UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CAMBRIDGE INDUSTRIES USA INC.,

Petitioner

v.

APPLIED OPTOELECTRONICS, INC.,

Patent Owner

Case No. IPR2025-00434
U.S. Patent No. 10,379,301

DECLARATION OF DR. ANDREW G. KIRK IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 10,379,301

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TABLE OF CONTENTS

TABLE OF EXHIBITS

Exhibit	Short Name	Description
Ex. 1001	’301 Patent	U.S. Patent No. 10,379,301
Ex. 1002	’301 File History	File History of U.S. Patent No. U.S. Patent No. 10,379,301
Ex. 1003	Kirk Declaration	Declaration of Dr. Andrew G. Kirk
Ex. 1004	Kirk CV	*Curriculum Vitae* of Dr. Kirk
Ex. 1005	Viswanadham	ESSENTIALS OF ELECTRONIC PACKAGING, P. Viswanadham, ASME (2011), pp. 7-9.
Ex. 1006	Pecht	HANDBOOK OF ELECTRONIC PACKAGE DESIGN, M. Pecht, Ed., Marcel Dekker, Inc. (1991), pp. 76-83, 173-178, 515-517.
Ex. 1007	Shen	U.S. Patent Pub. No. US 2016/0349451
Ex. 1008	Shen provisional	U.S. prov. patent appln SN 62/166015
Ex. 1009	Soldano	U.S. Patent No. 9,768,901
Ex. 1010	Scheduling Order	Scheduling Order dated August 7, 2024, in *Applied Optoelectronics, Inc. v. Cambridge Industries USA, Inc.*, No. 3:24-cv-01010-JD (N.D. Cal.)
Ex. 1011	Claim Terms	Joint Claim Construction and Pre-Hearing Statement in *Applied Optoelectronics, Inc. v. Cambridge Industries USA, Inc.*, No. 3:24-cv-01010-JD (N.D. Cal.)

DECLARATION OF DR. ANDREW G. KIRK

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. 10,379,301 ("the '301 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 '301 Patent and to evaluate whether certain claims of the '301 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 '301 Patent, which I am informed is, for purposes of the '301 Patent, is the earliest effective filing date of Chinese application CN 103460078, May 23, 2016.

22. I have been asked to identify the level of skill in the art pertinent to the '301 Patent. It is my opinion that a person of ordinary skill in the art pertinent to the '301 Patent would have had at least a bachelor's degree in electrical engineering, computer engineering, computer science, or similar discipline and had approximately two years of experience with optical communications and networks. 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 May 2016 would have been familiar with MSA optical specifications and photonics module components. The '301 Patent concerns itself with photonics modules for use in optical networking systems, as well as the miniaturization of those technologies. Thus, a POSITA in May 2016 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 (May 23, 2016), and for many years 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 2016, 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 '301 Patent have been based on the perspective of a person of ordinary skill in the art as of around May 2016. 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 2016-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:

- "**Viswanadham**" Ex. 1005, ESSENTIALS OF ELECTRONIC PACKAGING, P. Viswanadham, ASME (2011), pp. 7-9.
- "**Pecht**" Ex. 1006, HANDBOOK OF ELECTRONIC PACKAGE DESIGN, M. Pecht, Ed., Marcel Dekker, Inc. (1991), pp. 76-83, 173-178, 515-517.
- **"Shen"** Ex. 1007, which is U.S. Patent Application Publication No. US 2016/0349451, filed on May 24, 2016, and published on December 1, 2016, which claims priority to, and incorporates by reference, Shen U.S. Provisional

Application No. 62/166,015, Ex. 1008, filed May 25, 2015.

- "**Soldano"** Ex. 1008, which is U.S. Patent No. 9,768,901, filed on February 12, 2015, and issued on September 19, 2017, claiming priority to U.S. Provisional Patent Application 62/082,529, filed November 20, 2014.

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 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 May 2016, the earliest alleged priority date of the '301 Patent.

39. Optical receiving modules are designed to receive an optical signal from an optical fiber and convert the received optical signal into an electrical signal. *See* Ex. 1001, 1:12-15. Multi-channel (also known as multiwavelength) optical receiving modules receive a single multiwavelength optical signal and separate that signal into separate multiple channel wavelengths, which channel wavelengths then are converted to electrical signals for further processing. *See* Ex. 1001, 1:37-54. The use of multiwavelength optical signals maximizes the system transmission rate

over long distances, thereby allowing for a higher volume of data throughput. Ex. 1001, 1:12.

a. Pluggable Optical Transceiver Modules

40. The optical-to-electrical interface is where electrical and fiber cables are connected to one another via an optical transceiver module. To allow the electrical and fiber cables to communicate with one another, the optical transceiver module converts between optical and electrical signals. Ex. 1001, 1:12-15.

41. Traditionally, optical transceiver modules were bulky and mounted in a relatively fixed configuration, such as mounted on a circuit card located in a computer, peripheral device, or on a shelf in an equipment rack. But as optical networks increased in popularity, the market requirement to expand the capacity of network equipment required improvements in the density of the network equipment. *Id.*, 1:15-22. This requirement manifested itself in a need to improve the density of optical interfaces at a faceplate, which led to the creation of a new type of transceiver: a Small Form Factor (SFF) device.

42. The availability of SFF devices enabled high port densities in optical transmission systems. However, while solving the density problem, the SFF package had to be soldered down to the board, making replacement and repair a difficult process. To resolve the drawbacks of the SFF device, it was desirable to produce smaller hot-pluggable optical transceivers that could be easily removable.

43. In the late 1990s and early 2000s, photonics module developers began developing and designing transceiver modules that could be inserted into and removed from a live circuit pack without disrupting service or impacting the performance of any other ports already in service, leading to the creation of Small Form-factor Pluggable (SFP) transceivers. The SFP modules were similar in size to the SFF devices, but were hot-pluggable, offering full flexibility and permitting a mix of various transceiver types on a single circuit pack, while easing replacement in the case of transceiver failure.

44. In order to facilitate simple pluggable insertion and removal from the host device, these transceiver modules were constructed with a protective cage mounted at the front of the host device and an electrical interface having an electrical connector. The electrical interface provides all necessary input and output signals from the transceiver module to the host device.

45. In an effort to standardize industry offering intercompatibility, system vendors supported Multi-Source Agreements ("MSA") − agreements between component suppliers to define and specify all the physical and electrical requirements for specific pluggable form factors. With MSAs in place, system vendors could concentrate on system architecture and advanced optical research and development. Several MSA optical module types were known by 2003, including but not limited to:

- Small form-factor pluggable (SFP) (*see* INF-8074i Specification for SFP (Small Formfactor Pluggable) Transceiver, Rev. 1.0, May 12, 2001); and
- 10G small form factor pluggable (XFP) (initial publication in March 2002; 10 Gigabit Small Factor Pluggable Module, XFP Revision 4.5).

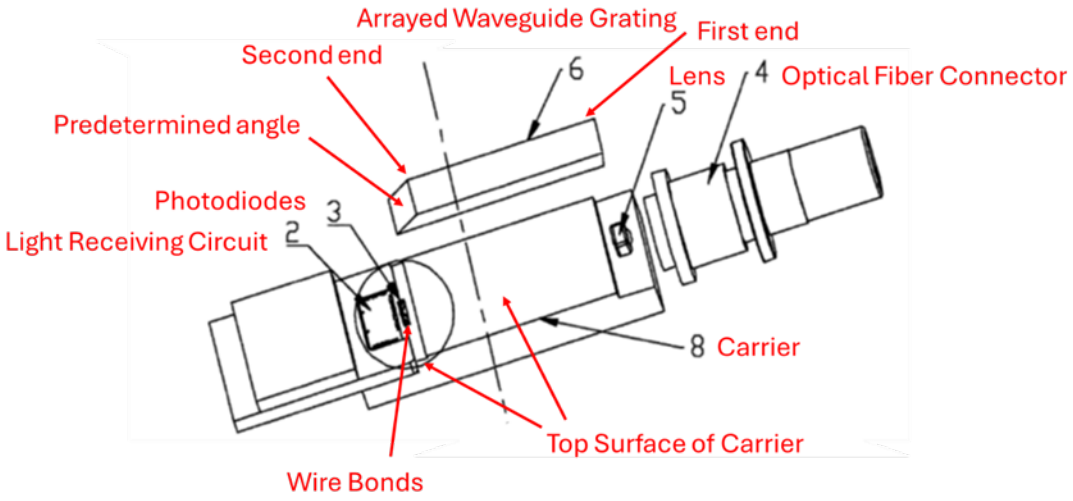
46. A POSITA in 2016 would have understood that the form factor used for the transceiver depends on the type of data, speed, and distance between communication devices.

VI. The '301 Patent

47. The '301 Patent generally relates to an optical receiving module in which an optical demultiplexer, in the form of an arrayed waveguide grating ("AWG") is coupled to photodetectors by an angled end portion of the AWG. Such arrangements, and the use thereof, were well-known to persons of skill in the art (POSITAs) of photonics module and planar light circuit ("PLC") design at the time the application that matured into the '301 patent was filed.

