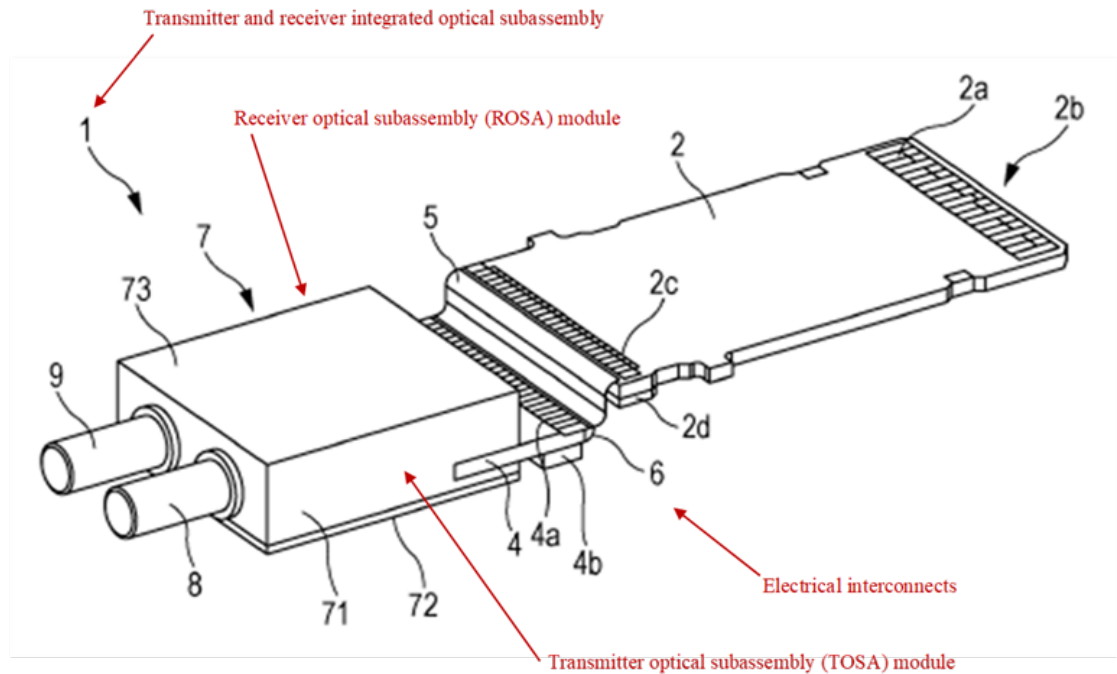


FIG. 1B (Mizobuchi)

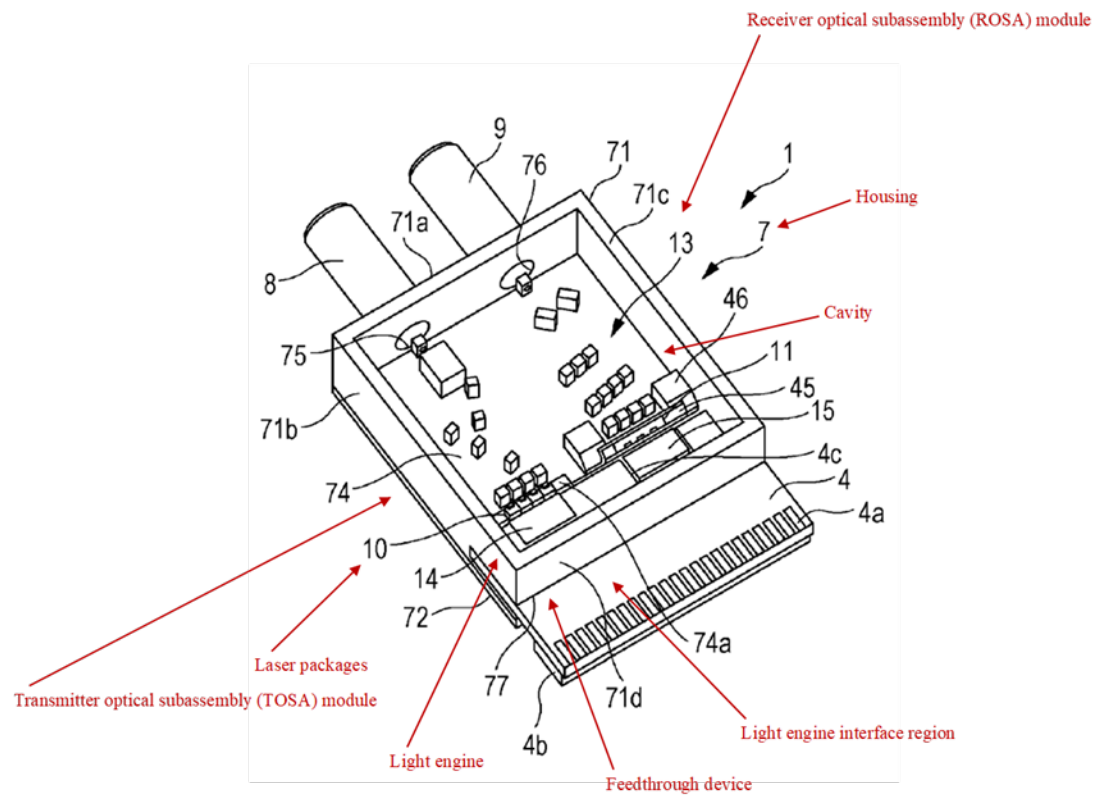


FIG. 3A (Mizobuchi)

**ii. Claim 1: [1b] a hermetically-sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;**

74. Mizobuchi discloses that the TOSA includes hermetically sealed light engines housing that defines a hermetic-sealed cavity with multiple laser packages disposed therein. *See* Ex. 1006, FIG. 3A, 5:43-50, 7:15-21, 12: 46-48. Each of the laser packages (“light emitting elements”) is configured to emit an associated channel wavelength optical signal. *Id.*

**iii. Claim 1: [1c] a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically-sealed light engine;**

75. Mizobuchi discloses a first circuit board that has first and second surfaces disposed opposite each other and defines a substrate. *See* Ex. 1006, FIGS. 2, 3A, 4:22-5:34, 6:32-60. The substrate defined by the first circuit board carries a light engine driving circuit and includes an electrical coupling region that connects to a transmit circuit and a light engine interface region. *Id.*, FIG. 2, 3:44-55. The light engine interface region is electrically coupled with a second circuit board that extends into the hermetically sealed light engine. *Id.*, FIG. 2, 3:65-4:5.

