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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NKT PHOTONICS INC.
and NKT PHOTONICS A/S
Petitioners

v.

OMNI CONTINUUM LLC
Patent Owner

Case No. IPR2025-00839
Patent 7,433,116

PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 7,433,116 B2 UNDER 35 U.S.C. §§ 311–19 and 37 C.F.R. § 42.100 *et seq*.

TABLE OF CONTENTS

Page

TABLE OF AUTHORITIES

Cases **Page(s)**

Statutes

Rules

I. INTRODUCTION

NKT Photonics Inc. and NKT Photonics A/S ("Petitioners") respectfully request *inter partes* review for Claims 1-4, 9, 11-14, 16-25, and 30-35 of U.S. Patent 7,433,116 ("'116 Patent") (EX1001) in accordance with 35 U.S.C. §§311-19 and 37 C.F.R. §42.100 *et seq*.

II. MANDATORY NOTICES PURSUANT TO 37 C.F.R. §42.8(a)(1)

A. Real Parties-In-Interest

Petitioners certify that NKT Photonics Inc. and NKT Photonics A/S are the real parties-in-interest in this proceeding. NKT Photonics Inc. is a subsidiary of NKT Photonics A/S.

NKT Photonics A/S is a wholly owned subsidiary of Photonics Management Europe SRL, which is a wholly owned subsidiary of Hamamatsu Photonics K.K. While Photonics Management Europe SRL and Hamamatsu Photonics K.K. are not parties, Petitioners list them as real parties-in-interest out of an abundance of caution.

B. Identification of Related Matters Under 37 C.F.R. §42.8(b)(2)

The following judicial or administrative matters would affect, or be affected by, a decision in this proceeding:

Related District Court and PTAB Matters

Cheetah Omni LLC and Omni Continuum, LLC v. NP Photonics, Inc., Civil Action No. 4:14-cv-02070 (D. Ariz.) (Dismissed on June 6, 2014) which was transferred from the Eastern District of Texas (*Cheetah Omni, LLC v. NP Photonics*, Civil Action No. 6:13-cv-00418 (E.D. Tex.)); and

Omni Continuum LLC v NKT Photonics Inc. and NKT Photonics A/S, Civil Action No. 1:24-cv-11007 (D. Mass.) (filed April 17, 2024) (pending) (the "Related Litigation").

Related Applications

The '116 Patent issued from U.S. Patent Application No. 10/812,608, filed on March 30, 2004, which is a continuation of U.S. Patent Application No. 10/757,341, filed on January 13, 2004 (U.S. Patent 7,259,906), which is a continuation of U.S. Patent Application No. 10/652,276, filed on August 29, 2003 (Abandoned), and claims priority to U.S. Provisional Application No. 60/408,025, filed September 3, 2002.

U.S. Patent Application No. 16/015,782, filed on June 22, 2018 (abandoned) is a continuation of U.S. Patent Application No. 15/710,804, filed on September 20, 2017 (U.S. Patent 10,004,402), which is a continuation of U.S. Patent Application No. 15/258,133, filed on September 7, 2016 (U.S. Patent 9,770,174), which is a continuation of U.S. Patent Application No. 14/734,069, filed on June 9, 2015 (US Patent 9,456,751), which is a continuation of U.S. Patent Application No. 14/476,082, filed on September 3, 2014 (U.S. Patent 9,055,868), which is a continuation of U.S. Patent Application No. 14/186,814, filed on February 21, 2014

(US Patent 9,456,750), which is a continuation of U.S. Patent Application No. 13/913,853, filed on June 10, 2013 (U.S. Patent 8,848,282), which is a continuation of U.S. Patent Application No. 13/531,853, filed on June 25, 2012 (U.S. Patent 8,679,011), which is a continuation of U.S. Patent Application No. 13/349,244, filed on January 12 2012 (U.S. Patent 8,472,108), which is a continuation of U.S. Patent Application No. 13/078,547, filed on April 1, 2011 (abandoned), which is a divisional of U.S. Patent Application No. 12/625,253, filed on November 24, 2009 (US Patent 8,098,423), which is a divisional of U.S. Patent Application No. 12/206,432, filed on September 8, 2008 (U.S. Patent 7,633,673), which is a divisional of U.S. Patent Application No. 10/812,608, filed on March 30, 2004 (U.S. Patent 7,433,116).