48. The '301 patent generally describes and claims a multiwavelength parallel optical receiving device having a carrier, a light receiving chip disposed on the carrier, an AWG disposed on the carrier having a first end that couples to an optical fiber connector to receive an optical signal comprised of multiple channel wavelengths, and a second end opposite the first end, and a plurality of optoelectronic diodes disposed on the carrier and electrically connected to the light

receiving chip, wherein the input optical signal is divided into a plurality of channel wavelengths in parallel and a top surface of the output end of the AWG has a predetermined angle of between 41 and 46 degrees that reflects the plurality of channel wavelengths to photosensitive surfaces of the optoelectronic diodes. Ex. 1001, Abstract, 1:37-53; claim 1.



Ex. 1001, FIG. 1 (partial, annotated)

49. The '301 Patent describes that the light receiving circuit processes the output of the photodiodes to generate electrical signals for further processing. As described in the '301 Patent, and as would have been generally understood by a POSITA, the light receiving circuit may be transimpedance amplifier ("TIA"), Ex. 1001, 3:5-9.

50. As I will describe, the '301 Patent describes and claims photonics structures that were well-known to persons of skill in the art of optical fiber communications ("POSITAs") before the application for the '301 Patent was filed.

See, e.g., Ex. 1007, ¶¶ [0006]-[0007]. In my opinion, the '301 Patent only removes from the public domain that which was well known to POSITAs at the time the application for the '301 Patent was filed.

51. I have been asked to evaluate Claims 1-7 of the '301 Patent. I have reproduced these challenged claims below:

Claim	Recitation
[1a]	A multi-channel parallel optical receiving device, comprising:
[1b]	a carrier;
[1c]	a light receiving chip disposed on a top surface of an end of the carrier;
[1d]	a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via bonding wire, wherein the optoelectronic diodes and the light receiving chip are disposed directly on the same top surface of the end of the carrier;
[1e]	an optical fiber connector disposed in an end of the carrier;
[1f]	an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber wherein the top surface of the carrier underlies the middle of the arrayed waveguide grating; and
[1g]	wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel, wherein the predetermined angle of the top surface defined by the output end of the arrayed waveguide grating is in a range of 41 to 46 degrees such that the top surface provides the reflection.

Claim	Recitation
[2]	The multi-channel parallel optical receiving device according to claim 1, wherein the top surface of the end of the carrier is defined at least in part by a circuit board and wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the circuit board.
[3]	The multi-channel parallel optical receiving device according to claim 1, wherein the amount of the optoelectronic diodes is equal to the amount of optical paths divided by the arrayed waveguide grating.
[4]	The multi-channel parallel optical receiving device according to claim 1, wherein the predetermined angle of the top surface of the output end of the arrayed waveguide grating is 42 degrees.
[5]	The multi-channel parallel optical receiving device according to claim 1, wherein a first lens, for coupling the optical fiber, is disposed between the input end of the arrayed waveguide grating and the optical fiber connector.
[6]	The multi-channel parallel optical receiving device according to claim 1, wherein the input end of the arrayed waveguide grating is inserted directly into the optical fiber connector and a graded index lens is disposed in an end where the optical fiber connector and the arrayed waveguide grating connect.
[7a]	A multi-channel parallel optical receiving device, comprising:
[7b]	a carrier;
[7c]	a light receiving chip disposed on a top surface of an end of the carrier;
[7d]	a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via wire bonding, wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the same top surface of the end of the carrier;
[7e]	an optical fiber connector disposed in an end of the carrier;
[7f]	an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber;

Claim	Recitation
[7g]	wherein the top surface of the carrier that defines the midpoint of the carrier underlies the middle of the arrayed waveguide grating; and
[7h]	wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle of 42 degrees, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel.

VII. Prosecution History of the '301 Patent, Ex. 1002.

52. Patent Owner filed Application No. 15/432,242 (the "'242 Application"), which issued as the '301 Patent on August 13, 2019, on February 14, 2017, claiming priority to Chinese patent application CN 1 03460078, filed May 23, 2016.

53. A non-final action was mailed August 29, 2017, rejecting application claims 1-7. Ex. 1002, pp. 239-252. Application claims 1-4 and 6 were rejected as anticipated by U.S. Patent Application Publication US 2017/0168252 to Pezeshki et al. ("Pezeshki") and also as obvious over U.S. Patent Application Publication US 2016/0349451 to Shen et al. ("Shen") in view of Pezeshki. *Id*., pp. 242-247. Application claims 5 and 7 were rejected as obvious over Pezeshki and in view of U.S. Patent Application Publication US 2003/0174964 to Gao et al. ("Gao"). *Id.*, pp. 247-250. At page 6 of the Office action, the Examiner correctly noted that Shen discloses dividing a multi-channel optical signal into a plurality of channel

wavelengths. *Id*., p. 245. For reasons that are unclear to me, as explained *infra*, the Office action asserts that "Shen does not expressly teach that the [optoelectronic] diode receiver is a plurality of OE diodes that are split into separate receiving portions." The Examiner instead relied on Pezeshki for this feature. *Id*., p. 246.

54. In an Amendment filed February 28, 2018, Patent Owner amended application claim 1 to recite that the optoelectric diodes and light receiving chip are disposed on the same surface of the carrier; a substantial portion of the arrayed waveguide grating is disposed on the top surface of the carrier; and that a predetermined angle at the output end of the arrayed waveguide grating is in a range of 41 to 46 degrees. Patent Owner argued that these limitations were not taught by Pezeshki or Shen. Ex. 1002, pp. 223-231.

55. A Final action was mailed on April 13, 2018, rejecting the application claims as indefinite regarding what constituted a "substantial portion" of the AWG. Ex. 1002, pp. 169-170. All application claims also were rejected as anticipated by U.S. Patent Application Publication US 2017/0307819 to Ho et al. ("Ho"). *Id*., pp. 171-173. The Final action also rejected application claims 1-3 and 6 as anticipated by U.S. Patent 9,341,786 to Gamache et al. ("Gamache"), application claims 5 and 8 as obvious over Gamache in view of U.S. Patent 7,162,124 to Gunn, III et al. ("Gunn"), and application claim 7 further in view of U.S. Patent Application Publication US 2003/0174964 to Gao et al. ("Gao"). *Id*., pp. 173-181. The Final

action repeated the rejection of application claims 1-3 and 6 as obvious over Shen in view of Pezeshki, application rejected claims 5 and 8 further in view of Gunn and application claim 7 further in view of Gao. *Id*., pp.181-186. The Final action also rejected Patent Owner's arguments as set forth in the Remarks filed February 28, 2018. *Id*., pp.186-187.

56. Patent Owner filed an Amendment and Reply on July 13, 2018, attempting to further amend and distinguish the claims. Ex. 1002, pp. 155-163. That Amendment was not entered until a Request for Continued Examination was filed on August 13, 2018. *Id*., pp.140-142.

57. On September 13, 2018, a non-final action was mailed, repeating the obviousness rejections set forth in the prior Final action based on Shen, Pezeshki, Gunn, Gamache, and Gao, and rejecting Patent Owner's arguments as not persuasive. Ex. 1002, pp. 113-131

58. Patent Owner filed a Reply on December 13, 2018, arguing that the claim amendments filed on August 13, 2018, adequately distinguished over the prior art. Ex. 1002, pp. 93-111. Specifically, Patent Owner argued that in amended application claim 1, the photodiodes and light receiving chip are disposed "directly" on the "same surface" of the carrier, whereas in Shen those components are located on different surfaces. *Id*., pp. 103-108. Patent Owner disagreed with the Examiner's contention that a POSITA would have been motivated to place both

components of "Chen" (sic, Shen) on the "same surface." *Id*., pp. 103-104. Patent Owner argued that the claimed feature simplified manufacture by reducing the length of wire bonds connecting the diodes to the light receiving chip. *Id*.. pp. 104-106. Patent Owner also argued that Gamache taught an integrated design, rather than separate wire-bonded components as described in its specification. *Id*., pp. 106-108. While Patent Owner disputed the Examiner's common-sense obviousness contentions, Patent Owner submitted no expert evidence that the proposed combinations would not have been entirely obvious to a POSITA.

59. A Non-final action was mailed January 28, 2019, rejecting all pending claims. Ex. 1002, pp. 77-84. The Examiner noted that "a/the 'top surface of the carrier' need[s] more specificity because this 'top surface' includes 'three distinct surface sections/levels'" that are not in the "**same plane**," rendering the claims indefinite. *Id*., p. 80 (emphasis in original). Nonetheless, the Examiner credited the Patent Owner's unsubstantiated arguments in the December 13, 2018, Reply and indicated the application claims contained allowable subject matter. *Id*.

60. Patent Owner filed an Amendment on April dated April 29, 2019, further amending the claims to clarify on which "top surface" the various components are disposed. Ex. 1002, pp. 71-76. While those amendments specified where on the top surfaces the components were located, they did not address whether those "top surfaces" all are on the same plane or different planes. *Id*.