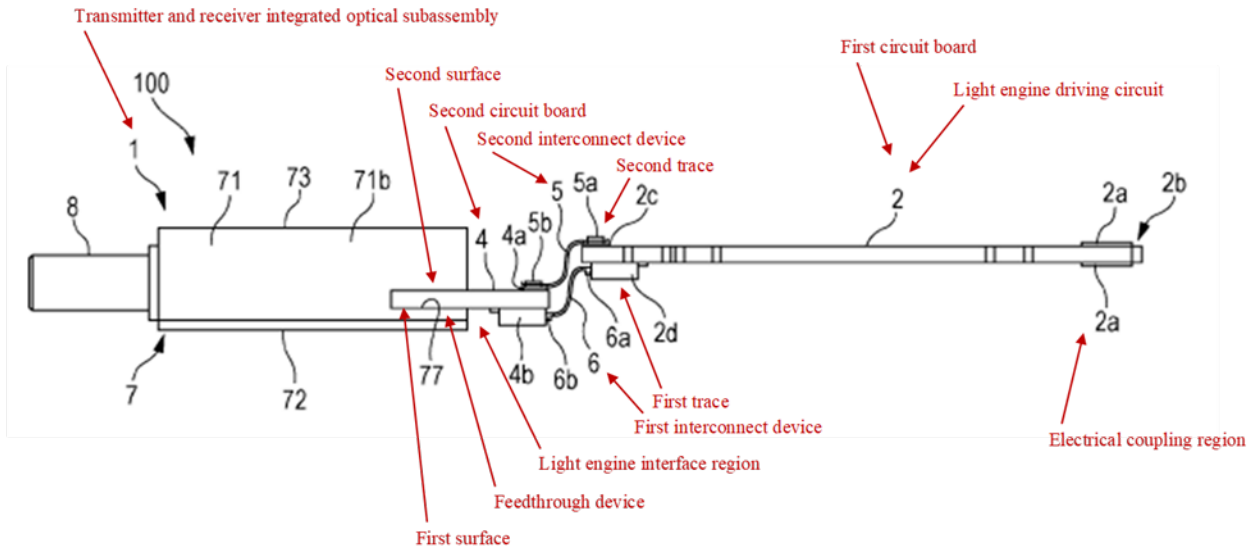


FIG. 2 (Mizobuchi)

iv. **Claim 1: [1d] a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically-sealed light engine to output one or more channel wavelengths;**

76. Mizobuchi discloses a light engine driving circuit disposed on the substrate that includes a clock data recovery (“CDR”) circuit and a power supply circuit. *See* Ex. 1006, FIGS. 2, 3A, 3:57-64, 12:27-41. The light engine driving circuit provides RF and power signals to drive the hermetically sealed light engine to output one or more channel wavelengths. *Id.*, 3:65-4:18.

v. **Claim 1: [1e] wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal**

77. In my opinion, a POSITA would have understood that RF and power signals are carried on opposite surfaces on the first and second circuit boards 2 and 4 of Mizobuchi to correspond to the arrangement of RF and power signal traces on the flexible printed circuits (FPCs) 5 and 6. *Id.*, 4:19-65. It further is my opinion that a POSITA would have understood that Mizobuchi discloses that the substrate (circuit board 2) includes a first trace disposed on its first (lower) surface to provide the power signal and a second trace disposed on its second (upper) surface to provide the RF signal. Ex. 1006, FIG. 2, 5:18-21 (“low-speed electrical signals of 1 MHz or lower including direct-current signals and power source signals are transmitted between both the circuit boards 2 and 4 through this second FPC 6.”); *id.*, 5:4-17 (“high-speed electrical signals of 1 GHz or higher is transmitted between both the circuit boards 2 and 4 through this first FPC 5. The first FPC5 is directly connected to both the circuit boards 2 and 4 by soldering and provided with the impedance lines for high-speed transmission”).

78. Thus, in my opinion, Mizobuchi discloses first and second traces disposed in an opposing arrangement (on opposite sides of circuit boards 2 and 4), to provide electrical isolation therebetween and thereby reduce electrical interference between the power signal and the RF signal. Moreover, this design is fully consistent, e.g., with Hartzell, Ex. 1008, ¶¶ [0028]-[0033], which discusses a well-known electronics design technique to locate RF signal and power signals on

separate planes in an optical communication module to reduce interference.

**vi. Claim 1: [1f] a feedthrough device to electrically couple the at least one laser package to the light engine driving circuit; and**

79. Mizobuchi discloses a feedthrough device that electrically couples the laser packages to the light engine driving circuit. *See* Ex. 1006, FIGS. 2, 3A, 6:32-37, 6:61-7:64.

**vii. Claim 1: [1g] wherein the feedthrough device is defined by at least a first surface disposed opposite a second surface, and wherein the first and second surfaces extend substantially parallel with the first and second surfaces of the substrate.**

80. Mizobuchi discloses the feedthrough device is defined, in part, by a first surface and a second surface of the second circuit board, such that the first surface and the second surface of the feedthrough device extend substantially parallel with the respective opposing surfaces of the substrate. *See* Ex. 1006, FIG. 2, 6:32-60.

81. For the foregoing reasons, Mizobuchi anticipates Claim 1.

**viii. Claim 2: The TOSA module of claim 1, further comprising at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically-sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically-sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different.**

82. In my opinion, Mizobuchi discloses that a first interconnect device of a first type is electrically coupled to the first trace and a corresponding trace of the

housing of the hermetically sealed light engine to provide the power signal. Mizobuchi describes that the power traces of FPC 6 are coupled to circuit boards 2 and 4 by an easily removable FPC connector, a first type of interconnect device. Ex. 1006, 5:23-27, 32-34, 12:27-41 (“first FPC 5 for the high-speed electrical signals and the second FPC 6 for low-speed electrical signals including the power source signals are separately provided. This allows the first and second FPCs 5 and 6 to be formed of different materials and have different structures. Thus, the cost can be reduced by using, for example, a low-cost FPC as the second FPC 6.”)

83. Mizobuchi further describes a second interconnect device of a second type that is electrically coupled to the second trace and a corresponding trace of the housing of the light engine to provide the RF signal. *Id.* In my opinion, this corresponds to the RF signal traces on circuit boards 2 and 4 being coupled by FPC 5, which is soldered to the respective electrode pads of circuit boards 2 and 4. *Id.*, 5:4-10, 5:29-31. Accordingly, Mizobuchi discloses a first type of first interconnect device (which carries the power signal) that is different than a second type of a second interconnect device (which carries the RF signal), as required by Claim 2. *Id.* For the device of Claim 1, *see supra*, Sections X.a.i-vii.

84. Accordingly, in my opinion, a POSITA would have understood that Mizobuchi anticipates Claim 2.

**ix. Claim 3: The TOSA module of claim 2, wherein the first type of interconnect device is a DC bus bar interconnect.**

85. It is my opinion that a POSITA would have understood in April 2018 that a DC busbar was a well-known method of distributing power in a direct current voltage distribution system. A POSITA further would have understood the advantages of using a DC busbar to power to multiple lasers, as the power requirements for driving laser packages would be similar, and use of a busbar would conserve space on the interconnect device for electrically coupling the power signal on the first (lower) surface of the Mizobuchi circuit boards 2 and 4. Accordingly, it would have been a simple design choice for a POSITA to use a DC busbar for the first type of interconnect for the power signals, as an alternative to the FPC connector suggested in Mizobuchi for FPC 6. *See* Ex. 1006, FIG. 2, 12:11-15, 12:35-41. For the device of Claim 2, *see supra*, Sections X.a.viii.