C. Lead and Backup Counsel

Pursuant to 37 C.F.R. §§42.8(b)(3) and 42.10(a), Petitioners hereby identify its lead and backup counsel as follows:

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Powers of Attorney are being filed concurrently herewith in accordance with 37 C.F.R. §42.10(b).

D. Service Information Under 37 C.F.R. §42.8(b)(4)

Petitioners consent to e-mail service at the addresses listed above.

III. FEES

The Office is authorized to charge Deposit Account 02-4800 for fees required by §42.15(a).

IV. REQUIREMENTS UNDER 37 C.F.R. §42.104

A. Grounds for Standing

Pursuant to 37 C.F.R. §42.104(a), Petitioners certify that the ’116 Patent is available for *inter partes* review pursuant to 37 C.F.R. §42.102(a)(2). Petitioners are not barred or estopped from requesting *inter partes* review challenging the claims of the ’116 Patent on the grounds identified herein.[1]

This Petition is filed within one year from the date on which Patent Owner served an infringement complaint on Petitioners in the Related Litigation.

Neither Petitioners nor its privies have received a Final Written Decision under 35 U.S.C. §318(a) regarding any claim of the ’116 Patent on any ground that was raised or could have been raised by them in any *inter partes* review, post grant review, or covered business method patent review.

B. Identification of Challenges and Precise Relief Requested

Pursuant to 37 C.F.R. §42.104(b), Petitioners challenge Claims 1-4, 9, 11-14, 16-25, and 30-35 of the ’116 Patent, and request that these claims be found unpatentable over the prior art for the reasons given below.

Ground	References	Basis	Claims Challenged
1	U.S. Publication 2003/0012491 (“Shaw”) (EX1004)	§102(e)	1-4,9,11-14, 16-25,30-35
2	Shaw (EX1004)	§103(a)	1-4,9,11-14, 16-25,30-35

[1] The Federal Circuit has confirmed that the Board has jurisdiction over *inter partes* review of expired patents. *Apple Inc. v. Gesture Technology Partners, LLC*, No. 23-1501 (Fed. Cir. 2025).

Ground	References	Basis	Claims Challenged
3	Shaw (EX1004) and U.S. Patent 6,239,903 ("Islam") (EX1005)	§103(a)	1-4,9,11-14, 16-25,30-35

In addition, Petitioners rely upon evidence listed in the Exhibit List, including the Declarations and *Curriculum Vitae* of Dr. Scott Diddams (EXs1009-1010) and Dr. Sylvia Hall-Ellis (EXs1011-1012), in their entirety.

C. Prior Art Qualification of Asserted References

The '116 Patent was filed on March 30, 2004 as U.S. Patent Application No. 10/812,608 ("'608 Application"). EX1002. The '116 Patent is not entitled to the priority date of September 3, 2002 (the filing date of U.S. Provisional Application No. 60/408,025) ("'025 Provisional") but rather is *at best* entitled to the priority date of August 29, 2003 (the filing date of U.S. Patent Application No. 10/652,276) ("'276 Application"). Even if the '116 Patent is entitled to the priority date of September 3, 2002, all of the applied references in this Petition are prior art.[2]

As stated below, Shaw was filed on July 12, 2001 and published on January 16, 2003, and is prior art at least under 35 U.S.C. §§102(a)&(e).

[2] Petitioners do not concede that any challenged claim is entitled to an effective filing date of September 3, 2002 or August 29, 2003.