Nonetheless, a Notice of Allowance was mailed May 13, 2019, including a Notice of Allowability stating that "Applicant has made specific corrections to clearly identify the three distinct "top surface" portions of the carrier element (reference #8 in Fig. 1)…" *Id*., pp. 31-39. The Notice of Allowability further states: "The Examiner is unable to make a prima facie case for obviousness for such combination, most particularly in which the 'light receiving chip' (2) and the 'optoelectronic diodes' (3) are disposed *directly* on the same surface of the end of the carrier (left end/side in Fig. 1 *same* surface)." *Id*., p. 37 (emphasis in original). The '301 patent issued on August 13, 2019. *Id*., p. 25.

VIII. Claim Construction

61. 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). 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).

62. It is my opinion that in deciding this Petition, the Board will need to construe the terms "carrier" and "the same top surface" as used in Claims 1-7. In particular, in my opinion the term a "carrier" should be construed as "***a ceramic or***

silicon substrate," i.e., a ceramic or similar rigid substrate having high thermal conductivity and designed to carry an integrated chip, as that term generally is understood, and would have been understood in 2016, by POSITAs. *See, e.g.*, Ex. 1005, pp. 7-9. A carrier is distinguished from a printed circuit board, which typically comprises fiberglass or plastic. *Id.*, pp. 8-9; *see also* Ex. 1006, pp. 76-83, 173-178, 515-517.

63. The foregoing distinction is recognized in the '301 Patent. *See, e.g.*, Ex. 1001, 4:6-11 ("The plurality of optoelectronic diodes may be disposed on the same circuit board. The position of the optoelectronic diodes may become definitive so as to simplify and streamline the manufacturing process. The optoelectronic diodes may be disposed onto the carrier 8 simultaneously, minimizing the iteration of disposing the optoelectronic diodes."). As discussed in my analysis of Claim 2 below, that claim introduces some ambiguity into the foregoing distinction.

64. My further view is that the phrase "the same top surface of the end of the carrier" (claims 1 and 7) should be construed to mean "***the topmost surface of the carrier***," without respect to whether that surface has is defined by more than one elevation. *See* Ex. 1001, FIGS. 1-2, 2:66-3:5, 3:9-12, 4:6-11. Notably, as illustrated in FIG. 1 of the '301 Patent, the carrier "top surface" spans multiple elevations. As discussed with respect to prosecution of the '301 Patent, the "same

top surface" does not refer to a single plane, but rather the topmost surface of distinct adjacent surfaces.

65. Notwithstanding the foregoing, I understand from counsel for CIG USA that a claim term should be construed the same way for determining both invalidity and infringement. I understand that in pending litigation between the Patent Owner and CIG USA, that Patent Owner contends that all claim terms in the '301 Patent should be given "plain and ordinary meanings." Patent Owner has urged the District Court to adopt a definition of "carrier" as "one or more components for supporting ROSA components such as an AWG." Ex. 1011, p. 6.

66. I understand that in its infringement claim charts exchanged in the pending district court litigation, Patent Owner has identified as the claimed "carrier" the printed circuit board employed in Petitioner's products. Because the term "carrier" should be construed consistently for invalidity as for infringement, I adopt for purposes of my invalidity analyses herein the construction of "carrier" urged by the Patent Owner in its infringement contentions.

IX. Prior Art References

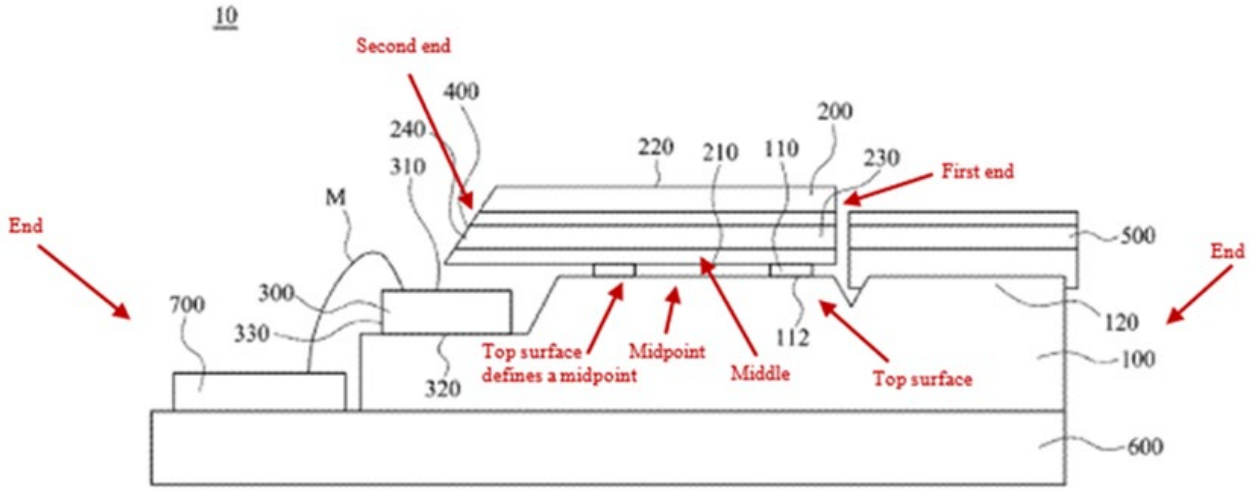
a. Shen Overview

67. U.S. Patent App. Pub. No. US 2016/0349451 ("Shen"), Exhibit 1007 filed on May 24, 2016, and published on December 1, 2016, claims priority to U.S. Provisional Patent Application 62/166,015, filed May 25, 2015, Exhibit 1008. Shen

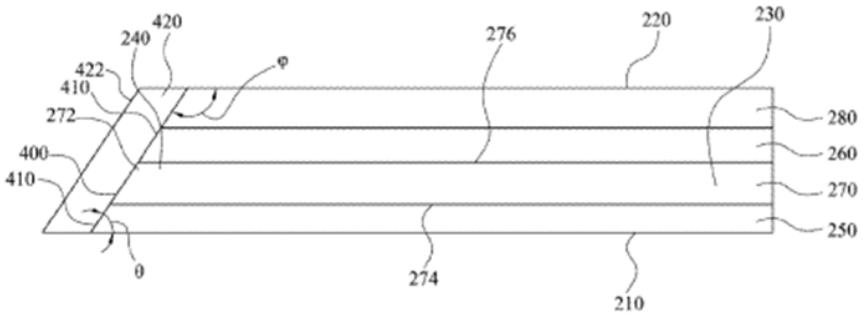
incorporates by reference the Shen Provisional Application. Ex. 1007, ¶ [0001].

68. I understand from counsel for CIG USA that the Shen provisional application and corresponding parts of the Shen non-provisional application qualify as prior art under at least 35 U.S.C. §102(a)(2). Shen, Ex. 1007, was cited and considered during prosecution of the '301 patent, but only in combination with Pezeshski as discussed in Section VII above; Ex. 1008 was not considered.

69. Shen discloses an optical receiver module having an AWG (200) mounted on a carrier (100), in which an input multi-wavelength optical signal is demultiplexed. The resulting individual channel wavelengths transit corresponding waveguides and are redirected to photodetectors (300) by an angled surface end (400) of the AWG. Ex. 1007, Abstract, FIGS. 1-4; Ex. 1008, pp. 5-8.



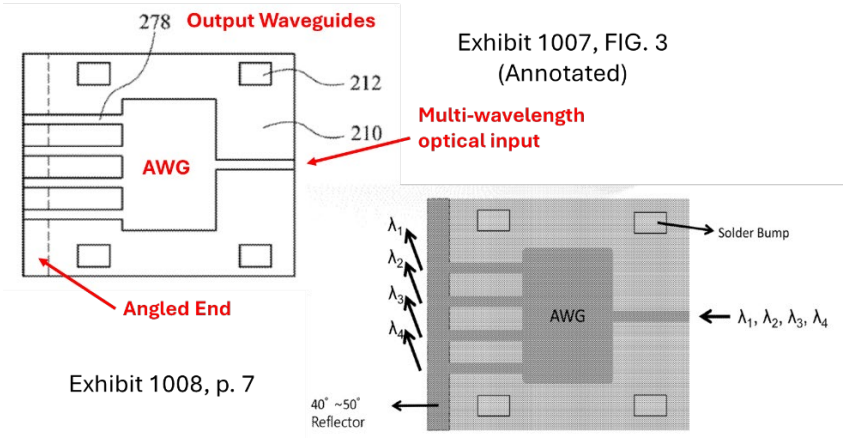
Ex. 1007, Fig 1 (annotated)



Ex. 1007, FIG. 4

70. In my opinion, the Patent Examiner erred, during prosecution of the '301 Patent, in concluding that Shen does not teach "that the OE diode receiver is a plurality of OE diodes that are split into separate receiving portions." *See* Ex. 1002, p. 182. FIG. 3 of Shen plainly illustrates that AWG of Shen divides the multiwavelength incoming signal into multiple separate channel wavelengths. Ex. 1007, FIG. 3, ¶¶ [0036], [0043], Ex. 1008, p. 7.