86. Accordingly, a POSITA would have understood that Mizobuchi anticipates Claim 3.

**x. Claim 4: The TOSA module of claim 2, wherein the second type of interconnect device is a wire bond.**

87. It is my opinion that a POSITA would have understood in April 2018 that wire bonds are especially suitable for interconnecting semiconductor chips to package leads for carrying RF signals. A POSITA further would have understood that wire bonds provide a direct electrical and thermal path between the coupled

semiconductor components that helps to dissipate heat generated by RF signals.

88. In my opinion, it would have been a simple design choice for a POSITA to use wire bonds as the second type of interconnect for coupling the RF signals, as an alternative to the soldered connections for FPC 5 described in Mizobuchi. *See* Ex. 1006, FIG. 2, 12:8-11, 12:27-34. For the device of Claim 2, *see supra*, Sections X.a.viii.

89. Thus, in my opinion, a POSITA would have understood that Mizobuchi anticipates Claim 4.

**xi. Claim 5: The TOSA module of claim 1, further comprising at least one ground trace disposed on the second surface adjacent the second trace.**

90. It is my opinion that, as a matter of simply understanding RF electronics, a POSITA would have understood in April 2018 that providing a ground trace between adjacent traces carrying RF signals would provide isolation and reduce crosstalk between the RF signals. A POSITA further would have understood the advantages of using a ground trace amongst the RF signal traces on the upper surface of circuit boards 2 and 4 of Mizobuchi to provide further isolation of the RF signals. Indeed, Mizobuchi discloses that the at least one impedance line provided on the upper surface of circuit boards 2 and 4 (which carries the RF signals) may be a grounded co-planar line. Ex. 1006, 14:30-15:21.

91. In my opinion, in view of the emphasis in Mizobuchi on isolating the power and RF signals, a POSITA would have understood it to be a simple design choice to use in Mizobuchi a ground trace disposed on the second surface, adjacent to the second trace carrying RF signals, to reduce crosstalk between RF signals. *See* Ex. 1006, FIG. 2, 12:8-11, 12:27-34. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

92. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 5.

**xii. Claim 6: The TOSA module of claim 5, further comprising a DC bus bar interconnect device electrically coupled to the at least one ground trace and a wire bond electrically coupled to the second trace.**

93. As discussed for Claims 3-5 above, in my opinion, a POSITA in April 2018 would have been thoroughly familiar with use DC busbars, wire bonds and locating ground traces adjacent to RF signal traces, and moreover, would have considered the use of any or all of these features to be simple design choices in implementing the optical transceiver of Mizobuchi. Claim 6 simply combines these well-known and well-understood alternative design features. Based on the disclosure of Mizobuchi and my understanding of the knowledge possessed by those of skill in the art, a POSITA in April 2018 would have understood that Claim 6 is anticipated. For the device of Claim 5, *see supra*, Section X.a.xi.

94. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 6.

**xiii. Claim 7: The TOSA module of claim 1, wherein the electrical isolation is provided at least in part by a width of the substrate and/or material properties of a material that forms the substrate.**

95. It is my opinion that a POSITA would have understood in April 2018 that varying the width of a substrate or varying the material properties of the substrate would improve electrical isolation of traces disposed in an opposing arrangement on the substrate. Ex. 1006, 4:26-29 (“The first circuit board 2 and the second circuit board 4 each include, for example, a ceramic multilayer board.”). *See also* Ex. 1008, ¶¶ [0028]-[0033]. Accordingly, a POSITA would have understood that such techniques could be used to enhance isolation between the power signals and RF signals in Mizobuchi. *See* Ex. 1006, FIG. 2, 12:35-41. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

96. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 7.

**xiv. Claim 8: The TOSA module of claim 1, further comprising a plurality of electrical interconnects that brace the substrate to the housing of the hermetically sealed light engine.**

97. It is my opinion a POSITA in April 2018 would have understood that it often is necessary to mechanically strengthen physical interconnections between circuit boards to account, e.g., for differential thermal expansion of the boards

caused by the electrical components located thereon or bending stresses. A POSITA further would have understood that RF signal electronics and laser packages often generate high heat loads that can exacerbate mechanical stresses imposed by thermal expansion. Accordingly, a POSITA would have understood that in Mizobuchi, part of circuit board 4 of the feedthrough device is secured by solder in the opening 77 plus the slots in either side wall 71b and 71c. Ex. 1006, FIG. 3A, 6:32-43. A POSITA would have understood that it would have been a simple matter of design choice also to use a plurality of electrical interconnects to brace the substrate in the housing of the light engine. For the device of Claim 1, *see supra*, Section X.a.i-vii.

98. Accordingly, in my view, a POSITA would have understood that Mizobuchi anticipates Claim 8.

**xv. Claim 9: The TOSA module of claim 1, wherein the feedthrough device is configured to directly couple to the substrate with an end-to-end connection.**

99. A POSITA in April 2018 would have understood that adjacent circuit boards readily could be joined using end-to-end connectors. In my opinion, a POSITA would have understood that it would have been a simple matter of design choice to use an end-to-end connector to couple the circuit board of the feedthrough device (circuit board 4) to the circuit board 2 of Mizobuchi. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

100. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 9.

**xvi. Claim 10: The TOSA module of claim 1, wherein the first and second surfaces of the feedthrough device are substantially coplanar with the first and second surfaces of the substrate when the feedthrough device and substrate are coupled together.**

101. In my opinion, a POSITA in April 2018 would have understood that having adjacent connected circuit boards be coplanar would be a matter of design choice, based on the type of connector used and the desired length of the housing accommodating the optical module. For example, use of an end-to-end connector necessarily would result in the joined boards being coplanar.

102. I note that the '024 Patent does not provide or explain what benefit would be achieved by making the feedthrough device coplanar with the substrate. On the contrary, such an arrangement would seem undesirable as potentially elongating the transceiver module. However, a POSITA further would have understood this connection mode as being a simple matter of design choice if space was available. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

103. A POSITA would have understood that Mizobuchi anticipates Claim 10.

**xvii. Claim 11: The TOSA module of claim 1, further comprising at least one trace for receiving the power signal from the light engine driving circuit disposed on the first surface of the feedthrough and at least one trace for receiving the RF signal from the light engine driving circuit disposed on the second surface.**

104. A POSITA would have understood that it was well-known in April 2018 that RF signals could be isolated from power signals to reduce interference by placing the signals on opposite sides of the circuit boards, or alternatively, by physically spacing apart the power and RF signal traces on the same side of a substrate. A POSITA therefore would have understood that although less desirable, such a design readily could be used in the optical transceiver of Mizobuchi provided that the width of circuit boards 2 and 4 could accommodate a power trace on the upper surface of the boards, and that such a choice involves no inventive effort. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

105. Accordingly, in my view a POSITA would have understood that Mizobuchi anticipates Claim 11.

**xviii. Claim 12: An optical transceiver comprising:**  
**a housing;**  
**a transmitter optical subassembly (TOSA) module disposed in the housing, the TOSA module comprising:**  
**a hermetically-sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package disposed within the hermetic-sealed cavity;**  
**a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically-sealed light engine;**  
**a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically-sealed light engine to output one or more channel wavelengths; and**  
**wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal, and at least a second trace**

**disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal;**

**at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically-sealed light engine to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically-sealed light engine to provide the RF signal, the first and second types of interconnect devices being different;**

**a receive optical subassembly (ROSA) module disposed in the housing.**

106. Claim 12 combines the limitations of Claims 1 and 2 of the '024 Patent, except that (i) it requires at least first and second “interconnect devices” instead of a “feedthrough device;” and further requires (ii) that the TOSA be located in the housing of an optical transceiver; and (iii) that the transceiver include a receive optical subassembly (ROSA) in the housing. *See* Ex. 1002, pp. 32-33 (referring to application claim 14).