Islam was filed on April 25, 2000 and granted (*i.e.*, published) on May 29, 2001, and is prior art at least under 35 U.S.C. §102(b).

D. Priority Date for the ’116 Patent

The ’116 Patent was filed as a continuation application, claiming priority to (a) U.S. Patent Application No. 10/757,341, filed January 13, 2004; (b) the ’276 Application, filed on August 29, 2003; and (c) the ’025 Provisional, filed September 3, 2002. Yet, the ’025 Provisional (EX1003) does not provide adequate disclosure to support a valid priority claim to September 3, 2002. EX1006 is a comparison of the ’025 Provisional disclosure with that of the ’116 Patent. Independent Claim 1 of the ’116 Patent recites a “wavelength shifter operable to receive the first optical signal and to wavelength shift at least a portion of the first optical signal based at least in part on a Raman effect,….” Independent Claim 25 of the ’116 Patent recites “receiving the first optical signal at a wavelength shifter, the wavelength shifter comprising a first waveguide structure and a second waveguide structure,…shifting at least the first wavelength to an intermediate optical wavelength using the first waveguide structure based at least in part on a Raman effect….” Yet the ’025 Provisional is devoid of any discussion related to wavelength shifting, let alone use of Raman effects to induce/facilitate wavelength shifting. EX1009, ¶¶45-46. Therefore, Patent Owner cannot properly assert a valid claim to priority of September 3, 2002, and can *at best* only assert a priority claim to the ’276

Application, filed on August 29, 2003. The ’025 Provisional fails to provide sufficient written description to qualify it as a priority document.

E. Prior Art Date for Shaw

Shaw was filed on July 12, 2001 (“Original Shaw Filing”; EX1007). On November 15, 2001, the applicant revised the Original Shaw Filing by filing replacement sheets replacing original FIGS. 1-8 with amended FIGS. 1-8 to present the U.S. Patent & Trademark Office (“PTO”) with a formal set of drawings. No other changes were made to the Original Shaw Filing. Shaw published as U.S. 20030012491A1 on January 16, 2003 (“the ’491 Publication”). With the exception of minor formality changes made by the PTO and the inclusion of the formal drawing set, the ’491 Publication published with the same subject matter that appeared in the Original Shaw Filing. A comparison between the Original Shaw Filing and the ’491 Publication is presented in EX1008. EX1008 also shows that the Original Shaw Filing provides written description for all elements of at least one independent claim appearing in the ’491 Publication. *See Ex Parte Ravi Kumar Reddy Kanamatareddy*, No. 2017-006692, 2018 WL 1963956, at *5 (PTAB Apr. 19, 2018).

Shaw is therefore prior art at least under 35 U.S.C. §102(e) with a valid priority claim to July 12, 2001 and under 35 U.S.C. §102(a) with a priority claim to January 16, 2003.

V. BACKGROUND

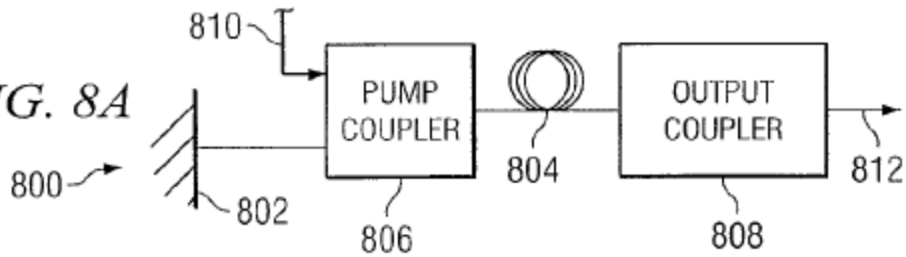
A. The Purported Invention

The '116 Patent purports to provide an infrared light source capable of wavelength shifting at least a portion of an optical signal based in part on a Raman effect. EX1001, Abstract; EX1009, ¶33. It purports that the infrared light source can be included with a medical device that facilitates detection/removal of cancerous cells by using an optical signal in the infrared wavelength range. EX1001, 14:35-64; EX1009, ¶33. It purports to wavelength shift an optical signal to prevent or reduce damage to tissue during a surgical procedure. EX1001, 14:65-15:53; EX1009, ¶33.