71. As shown in the figures reproduced below, Shen teaches that the input multi-wavelength optical input signal is demultiplexed by the AWG and transmitted via separate spaced-apart channel wavelength waveguides (278) to the angled end (400), where the light is directed to the photodetector array (300).

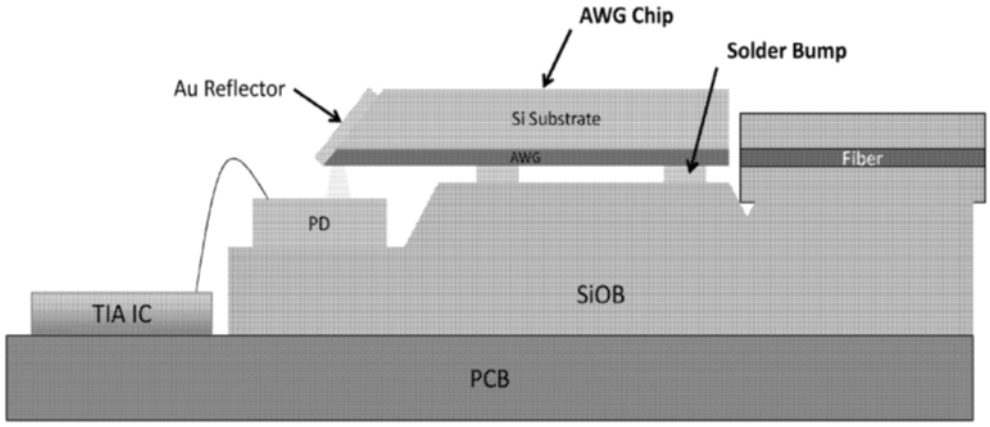


72. In my opinion, a POSITA would have understood that detector 300 must necessarily include ***discrete*** photodiodes configured to receive the optical signals from spaced-apart waveguides (278) so as to thereby convert the channel wavelength optical signals to electrical signals. Otherwise, crosstalk between the optical signals exiting the adjacent wavelength channels would render the detector useless.

73. As I further explain below in my analysis of the Claims 1-7, Shen discloses and anticipates the configuration described and claimed in the '301 Patent. Although the Patent Owner amended the claims during prosecution of the '301 Patent purportedly to address the prior art, in my opinion those amendments do not sufficiently distinguish the claimed invention from Shen. *See* Ex. 1007, FIGS. 1, 4, ¶¶ [0038]-[0039], [0046], Ex. 1008.

74. Moreover, Shen teaches an optical connection module having a carrier consisting of a silicon optical bench (SiOB) substrate. Thus, even if the term "carrier" is construed as a POSITA would have understood it – as a specific type of heat-resistant rigid ceramic material, as opposed to a PCB, Shen explicitly discloses that structure. Specifically, Ex. 1008 at page 8 explicitly states that "TIA IC [the transimpedance amplifier integrated circuit, equivalent to the claimed "light receiving circuit"] may be located on the same substrate (SiOB) with PD [photodetector] or located on the PCB [printed circuit board] and connected (sic)

the PD on SiOB through wire bonding." Ex. 1008, p. 8.

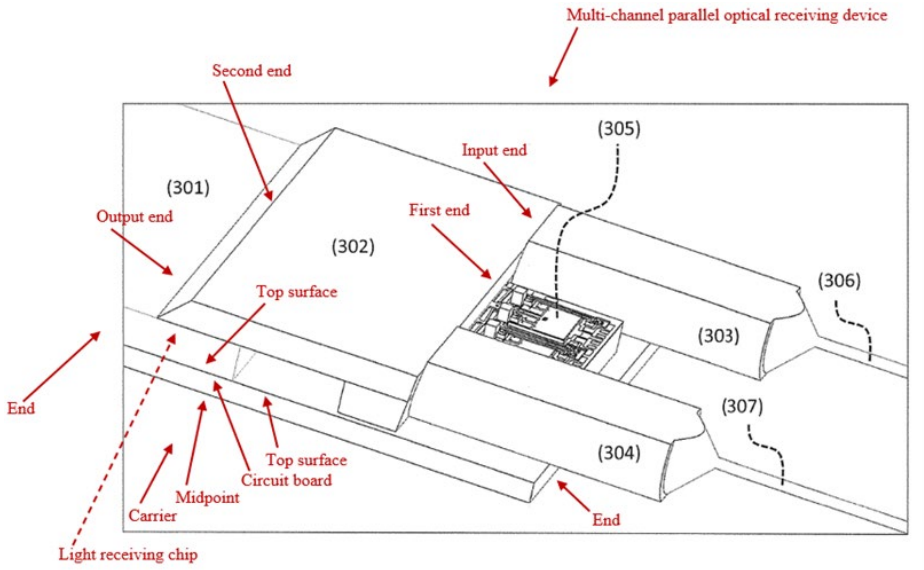


Ex. 1008, p. 6.

b. Soldano Overview.

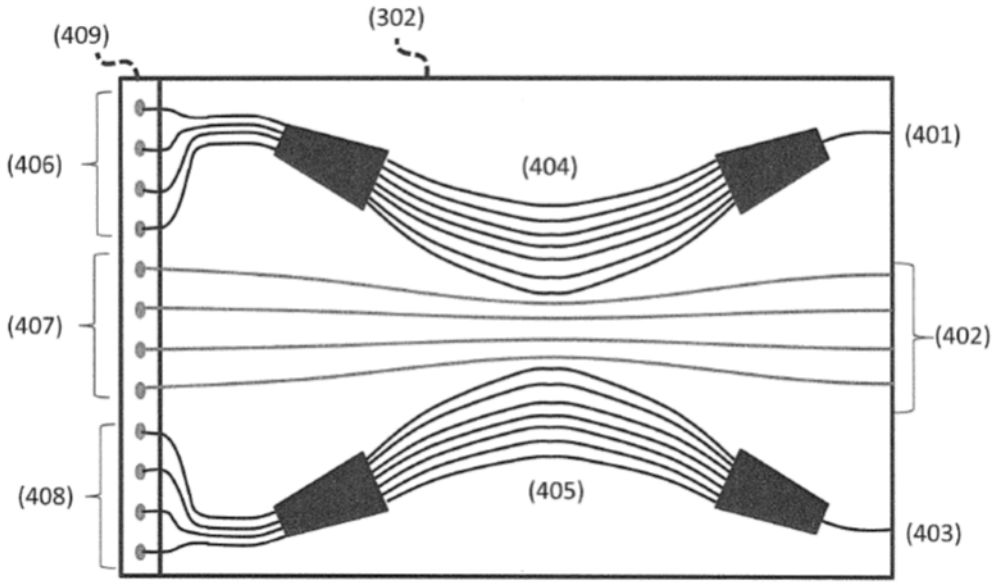
75. Soldano, U.S. Patent No. 9,768,901 ("Soldano"), Ex. 1009, was filed on February 12, 2015, and issued on September 19, 2017. Soldano claims priority to U.S. Provisional Patent Application 62/082,529, filed November 20, 2014. I understand that Soldano qualifies as prior art under at least 35 U.S.C. §102(a). Soldano was cited by the Examiner in a Notice of References included with the August 29, 2017, Office action, but was not applied in a rejection or otherwise considered during prosecution of the '301 Patent.

76. Soldano teaches a photonic lightwave circuit (PLC, 302) that includes an arrayed waveguide grating, wherein an angled, polished end (409) of the PLC directs light from channel wavelength waveguides (406) to photodiodes (505) on a silicon photonics chip (301). Ex. 1009, FIGS. 3-4, 7:63-8:24; 10:10-19.

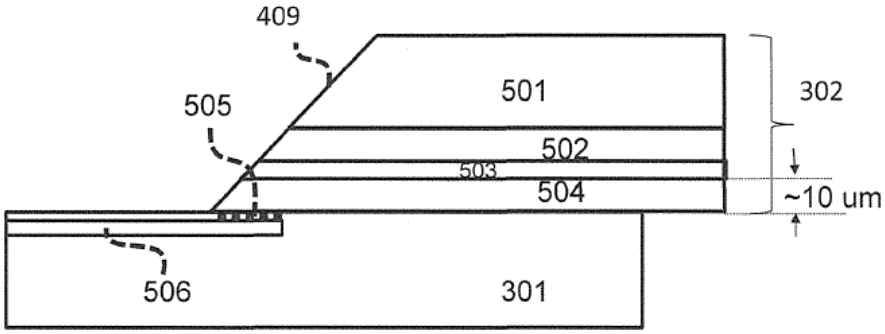


Ex. 1009, FIG. 3 (annotated)

77. Soldano describes an optical transceiver module that includes a receiver and a transmitter, both of which use an AWG to de-multiplex and multiplex, respectively, the incoming and outgoing optical signals, as illustrated in FIG. 4, reproduced below.