107. As I explained above with respect Claims 1 and 2 in my analysis of the claimed “feedthrough device,” *supra*, Sections X.a.i-vii, Mizobuchi discloses first and second interconnect devices (FPC 5 and 6) that separately carry RF signals and power signals between corresponding traces of the substrate and hermetically sealed light engine. Mizobuchi also discloses an optical transceiver that includes a TOSA within a hermetically sealed housing and a ROSA disposed within the housing. Ex. 1006, FIGS. 2, 3A, 3:26-31.

108. In my opinion, Mizobuchi also discloses all of the limitations of Claim 12 for the reasons set forth and for Claims 1 and 2. *See supra*, Sections X.a.i-xviii.

109. Accordingly, in my view, a POSITA would have understood that Mizobuchi anticipates Claim 12.

**xix. Claim 13: The optical transceiver of claim 12, wherein the first type of interconnect device comprises a DC bus bar disposed on the first and second surfaces of the substrate.**

110. Claim 13 includes all of the limitations of Claims 12 and 3. Accordingly, a POSITA would have understood that Mizobuchi, together with knowledge of skill in the art, discloses all of the limitations of Claim 13 for the reasons set forth *supra* for Claims 12 and 3. *See supra*, Sections X.a.xviii and ix.

111. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 13.

**xx. Claim 14: The optical transceiver of claim 12, wherein the second type of interconnect device is a wire bonds.**

112. Claim 14 includes all of the limitations of Claims 12 and 4. Accordingly, a POSITA would have understood that Mizobuchi, together with knowledge of skill in the art, discloses all of the limitations of Claim 14 for the reasons set forth *supra* for Claims 12 and 4. *See supra*, Sections X.a.xviii and x.

113. A POSITA would have understood that Mizobuchi anticipates Claim 14.

**xxi. Claim 15: A transmitter optical subassembly (TOSA) module comprising:**

**a hermetically-sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;**

**a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically-sealed light engine;**

**a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically-sealed light engine to output one or more channel wavelengths;**

**wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal; and**

**at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically-sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically-sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different.**

114. Claim 15 combines all of the limitations of Claims 1 and 2, except that Claim 15 requires at least first and second “interconnect devices” instead of a “feedthrough device.” Ex. 1002, pp. 32-33 (referring to application claim 18)

115. As I explained above with respect Claims 1 and 2 in my discussion of the claimed “feedthrough device,” *supra*, Sections X.a.i-viii, Mizobuchi discloses

first and second interconnect devices (FPC 5 and 6) that separately carry RF signals and power signals between corresponding traces of the substrate and the hermetically sealed light engine. Mizobuchi also discloses all of the other limitations of Claim 15 for the reasons set forth *supra* for Claims 1 and 2. *See supra*, Sections X.a.i-xviii.

116. In my opinion, a POSITA would have understood that Mizobuchi anticipates Claim 15.

**xxii. Claim 16: The TOSA module of claim 15, wherein the first type of interconnect device is a DC bus bar interconnect.**

117. Claim 16 includes all of the limitations of Claims 15 and 3. Accordingly, a POSITA would have understood that Mizobuchi, together with knowledge of skill in the art, discloses all of the limitations of Claim 16 for the reasons set forth *supra* for Claims 15 and 3. *See supra*, Sections X.a.xxi and ix.

118. Thus, a POSITA would have understood that Mizobuchi anticipates Claim 16.

**xxiii. Claim 17: The TOSA module of claim 15, wherein the second type of interconnect device is a wire bond.**

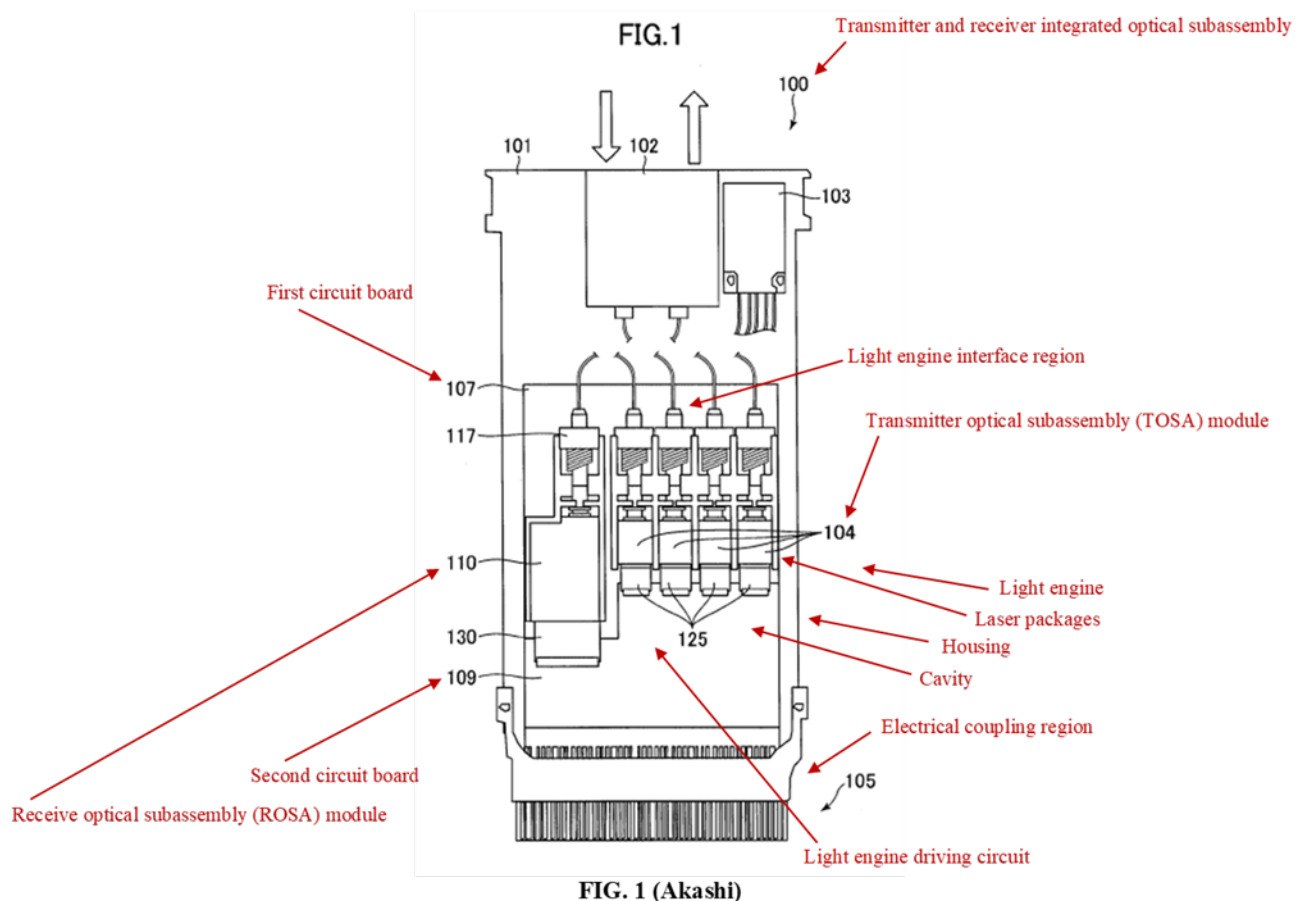
119. Claim 17 includes all of the limitations of Claims 15 and 4. Accordingly, a POSITA would have understood that Mizobuchi, together with knowledge of skill in the art, discloses all of the limitations of Claim 17 for the reasons set forth *supra* for Claims 15 and 4. *See supra*, Sections X.a.xxi and x.