FIGS. 8-9 of the '116 Patent and the corresponding description in Columns 16-20 of the specification purportedly describe embodiments of the claimed invention. EX1009, ¶34.

In the embodiment shown in FIG. 8A, a pump signal (810) is coupled (or combined) via coupler 806 into a cavity (bounded by reflector 802 and wavelength separator/output coupler 808) that contains gain fiber 804. EX1001, 17:18-49; EX1009, ¶35. Wavelength separator 808 partially reflects the wavelength-shifted light (812) to maintain lasing in the cavity. EX1001, 17:37-49; EX1009, ¶35. Gain fiber 804 shifts the incoming light from pump signal 810 via the Raman effect as this shifted light 812 bounces back and forth between reflector 802 and wavelength separator 808. EX1001, 15:1-6, 17:18-27; EX1009, ¶35.

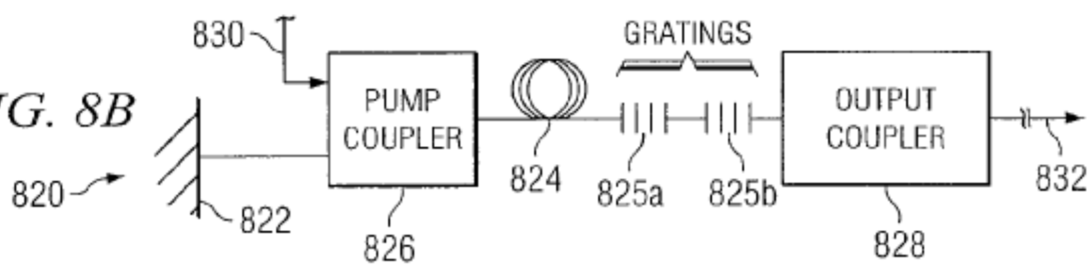
FIG. 8A



Using the nomenclature of the claims, embodiment 800 is a Raman wavelength shifter (or just wavelength shifter) because it is the device coupled to pump laser 810 to shift the shorter pump wavelength to a longer infrared wavelength. EX1001, 14:65-15:6; EX1009, ¶36. Gain fiber 804 is a waveguide structure because it is an optical fiber. EX1001, Abstract, 14:38-41,17:20-22; EX1009, ¶36.

FIGS. 8B-8D describe variations on this embodiment. FIG. 8B describes another cavity configuration with additional selecting elements 825a and 825b (*e.g.*, gratings or Fabry-Perot filters) that preferentially transmit only a portion of a desired wavelength to be outputted from the device. EX1001, 18:5-20; EX1009, ¶37.

FIG. 8B



FIGS. 8C and 8D describe configurations in which the selecting elements (845,847,865,867) act as reflectors at certain wavelengths to form separate cavities to allow multiple wavelength shiftings to occur in gain fibers 844 and 864. EX1001, 18:21-19:39; EX1009, ¶38. Each pair of selecting elements (*e.g.*, 845a and 847a) forms a separate cavity that will shift the wavelength of the incoming pump laser by successive amounts. EX1001, 18:45-59; EX1009, ¶38. In this way, a cascade occurs that allows the incoming pump laser light to be successively shifted to even longer wavelengths. EX1001, 18:45-59; EX1009, ¶38.