78. The AWG of Soldano includes an angled end configured to redirect the separate channel wavelengths resulting from demultiplexing the incoming optical signal to detectors, illustrated in FIG. 5, reproduced below.



X. Grounds

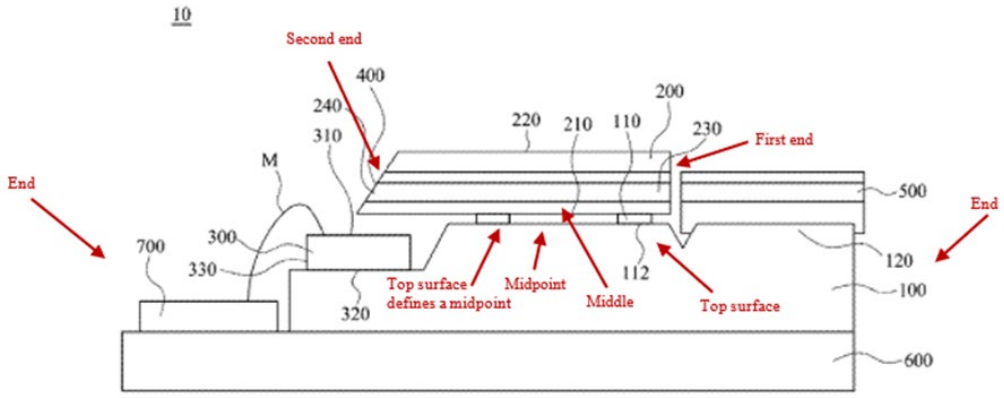
Grounds	Reference	Claims
Ground 1	Shen	1-7
Ground 2	Soldano	1-7

a. Ground 1: Shen Anticipates Claims 1-7.

79. In the analyses set forth below, I base my opinions on the disclosures of FIGS. 1-3 of the published Shen U.S. patent application, Ex. 1007, and the corresponding figures and supporting text of the Shen U.S. provisional patent application, Ex. 1008.

i. Claim 1: [1a] A multi-channel parallel optical receiving device, comprising:

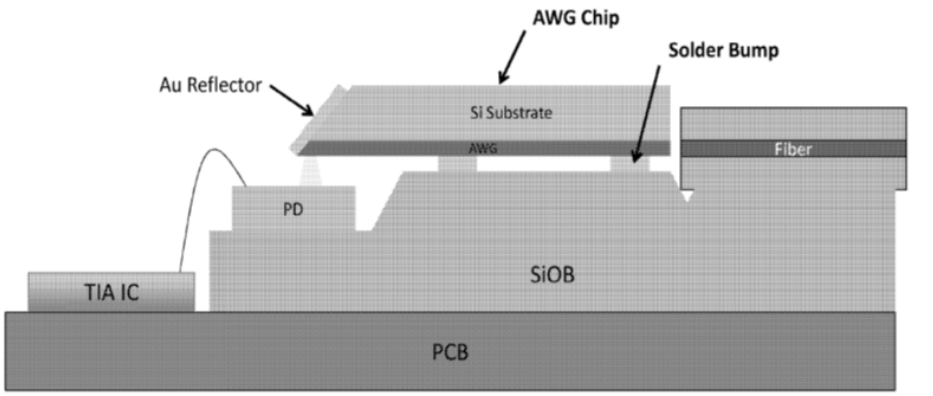
80. Shen discloses a multi-channel parallel optical receiving device (10). *See* Ex. 1007, FIG. 1, ¶¶ [0033], [0043], Ex. 1008, pp. 6-8.



Ex. 1007, FIG. 1 (annotated)

ii. Claim 1: [1b] a carrier;

81. As construed by Patent Owner, Shen discloses a carrier (substrate 100 and PCB 600). *See* Ex. 1007, FIG. 1, ¶¶ [0033], [0044]. In my opinion, a POSITA would have understood that it was simply a matter of design choice whether to use a multi-level substrate 100 in lieu of substrate 100 and PCB 600. And indeed, as described, *supra*, the Shen provisional application explains that the photodiodes and TIA IC (corresponding to the "light receiving circuit") both could be located on the SIOB substrate (which is a carrier, not a PCB) to minimize wire bonds. *See* Ex. 1008, pp. 6-8 (reproduced below).

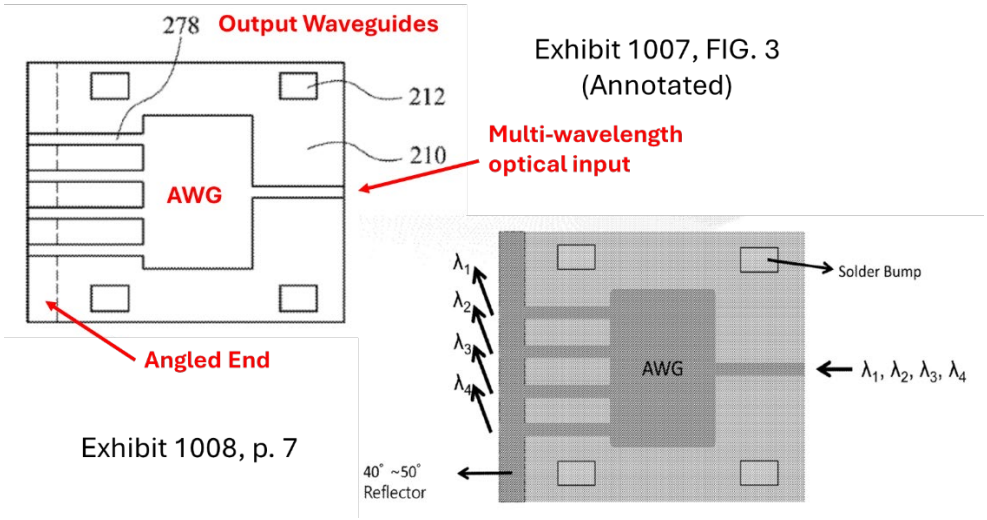


iii. Claim 1: [1c] a light receiving chip disposed on a top surface of an end of the carrier;

82. Based on my understanding regarding how the Patent Owner construes the term "carrier" for alleging infringement, Shen discloses a light receiving chip (700) located on a top surface of an end of the carrier (substrate 100 + PCB 600). *See* Ex. 1007, FIG. 1, ¶¶ [0033]-[0037], [0044]. In my opinion, a POSITA would have understood the Shen provisional application as explaining that it was simply a matter of design choice whether to locate the light receiving chip on the carrier rather than a PCB. *See* Ex. 1008, pp. 6-8;

iv. Claim 1: [1d] a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via bonding wire, wherein the optoelectronic diodes and the light receiving chip are disposed directly on the same top surface of the end of the carrier;

83. Shen discloses an optical detector (300) located on the top surface of the end of the carrier. As explained *supra*, Section VII, in my opinion, a POSITA would have understood that optical detector (300) necessarily includes a plurality of optoelectronic diodes, one for each channel wavelength output by the AWG. *See* Ex. 1007, FIG. 3, ¶ [0043]; Ex. 1008, p. 7, reproduced on the following page.



84. A POSITA would have had that understanding because the output waveguides (278) are spaced apart, and thus the optical detector (300) necessarily must have a plurality of spaced-apart photodetectors to receive the multiple channel wavelength optical signals output from the AWG.

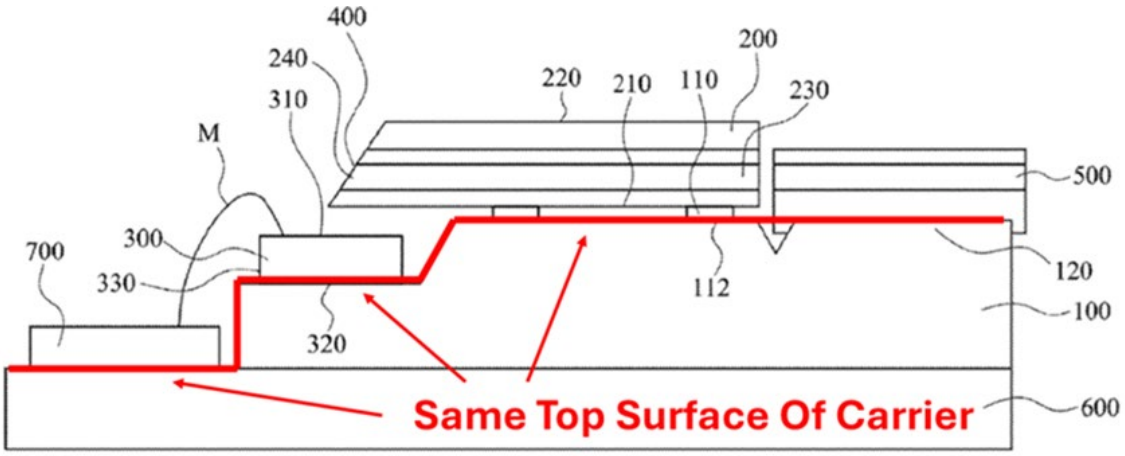
85. The optical detector (e.g., photodiodes) (300) and the light receiving chip (700) are located directly on the same top surface of the end of the carrier. *See* Ex. 1007, FIG. 1, ¶¶ [0033]-[0037], [0044]; *see also*, Ex. 1008, the Shen provisional application states at page 8 that "TIA IC [transimpedance amplifier integrated chip] may be located on the same substrate (SIOB) with PD [photodetector] or located on the PCB and connected to the PD on the SIOB through wire bonding."