120. Accordingly, in my view a POSITA would have understood that Mizobuchi anticipates Claim 17.

**b. Ground 1: Akashi anticipates Claims 1-17.**

**i. Claim 1: [1a] A transmitter optical subassembly (TOSA) module comprising:**

121. Akashi discloses a transmitter and receiver integrated optical subassembly that includes a TOSA module. *See* Ex. 1007, FIG. 1, ¶¶ [0008], [0016], [0026].



**ii. Claim 1: [1b] a hermetically-sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;**

122. Akashi discloses a hermetically sealed light engine having a housing that defines a hermetically sealed cavity, with multiple laser packages disposed within the cavity. Ex. 1007, FIG. 1, ¶¶ [0010], [0026], [0027]. A laser package of each TOSA 104 is configured as a light emitting element and emits an associated channel wavelength. *Id.* A POSITA would have understood that the TOSA 104 and ROSA 110 modules are enclosed within a hermetically sealed cavities to prevent environmental factors (e.g., dust) from degrading the performance of the lasers.

**iii. Claim 1: [1c] a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically-sealed light engine;**

123. Akashi discloses a first circuit board 107 that has first and second surfaces disposed opposite each other and defines a substrate; the first circuit board is connected to a second circuit board 109. Ex. 1007, FIG. 1, ¶ [0026]. The substrate defined by the first circuit board 107 includes an electrical coupling region (flexible printed circuits 125) and a light engine interface region (adjacent to optical connector 117). *Id.*, ¶ [0027]. The electrical coupling region is configured to electrically couple with a transmit connecting circuit and the light engine interface

region is configured to electrically couple with the hermetically sealed light engine via the second circuit board. *Id.*, ¶¶ [0026]-[0027].

**iv. Claim 1: [1d] a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically-sealed light engine to output one or more channel wavelengths;**

124. In my opinion, a POSITA would have understood that Akashi discloses a light engine driving circuit disposed on the substrate 107 that provides a RF signal and a power signal to drive the hermetically sealed light engine to output one or more channel wavelengths. *See* Ex. 1007, FIG. 1, ¶¶ [0026]-[0027].

**v. Claim 1: [1e] wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal**

125. In my opinion, a POSITA would have understood that Akashi discloses that the substrate 107 includes a first trace disposed on its first surface to provide the power signal and a second trace disposed on its second surface to provide the RF signal. Ex. 1007, FIGS. 1, 2, 6, ¶¶ [0010], [0015] (“In the optical module according to the aspect of the invention, the flexible printed circuit may further include one of surfaces on which a wire that transmits at least a high frequency [RF] signal is disposed, and the other surface on which a wire that supplies at least a fixed potential [DC voltage] is disposed, the one surface of the

flexible printed circuit may be arranged on the terminal portion side, and the other surface may be arranged on the lead fixing portion side”), Claim 6. The first trace and the second trace are disposed in an opposing arrangement, which provides electrical isolation and thereby reduces electrical interference between the power signal and the RF signal. *Id.*, ¶¶ [0015], [0030] [0033], [0038] ([0038] explains that circuit board configuration for the ROSA 110 applies equally to the design of TOSAs 104).

126. In addition, in my opinion a POSITA would have understood this configuration of the substrate 107 of Akashi to be required to match the design of the feedthrough device that couples the substrate to the TOSAs, which also has its first and second traces located in an opposing arrangement to reduce noise. *Id.* It is my further view that a POSITA would have understood that locating the RF and power signals on opposite sides of the substrate was the preferred design for RF electronics, e.g., as taught by Hartzell, Ex. 1008, to reduce interference between the power and RF signals. *See* Ex. 1008, ¶¶ [0028], [0038]-[0041].

**vi. Claim 1: [1f] a feedthrough device to electrically couple the at least one laser package to the light engine driving circuit; and**

127. Akashi describes a feedthrough device that includes flexible printed circuit 130 and a portion of circuit board 112 that extends from the hermetically sealed housing and couples the laser packages of the TOSAs 104 to the light driving engine on first circuit 107. Ex. 1007, FIG. 2, ¶¶ [0027]-[0028]. As discussed

above, Akashi plainly describes that the feedthrough device for the ROSA 110 applies equally to electrically couple the laser packages of TOSAs 104 to the light engine driving circuit. Ex. 1007, FIGS. 1, 2, ¶¶ [0030], [0038].

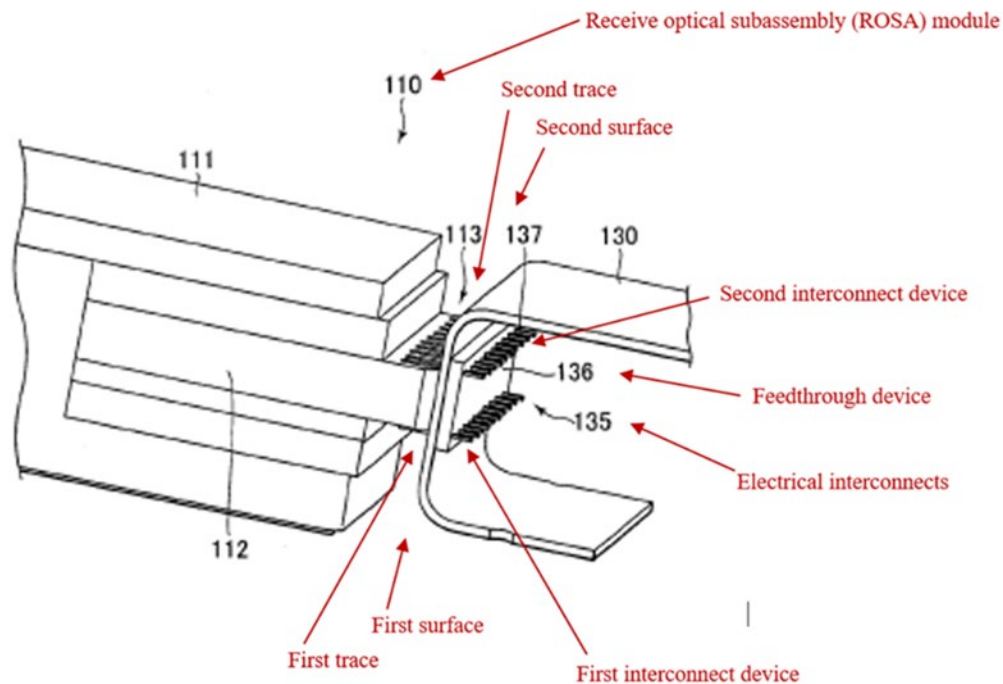
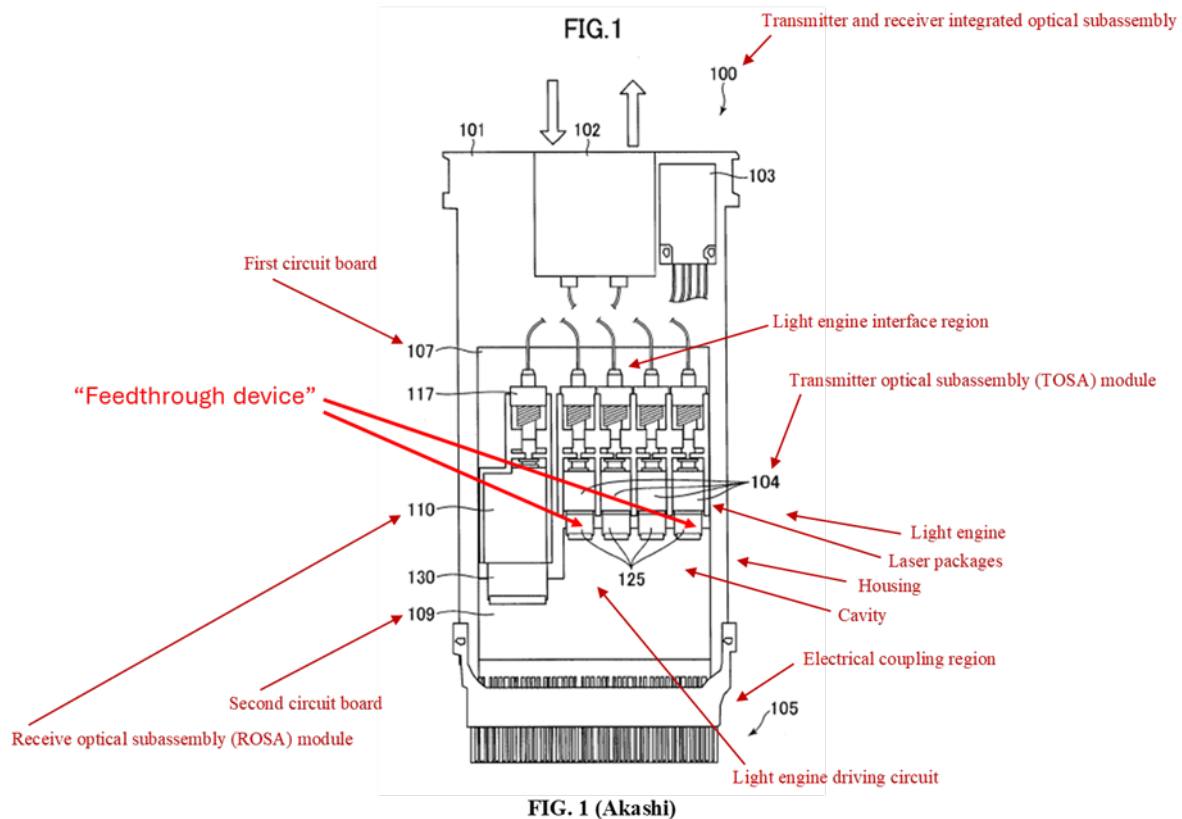


FIG. 2 (Akashi)

vii. **Claim 1: [1g] wherein the feedthrough device is defined by at least a first surface disposed opposite a second surface, and wherein the first and second surfaces extend substantially parallel with the first and second surfaces of the substrate.**

128. Akashi discloses a feedthrough device that includes flexible printed circuit 130 and a portion of the receiver substrate 112 that electrically couples the laser packages of the TOSAs to the light engine driving circuit on the first circuit 107. *Id.*, FIGS. 1, 2, ¶¶ [0010]-[0012], [0015], [0038]. Akashi discloses that the receiver substrate portion 112 of the feedthrough device extends substantially

parallel with the substrate 107. Ex. 1007, FIG. 1, ¶¶ [0010], [0015], [0026], [0031].



129. Thus, in my opinion, a POSITA would understand that Akashi discloses all of the elements of, and therefore anticipates, Claim 1.

**viii. Claim 2: The TOSA module of claim 1, further comprising at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically-sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically-sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different.**

130. It is my opinion that a POSITA would have understood, as a matter of design choice, that the flexible printed circuits disclosed in Akashi could be joined

to the traces on the upper and lower surfaces of the circuit boards of TOSAs 104 using any of the available connectors available in April 2018, for example, by soldering or using FPC connectors, as described *supra* for Mizobuchi, Ex. 1006. Further, it is my opinion that a POSITA would have understood Akashi to suggest such flexibility in choice of connectors with its disclosure of the embodiment of FIG. 8, which describes that the leads on the flexible printed circuit may be aligned in a single row. Ex. 1007, ¶¶ [0036]-[0038]

131. Thus, in my opinion a POSITA would have understood that it would have been a matter of design choice to use any of a variety of connections suitable for RF signal transmission, such as soldering, or wire bonds, to serve as a first interconnect device to couple to RF signals to the substrate 112 of the hermetically sealed light engine. *See* Ex. 1007, FIGS. 1, 2, ¶¶ [0010], [0014], [0015], [0033], [0038]. A POSITA also would have understood that it would have been a matter of design choice to use a second interconnect device of a second, different type, suitable for DC voltage, such as a DC busbar or FPC connector, to electrically couple a power signal to a corresponding trace of the housing of the light engine.

132. For the device of Claim 1, *see supra*, Sections X.b.i-vii. Accordingly, in my opinion, a POSITA would have understood that Akashi anticipates Claim 2.

**ix. Claim 3: The TOSA module of claim 2, wherein the first type of interconnect device is a DC bus bar interconnect.**

133. As discussed above with respect to Claim 2, it is my opinion a POSITA would have understood that it would have been a matter of design choice to use a first interconnect device of a first type, suitable for transmitting a DC voltage, such as a DC busbar or FPC connector, to electrically couple a power signal to a corresponding trace of the housing of the light engine. *See* Ex. 1007, FIGS. 1, 2, ¶¶ [0010], [0014], [0015], [0033], [0038]. For the device of Claims 1 and 2, *see supra*, Sections X.b.i-viii.