v. Claim 1: [1e] an optical fiber connector disposed in an end of the carrier;

86. Shen discloses an optical fiber connector (500) located in an end of the carrier (100). *See* Ex. 1007, FIG. 1, ¶ [0044]; Ex. 1008, pp. 6-8.

vi. Claim 1: [1f] an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber wherein the top surface of the carrier underlies the middle of the arrayed waveguide grating; and

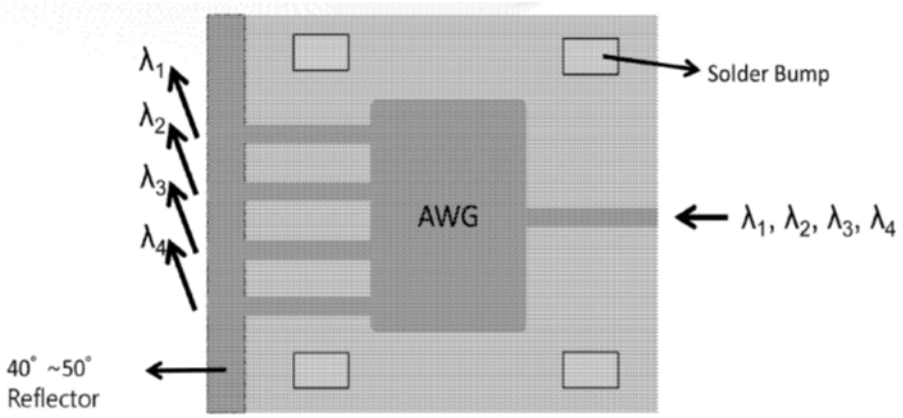
87. Shen discloses an arrayed waveguide grating (200) located on a top surface of the carrier that defines a midpoint of the carrier. The '301 Patent does not expressly define the term "midpoint," nor could I find any explanation in the '301 Patent for any benefit arising from this positioning of the AWG on the carrier. However, as indicated in the annotated version of FIG. 5 of Shen below, the AWG is located at about the midpoint of the top surface of the carrier. Moreover, in my opinion, a POSITA have understood the claimed location would have no effect on the functionality of the AWG, and instead would view the positioning of the middle of the AWG relative to the carrier as a simple design choice.



88. The AWG (200) of Shen has a first end, a middle, a second end located opposed the first end, and an input end (230) connected to the optical fiber connector (500) for receiving an input optical signal from the optical fiber. *See* Ex. 1007, FIGS. 1, 4, ¶ [0044] The top surface of the carrier underlies the middle of the AWG (200) as illustrated in the annotated version of FIG. 1 of Shen, reproduced above.

vii. Claim 1: [1g] wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel, wherein the predetermined angle of the top surface defined by the output end of the arrayed waveguide grating is in a range of 41 to 46 degrees such that the top surface provides the reflection.

89. Shen discloses that the input optical signal is divided into multiple channel optical signals in parallel by the AWG (200) based on their wavelengths. *See* Ex. 1007, FIG. 3; Ex. 1008, p. 7 (disclosing a multiwavelength input signal and separate channel wavelengths exiting the AWG). Shen discloses that "the [AWG] structure may include a plurality of optical channels. The optical channels are separated from each other… [and] may transmit the light within different wavelength ranges." *See* Ex. 1007, FIGS. 1 and 4; ¶ [0043], Ex. 1008, p. 7.



Ex. 1008, p. 7

90. A top surface (220) defined by an output end (240) of the AWG (200) is at a predetermined angle (θ), causing the multi-channel optical signals reflected by the top surface (220) defined by the output end (240) to be reflected to a photosensitive surface of the optical detector (300) (e.g., optoelectronic diodes) arranged in parallel. The predetermined angle (θ) of the top surface (220) defined by the output end (240) of the AWG (200) is in a range of 41 to 46 degrees. See Ex. 1007, FIGS. 1 and 4; ¶¶ [0038]-[0039], [0046]; Ex. 1008, p. 7 above (specifying the angle of the reflector as "40° ~ 50°").

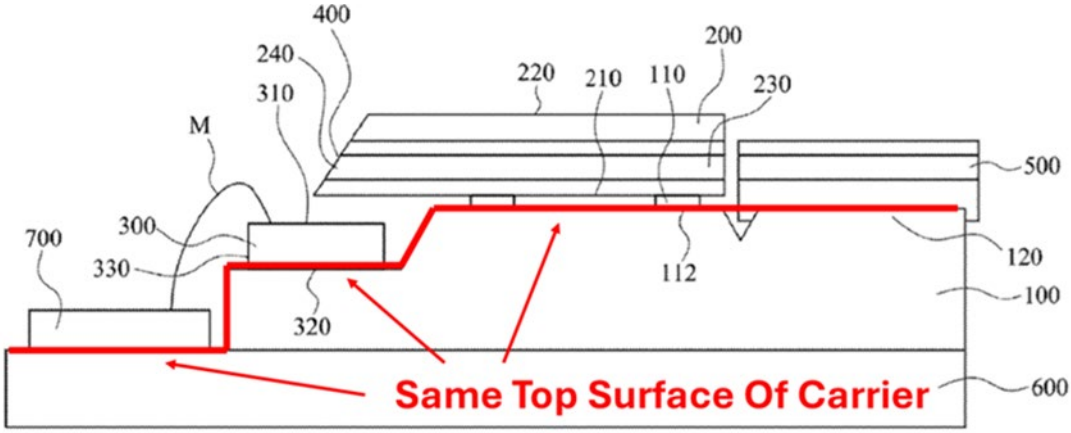
91. Thus, in my opinion, a POSITA would understand that Shen discloses all of the elements of, and anticipates, Claim 1.

viii. Claim 2: The multi-channel parallel optical receiving device according to claim 1, wherein the top surface of the end of the carrier is defined at least in part by a circuit board and wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the circuit board.

92. I note that whereas Claim 1 requires that the light receiving chip and

plurality of optoelectronic diodes both are disposed on the top surface of the end of the carrier, Claim 2 redefines the "carrier" of Claim 1 so that it includes a portion of the PCB (which in my view a POSITA would not regard as the claimed "carrier."). As thus recited in Claim 2, neither the light receiving circuit nor the diodes need be disposed on the "carrier", but instead both could be "directly disposed on the circuit board."

93. If the "end of the carrier" per Claim 2 includes the PCB, then FIG 1. of Shen – in which the light receiving circuit is disposed on the PCB and the diodes are disposed on the SiOB substrate – fully meets the limitation of Claim 1. Indeed, both components are "directly on top of the same top surface of the end of the carrier" (as per Claim 2 this can include the PCB), as depicted below.



94. For the foregoing reasons, it is my opinion, that Claims 1 and 2 do not distinguish over the prior art, and moreover, a POSITA would have understood that the locations of light receiving circuit and diodes is a matter of design choice.

95. Accordingly, a POSITA would have understood that it was a simple matter of design choice to locate both the light receiving chip (700) and photodiodes (300) directly located on PCB (600), instead of SIOB substrate (100), as the Shen provisional application expressly states that both components could be located on the SIOB substrate ("carrier"). *See* Ex. 1007, FIG. 1, ¶¶ [0037], [0044]; Ex. 1008, p. 7. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

96. Accordingly, for the foregoing reasons, it is my opinion that a POSITA would have understood that Shen anticipates Claim 2.

ix. Claim 3: The multi-channel parallel optical receiving device according to claim 1, wherein the amount of the optoelectronic diodes is equal to the amount of optical paths divided by the arrayed waveguide grating.

97. In my opinion, Shen discloses that the optical detector (300) includes a plurality of optoelectronic diodes equal to the number of optical paths (278) divided by the AWG (200). *See* Ex. 1007, FIGS. 1, 3, ¶¶ [0033], [0040], [0043]; Ex. 1008, p. 6. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

98. Accordingly, a POSITA would have understood that Shen anticipates Claim 3.

x. Claim 4: The multi-channel parallel optical receiving device according to claim 1, wherein the predetermined angle of the top surface of the output end of the arrayed waveguide grating is 42 degrees.

99. Shen, Ex. 1007, discloses that the predetermined angle (θ) of the top surface (220) of the output end (240) of the arrayed waveguide grating (200) may

be an acute angle, while the Shen provisional application, Ex. 1008, specifies an angle of 40° ~ 50°, which encompasses the claimed angle of 42 degrees. *See* Ex. 1007, FIGS.1, 4, ¶¶ [0039], [0046]; Ex. 1008, p. 7. Although I find no explanation in the '301 Patent for requiring an angle of precisely 42 degrees, it is my opinion that specifying a slight tilt form a 45-degree angle is an acknowledgement that optical couplings should have a slight angulation to prevent back reflection. Here, a POSITA would have understood that the angle of the end of the AWG need only be about one-half that needed for a butt joint, which is typically 8 degrees, so 41-42 degrees. Moreover, the specific angle would be a matter of design choice, e.g., based upon the material characteristics of the AWG and alignment of the AWG with the diodes. For the system of Claim 1, *see supra*, Sections X.a.i-vii.

100. Accordingly, in my opinion, a POSITA would have understood that Shen anticipates Claim 4.

xi. Claim 5: The multi-channel parallel optical receiving device according to claim 1, wherein a first lens, for coupling the optical fiber, is disposed between the input end of the arrayed waveguide grating and the optical fiber connector.

101. Shen discloses a multi-channel parallel optical receiving device according to claim 1, wherein an input end of the AWG may be coupled to the optical fiber connector via a lens. Ex. 1007, ¶ [0044]. In my opinion, a POSITA would have understood that such as lens may be a graded lens to assist propagation of the light delivered by the optical fiber connector (500) into the AWG (200),

thereby increasing optical coupling efficiency, and reducing dispersion and signal loss. For the device of Claim 1, *see supra*, Sections X.a.i-vii.

102. A POSITA would have understood that Shen anticipates Claim 5.

xii. Claim 6: The multi-channel parallel optical receiving device according to claim 1, wherein the input end of the arrayed waveguide grating is inserted directly into the optical fiber connector and a graded index lens is disposed in an end where the optical fiber connector and the arrayed waveguide grating connect.

103. Shen discloses that the input end of the AWG (302) is directly coupled to the optical fiber connector (303). *See* Ex. 1007, FIG. 3. Shen further discloses an embodiment of the optical receiving device where an optical passive device "may assist the light to propagate into the AWG structure … to increase the optical coupling efficiency … [and] may be, but is not limited to be, an optical fiber or a lens." Ex. 1007, ¶ [0044]. In addition, the use of graded index lenses was well known and commonly used by POSITAs in the field of optical communications at the time the '301 patent was filed.

104. Accordingly, it is my opinion that a POSITA would have understood that it would have been a simple design choice to use a graded index lens to "improve optical coupling between an optical fiber and an optical waveguide on a chip or substrate type configuration in the device of Shen '451 … to improve optical coupling efficiency." For the device of Claim 1, *see supra*, Sections X.a.i-vii.

105. A POSITA would have understood that Shen anticipates Claim 6.

xiii. Claim 7: A multi-channel parallel optical receiving device, comprising:

a carrier;

a light receiving chip disposed on a top surface of an end of the carrier;

a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via wire bonding, wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the same top surface of the end of the carrier;

an optical fiber connector disposed in an end of the carrier;

an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber;

wherein the top surface of the carrier that defines the midpoint of the carrier underlies the middle of the arrayed waveguide grating; and

wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle of 42 degrees, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel.

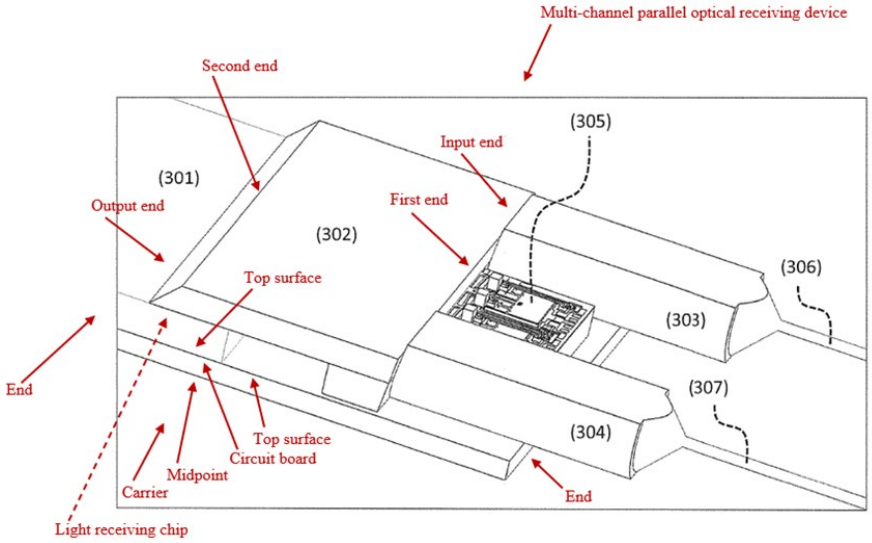
106. Claim 7 combines all of the elements of claims 1 and 4 as set forth in my analyses above. *See supra*, Sections X.a.i-vii and x.

107. Accordingly, in my opinion, Claim 7 is anticipated by Shen for the same reasons as described above for Claims 1 and 4.

b. Ground 2: Soldano Anticipates Claims 1-7

i. Claim 1: [1a] A multi-channel parallel optical receiving device, comprising:

108. Soldano, U.S. Patent No. 9,768,901, discloses a multi-channel parallel optical receiving device. *See* Ex. 1009, FIGS. 3, 5, 7:29, 8:28.



Ex. 1009, FIG. 3

ii. Claim 1: [1b] a carrier;

109. Soldano discloses a carrier. *See* Ex. 1009, FIGS. 3, 5, 7:29, 8:28. More particularly, Soldano discloses a silicon photonics chip coupled to an arrayed waveguide grating ("AWG") that includes a demultiplexer for an incoming multiwavelength optical signal and a multiplexer for outgoing optical signals. *Id.*, 9:5-12 The AWG may be coupled to detectors via grating couplers 505 and waveguides 506 of the silicon photonics chip. *Id.,* 9:52-64. In an alternative embodiment, Soldano describes that grating couplers could be replaced by

photodetectors that receive light directly from the channel wavelength waveguides of the AWG. *See* Ex. 1009, 10:10-19. The silicon photonics chip of Soldano corresponds to the claimed "carrier" of the '301 patent.

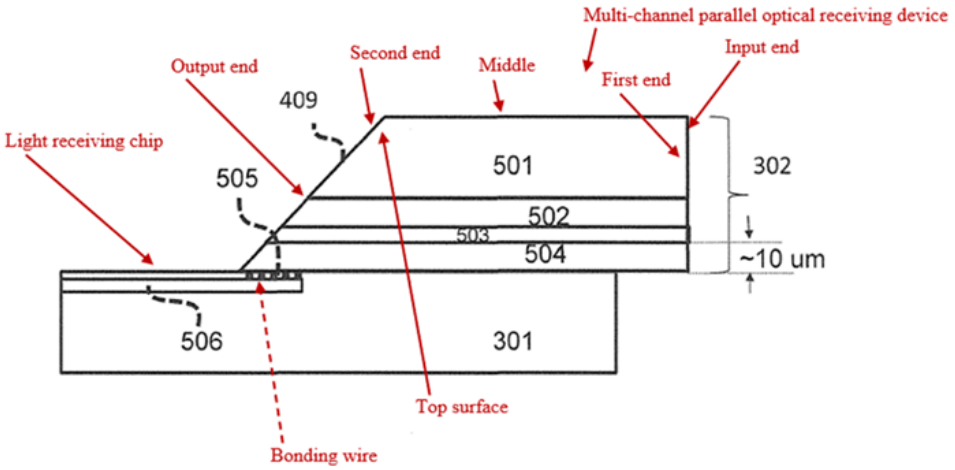


FIG. 1009, FIG. 5

iii. Claim 1: [1c] a light receiving chip disposed on a top surface of an end of the carrier;

110. Soldano discloses a light receiving chip located on a top surface of an end of the carrier. *See* Ex. 1009, FIGS. 3, 5, 8:8-10, 8:14-20, 9:15-20.

iv. Claim 1: [1d] a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via bonding wire, wherein the optoelectronic diodes and the light receiving chip are disposed directly on the same top surface of the end of the carrier;

111. Soldano discloses in an alternative embodiment a plurality of optoelectronic diodes (505) located on the top surface of the end of the carrier. *See* Ex. 1009, FIGS. 3, 5, 8:14-20. The plurality of optoelectronic diodes (505) are

electrically connected to the light receiving chip, which a POSITA would have understood could be accomplished via wire bonds. *See* Ex. 1009, 10:10-19. The optoelectronic diodes (505) and the light receiving chip are located directly on the same top surface of the end of the carrier. *See* Ex. 1009, FIGS. 3, 5, 8:4-8, 8:14-28, 10:10-25.

v. Claim 1: [1e] an optical fiber connector disposed in an end of the carrier

112. Soldano discloses an optical fiber connector (303) located in an end of the carrier. *See* Ex. 1009, FIG. 3, 7:24-32, 7:52-65.