134. Accordingly, a POSITA would have understood that Akashi anticipates Claim 3.

**x. Claim 4: The TOSA module of claim 2, wherein the second type of interconnect device is a wire bond.**

135. It is my opinion that, as discussed above with respect to Claim 2, a POSITA would have understood that it would have been a matter of design choice to use a second interconnect device of a second type, suitable for transmitting RF signals, such as a solder or a wire bond, to electrically couple an RF signal to a corresponding trace of the housing of the light engine. *See* Ex. 1007, FIGS. 1, 2, ¶¶ [0010], [0014], [0015], [0033], [0038]. For example, a POSITA would have understood that wire bonds provide a direct electrical and thermal path between the coupled semiconductor components that helps to dissipate heat generated by RF

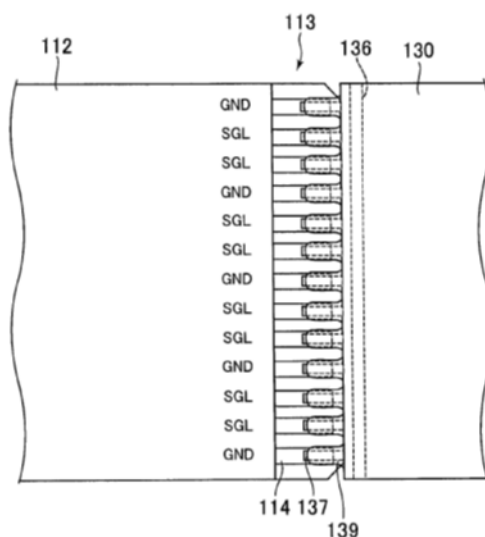
signals. For the device of Claims 1 and 2, *see supra*, Sections X.b.i-viii.

136. Thus, in my opinion, a POSITA would have understood that Akashi anticipates Claim 4.

**xi. Claim 5: The TOSA module of claim 1, further comprising at least one ground trace disposed on the second surface adjacent the second trace.**

137. It is my opinion that, as a matter of simply understanding RF electronics, a POSITA would have understood in April 2018 that providing a ground trace between adjacent traces carrying RF signals would provide isolation and reduce crosstalk between the RF signals. Moreover, Akashi discloses using at least one ground trace disposed adjacent to traces that carry RF signals for purposes of reducing interference. *See*, Ex. 1007, FIG. 4, (reproduced below), ¶ [0031]. For the device of Claim 1, *see supra*, Sections X.b.i-vii.

FIG.4



138. Thus, a POSITA would have understood that Akashi anticipates Claim 5.

**xii. Claim 6: The TOSA module of claim 5, further comprising a DC bus bar interconnect device electrically coupled to the at least one ground trace and a wire bond electrically coupled to the second trace.**

139. As I discussed above for Claims 3-5, a POSITA in April 2018 would have been thoroughly familiar with use DC busbars, wire bonds and ground traces placed adjacent to RF signal traces, and moreover, would have considered the use of these features to be simple design choices for implementing an embodiment of the optical transceiver of Akashi. Claim 6 simply combines these well-known and well-understood alternative design features. Thus, in my view, based on Akashi and the knowledge possessed by those of skill in the art, a POSITA in April 2018 would have understood that Claim 6 is anticipated. *See supra*, Sections X.b.ix-xi. For the device of Claim 5, *see supra*, Section X.b.xi.

140. Thus, in my opinion, a POSITA would have understood that Akashi anticipates Claim 6.

**xiii. Claim 7: The TOSA module of claim 1, wherein the electrical isolation is provided at least in part by a width of the substrate and/or material properties of a material that forms the substrate.**

141. It is my opinion that a POSITA would have understood in April 2018 that varying the width of a substrate or varying the material properties of the substrate would improve electrical isolation of traces disposed in an opposing

arrangement on the substrate. *See* Ex. 1007, FIGS. 1, 6, ¶ [0033]. Accordingly, a POSITA would have understood that such techniques could be used to enhance isolation between the power signals and RF signals in Akashi. For the device of Claim 1, *see supra*, Sections X.b.i-vii.

142. Thus, in my opinion, a POSITA would have understood that Akashi anticipates Claim 7.

**xiv. Claim 8: The TOSA module of claim 1, further comprising a plurality of electrical interconnects that brace the substrate to the housing of the hermetically sealed light engine.**

143. It is my opinion that A POSITA in April 2018 would have understood that it often is necessary to mechanically strengthen physical interconnections between circuit boards, e.g., to account for differential thermal expansion of the boards caused by the electrical components located thereon or bending stresses. A POSITA further would have understood that RF signal electronics and laser packages often generate high heat loads that can exacerbate mechanical stresses imposed by thermal expansion.

144. In my opinion, a POSITA would have understood that it would have been a simple matter of design choice to use a plurality of electrical interconnects to brace the substrate in the housing of the light engine in Akashi, especially since Akashi emphasizes the desirability of brace connection of the substrate to the housing of the hermetically sealed light engine. *See* Ex. 1007, FIG. 2, ¶¶ [0028],

[0029], [0030]. For the device of Claim 1, *see supra*, Sections X.b.i-vii.

145. Accordingly, in my view, a POSITA would have understood that Akashi anticipates Claim 8.

**xv. Claim 9: The TOSA module of claim 1, wherein the feedthrough device is configured to directly couple to the substrate with an end-to-end connection.**

146. In my view, a POSITA in April 2018 would have understood that adjacent circuit boards readily could be joined using end-to-end connectors. Accordingly, a POSITA would have understood that Akashi discloses that the first and second surfaces of the feedthrough device could, as a matter of design choice, be coupled to the substrate using an end-to-end connection. Ex. 1007, FIGS. 1, 2. For the device of Claim 1, *see supra*, Sections X.b.i-vii.

147. Thus, a POSITA would have understood that Akashi anticipates Claim 9.

**xvi. Claim 10: The TOSA module of claim 1, wherein the first and second surfaces of the feedthrough device are substantially coplanar with the first and second surfaces of the substrate when the feedthrough device and substrate are coupled together.**

148. In my opinion, a POSITA in April 2018 would have understood that having adjacent connected circuit boards be coplanar would be a matter of design choice, based on the type of connector used and the desired length of the housing accommodating the optical module. For example, use of an end-to-end connector necessarily would result in the joined boards being coplanar.

149. I do not find that the '024 Patent provides or explains any particular benefit that could be achieved by making the feedthrough device coplanar with the substrate. On the contrary, such an arrangement would seem undesirable as potentially elongating the transceiver module. However, a POSITA further would have understood this connection mode as being a simple matter of design choice if space was available. Ex. 1007, FIGS. 1, 2. For the device of Claim 1, *see supra*, Sections X.b.i-vii.