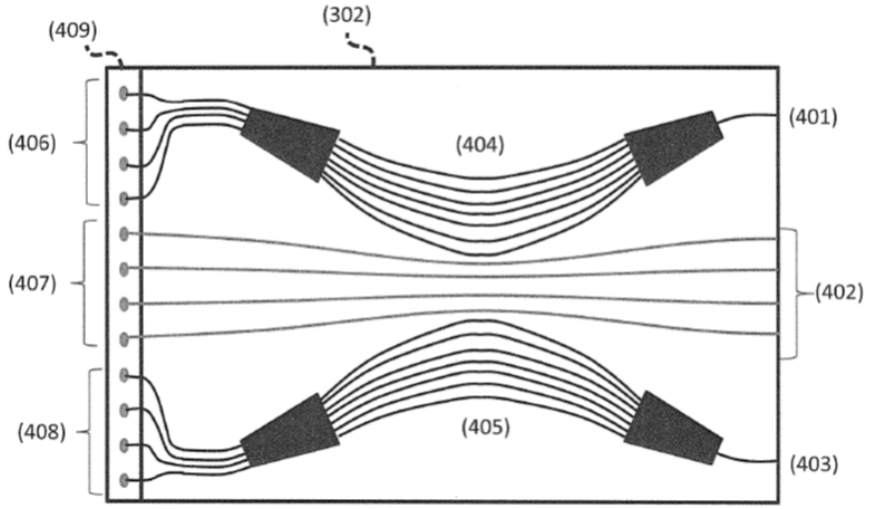
vi. Claim 1: [1f] an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber wherein the top surface of the carrier underlies the middle of the arrayed waveguide grating; and

113. Soldano discloses an arrayed waveguide grating (302) located on a top surface of the carrier that defines a midpoint of the carrier. *See* Ex. 1009, FIG. 3, 7:65-8:1. The arrayed waveguide grating has a first end, a middle, and a second end located opposite the first end. *See* Ex. 1009, FIG. 5, 7:65. An input end of the arrayed waveguide grating (302) is connected to the optical fiber connector (303) for receiving an optical signal from the optical fiber (306). *See* Ex. 1009, FIG. 3, 7:24-8:10. The top surface of the carrier underlies the middle of the arrayed

waveguide grating (302). *See* Ex. 1009, FIGS. 3, 5, 7:24-8:10.

vii. Claim 1: [1g] wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel, wherein the predetermined angle of the top surface defined by the output end of the arrayed waveguide grating is in a range of 41 to 46 degrees such that the top surface provides the reflection.

114. Soldano discloses the optical signal is divided into multiple channel wavelength optical signals in parallel by the arrayed waveguide grating (302). *See* Ex. 1009, FIGS. 4, 7, 29-8:28, 9:5-12.



Ex. 1009, FIG. 4

115. A top surface defined by an output end of the arrayed waveguide grating (302) is at a predetermined angle (409), causing the multiple channel wavelength optical signals reflected by the top surface to a photosensitive surface

of the plurality of optoelectronic diodes (505) arranged in parallel. *Id.*, 9:31-37, 10:10-19. The predetermined angle (409) of the top surface defined by the output end of the arrayed waveguide grating (302) redirects the optical signals from horizontal to vertical beams, which a POSITA would have understood to require an angle for the top surface in range of 41 to 46 degrees. *See* Ex. 1009, FIGS. 3, 5, 7:62-8:10, 9:31-10:25.

116. Accordingly, in my opinion, a POSITA would have understood that Soldano anticipates Claim 1.

viii. Claim 2: The multi-channel parallel optical receiving device according to claim 1, wherein the top surface of the end of the carrier is defined at least in part by a circuit board and wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the circuit board.

117. Soldano further discloses the top surface of the end of the carrier may be defined at least in part by a circuit board. The plurality of optoelectronic diodes (505) and the light receiving chip are directly located on the circuit board. *See* Ex. 1009, FIGS. 3, 5, 7:24-8:28, 9:52-10:25. For the device of Claim 1, *see supra*, Sections X.c.i-vii.

118. Accordingly, in my opinion, a POSITA would have understood that Soldano anticipates Claim 2.

ix. Claim 3: The multi-channel parallel optical receiving device according to claim 1, wherein the amount of the optoelectronic diodes is equal to the amount of optical paths divided by the arrayed waveguide grating.

119. Soldano discloses that the number of optoelectronic diodes (505) is equal to the number of optical paths output by the arrayed waveguide grating (302). *See* Ex. 1009, FIGS. 3, 5, 8:1-20, 8:61-9:45. For the device of Claim 1, *see supra*, Sections X.c.i-vii.

120. Accordingly, a POSITA would have understood that Soldano anticipates Claim 3.

x. Claim 4: The multi-channel parallel optical receiving device according to claim 1, wherein the predetermined angle of the top surface of the output end of the arrayed waveguide grating is 42 degrees.

121. Soldano discloses that the predetermined angle (409) of the top surface defined by the output end of the arrayed waveguide grating (302) redirects the optical signals from horizontal to vertical beams. *See* Ex. 1009, FIGS. 3, 5, 7:62-8:10, 9:31-10:25. A POSITA therefore would have understood Soldano to require an angle for the top surface of about 45 degrees. *Id*..

122. The ’301 Patent does not ascribe any particular benefit to having the predetermined angle (409) of the top surface of the output end of the arrayed waveguide grating (302) at precisely 42 degrees. In my opinion, a POSITA would have understood selection of a 42-degree angle would be preferable to reduce back reflection and also as a matter of design choice, depending upon the optical characteristics of the material selected for the PLC and alignment of the photodetectors and output end of the AWG. *See* Ex. 1009, FIGS. 3, 5, 7:35-37, 8:8-

14. For the system of Claim 1, *see supra*, Sections X.c.i-vii.

123. Accordingly, in my opinion, a POSITA would have understood Soldano to disclose a range of angles for the top surface of the output end of the AWG, which range would include 42 degrees, and therefore anticipate Claim 4.

xi. Claim 5: The multi-channel parallel optical receiving device according to claim 1, wherein a first lens, for coupling the optical fiber, is disposed between the input end of the arrayed waveguide grating and the optical fiber connector.

124. Soldano discloses a prior art method wherein a lens is used to couple light to the AWG input by positioning a lens between the optical fiber and an input end of the AWG. *See* Ex. 1009, 7:1-5. A POSITA would have understood at the time the application for the '301 patent was filed that lenses routinely were used in optical fiber connectors to couple optical signals from optical fibers to waveguides, such as an AWG, to thereby reduce signal loss. For the device of Claim 1, *see supra*, Sections X.c.i-vii.

125. Accordingly, in my opinion, a POSITA would have understood that use of a lens with the structure disclosed in Soldano would have been a simple design choice, and thus Soldano anticipates Claim 5.

xii. Claim 6: The multi-channel parallel optical receiving device according to claim 1, wherein the input end of the arrayed waveguide grating is inserted directly into the optical fiber connector and a graded index lens is disposed in an end where the optical fiber connector and the arrayed waveguide grating connect.

126. Soldano discloses the use of a lens to couple an optical signal with the

input end of a waveguide. *See* Ex. 1009, 7:1-5. The use of graded index lenses was known and commonly used in optical communications at the time the '301 Patent was filed, and a POSITA would have understood that using a graded index lens to improve optical coupling between an optical fiber and the AWG was a matter of design choice. Ex. 1002, p. 126. For the device of Claim 1, *see supra*, Sections X.c.i-vii.

127. Accordingly, in my view, a POSITA would have understood that using a graded lens in the optical connector of Soldano would have been a simple design choice, and thus Soldano anticipates Claim 6.

xiii. Claim 7: A multi-channel parallel optical receiving device, comprising:

a carrier;

a light receiving chip disposed on a top surface of an end of the carrier;

a plurality of optoelectronic diodes disposed on the top surface of the end of the carrier, and the plurality of optoelectronic diodes electrically connected to the light receiving chip via wire bonding, wherein the plurality of optoelectronic diodes and the light receiving chip are directly disposed on the same top surface of the end of the carrier;

an optical fiber connector disposed in an end of the carrier;

an arrayed waveguide grating further disposed on a top surface of the carrier that defines a midpoint of the carrier, the arrayed waveguide grating having a first end, a middle, and a second end disposed opposite the first end, and an input end of the arrayed waveguide grating connected to the optical fiber connector for receiving an optical signal from the optical fiber;

wherein the top surface of the carrier that defines the midpoint of the carrier underlies the middle of the arrayed waveguide grating; and

wherein the optical signal is divided into multi-channel optical signals in parallel by the arrayed waveguide grating based on their

wavelengths, a top surface defined by an output end of the arrayed waveguide grating is at a predetermined angle of 42 degrees, causing the multi-channel optical signals reflected by the top surface defined by the output end of the arrayed waveguide grating to be reflected to a photosensitive surface of the plurality of optoelectronic diodes arranged in parallel.

128. Claim 7 combines all of the elements of Claims 1 and 4 as analyzed above. *See supra*, Sections X.c.i-vii and x.

129. Accordingly, in my opinion, Claim 7 is anticipated by Soldano for the same reasons as described above for claims 1 and 4.

XI. Revision or Supplementation

130. In this report, I have presented my opinions regarding the invalidity of the challenged claims of the ’301 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.

Dr. Andrew G. Kirk