150. Thus, in my view a POSITA would have understood that Akashi anticipates Claim 10.

**xvii. Claim 11: The TOSA module of claim 1, further comprising at least one trace for receiving the power signal from the light engine driving circuit disposed on the first surface of the feedthrough and at least one trace for receiving the RF signal from the light engine driving circuit disposed on the second surface.**

151. Akashi discloses that the TOSA modules include at least one trace for receiving the power signal from the light engine driving circuit located on the first surface of the feedthrough device and at least one trace for receiving the RF signal from the light engine driving circuit located on the second surface. *See* Ex. 1007, FIGS. 1, 2; ¶¶ [0010], [0015], [0033], [0038] (explaining that circuit board configuration for the ROSA 110 also applies to the TOSAs 104). For the device of Claim 1, *see supra*, Sections X.b.i-vii.

152. Accordingly, in my view a POSITA would have understood that Akashi anticipates Claim 11.

**xviii. Claim 12: An optical transceiver comprising:**  
**a housing;**  
**a transmitter optical subassembly (TOSA) module disposed in the housing, the TOSA module comprising:**  
**a hermetically sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package disposed within the hermetic-sealed cavity;**  
**a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically sealed light engine;**  
**a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically sealed light engine to output one or more channel wavelengths; and**  
**wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal, and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal;**  
**at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically sealed light engine to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically sealed light engine to provide the RF signal, the first and second types of interconnect devices being different;**  
**a receive optical subassembly (ROSA) module disposed in the housing.**

153. Claim 12 combines the limitations of Claims 1 and 2 of the '024 Patent, except that (i) it requires at least first and second “interconnect devices”

instead of a “feedthrough device;” and further requires (ii) that the TOSA be located in the housing of an optical transceiver; and (iii) that the transceiver include a receive optical subassembly (ROSA) in the housing. *See* Ex. 1002, pp. 32-33 (referring to application claim 14).

154. In my opinion, Akashi discloses first and second interconnect devices that separately carry RF signals and power signals between corresponding traces of the substrate and hermetically sealed light engine. Specifically, Akashi discloses, in FIGS. 2 and 3, upper and lower sets of metal lead 137 that engage traces 113 on the top and bottom surfaces of substrate 112 (which extends into the hermetically sealed cavity). Ex. 1007, ¶¶ [0029]-[0031]. In my opinion, a POSITA would have understood that the upper and lower sets of metal leads 137 couple to respective RF signal and power traces located on substrate 112, and thus meet the claim limitation of first and second interconnect devices. Akashi also discloses an optical transceiver that includes a TOSA within a hermetically sealed housing and a ROSA disposed within the housing. Ex. 1007, FIGS. 1-3, ¶¶ [0010]-[0012], [0015], [0025]-[0027], [0038].

155. Akashi therefore discloses all of the limitations of Claim 12 for the reasons explained above as set forth and for Claims 1 and 2. *See supra*, Sections X.b.i-xviii. Accordingly, in my view, a POSITA would have understood that Akashi anticipates Claim 12.

**xix. Claim 13: The optical transceiver of claim 12, wherein the first type of interconnect device comprises a DC bus bar disposed on the first and second surfaces of the substrate.**

156. Claim 13 includes all of the limitations of Claims 12 and 3. In my opinion, a POSITA would have understood that Akashi, together with knowledge of skill in the art, discloses all of the limitations of Claim 13 for the reasons set forth *supra* for Claims 12 and 3. *See supra*, Sections X.b.xviii and ix.

157. A POSITA therefore would have understood that Akashi anticipates Claim 13.

**xx. Claim 14: The optical transceiver of claim 12, wherein the second type of interconnect device is a wire bonds.**

158. Claim 14 includes all of the limitations of Claims 12 and 4. Thus, in my opinion a POSITA would have understood that Akashi, together with knowledge of skill in the art, discloses all of the limitations of Claim 14 for the reasons set forth *supra* for Claims 12 and 4. For the device of Claims 1, *see supra*, Sections X.b.xviii and x.

159. Thus, a POSITA would have understood that Akashi anticipates Claim 14.

**xxi. Claim 15: The A transmitter optical subassembly (TOSA) module comprising:**

**a hermetically-sealed light engine with a housing that defines a hermetic-sealed cavity and at least one laser package for emitting an associated channel wavelength disposed within the hermetic-sealed cavity;**

**a substrate defined by first and second surfaces disposed opposite each other, the substrate including an electrical coupling region for electrically coupling with a transmit connecting circuit and a light engine interface region for electrically coupling with the hermetically-sealed light engine;**

**a light engine driving circuit disposed on the substrate to provide a radio frequency (RF) signal and a power signal to drive the hermetically-sealed light engine to output one or more channel wavelengths;**

**wherein the substrate includes at least a first trace disposed on the first surface to provide the power signal and at least a second trace disposed on the second surface to provide the RF signal, the first and second traces being disposed in an opposing arrangement to provide electrical isolation to reduce electrical interference between the power signal and the RF signal; and**

**at least a first interconnect device of a first type electrically coupled to the first trace and a corresponding trace of the hermetically-sealed light engine housing to provide the power signal, and at least a second interconnect device of a second type electrically coupled to the second trace and a corresponding trace of the hermetically-sealed light engine housing to provide the RF signal, the first and second types of interconnect devices being different..**

160. Claim 15 combines all of the limitations of Claims 1 and 2, except that Claim 15 requires at least first and second “interconnect devices” instead of a “feedthrough device. Ex. 1002, pp. 32-33 (referring to application claim 18). As I opined above with respect Claim 12, *supra*, Section X.b.xviii, Akashi discloses first and second interconnect devices that separately carry RF signals and power signals between corresponding traces of the substrate and hermetically sealed light engine. Akashi also discloses all of the other limitations of Claim 15 for the reasons set forth *supra* for Claims 1 and 2. *See supra*, Sections X.b.i-xviii.

161. Accordingly, in my opinion, a POSITA would have understood that Akashi anticipates Claim 15.

**xxii. Claim 16: The TOSA module of claim 15, wherein the first type of interconnect device is a DC bus bar interconnect.**

162. Claim 16 includes all of the limitations of Claims 15 and 3. In my opinion, a POSITA would have understood that Akashi, together with knowledge of skill in the art, discloses all of the limitations of Claim 16 for the reasons set forth *supra* for Claims 15 and 3. *See supra*, Sections X.b.xxi and ix.

163. A POSITA would have understood that Akashi anticipates Claim 16.

**xxiii. Claim 17: The TOSA module of claim 15, wherein the second type of interconnect device is a wire bond.**

164. Claim 17 includes all of the limitations of Claims 15 and 4. In my opinion, a POSITA would have understood that Akashi, together with knowledge of skill in the art, discloses all of the limitations of Claim 17 for the reasons set forth *supra* for Claims 15 and 4. *See supra*, Sections X.b.xxi and x.

165. Accordingly, in my view, a POSITA would have understood that Akashi anticipates Claim 17

**XI. Revision or Supplementation**

166. In this report, I have presented my opinions regarding the invalidity of the challenged claims of the '116 Patent based on the information available to me. My opinions are subject to change in view of opinions provided by the Patent Owner

or its expert, or any additional information that I may receive. I reserve the right to supplement my opinions accordingly.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed January 14, 2025 at Montreal, Canada.

A handwritten signature in blue ink, appearing to be 'A L' or 'A H' with a stylized flourish.

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Dr. Andrew G. Kirk