FIG. 8C

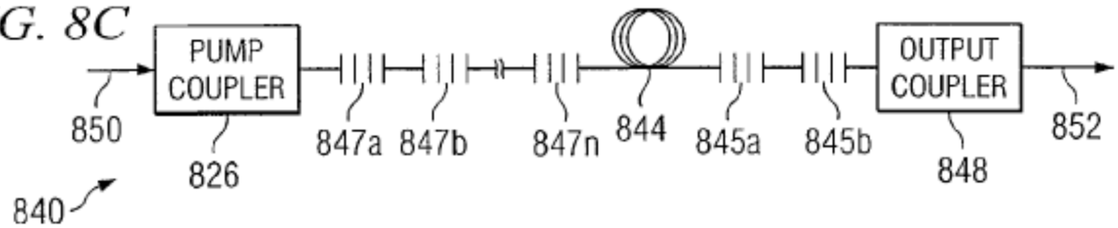
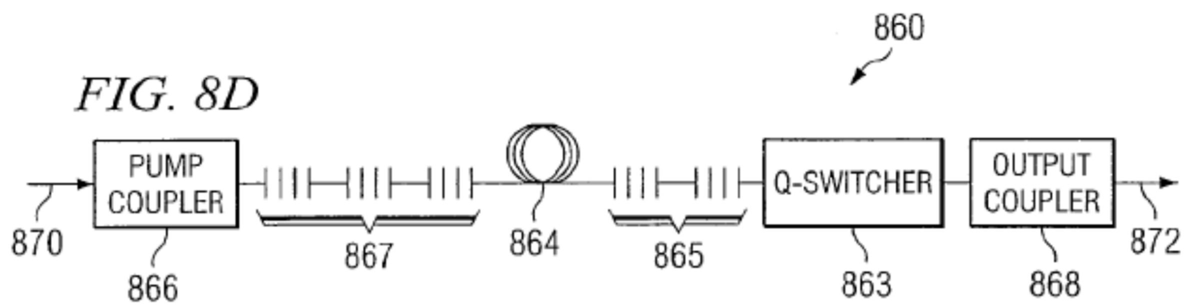


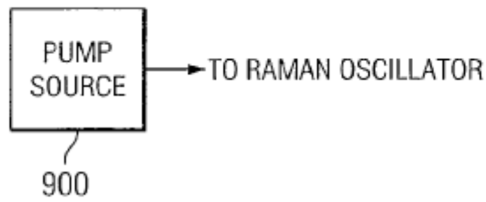
FIG. 8D



FIGS. 9A-9C describe embodiments of the pump sources (810, 830, 850, 870) that can be used with the configurations described in FIGS. 8A-8D. EX1001, 19:40-43; EX1009, ¶39.

The simplest, FIG. 9A, describes a single pump source 900 (such as a solid-state laser, laser diode, or fiber laser) that can produce an optical signal at a desired wavelength and power. EX1001, 19:47-59; EX1009, ¶40.

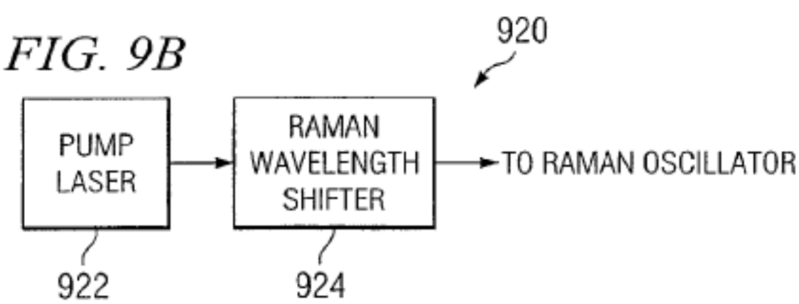
FIG. 9A



The “Raman oscillator” shown in these figures can be the Raman wavelength shifters 800, 820, 840, and 860 shown in FIGS. 8A-8D. EX1001, 19:55-59; EX1009, ¶41.

FIG. 9B adds an intermediate stage (Raman wavelength shifter) 924 after pump laser 922 but before the Raman oscillator to produce a first wavelength shift before the pump laser light is sent to the Raman oscillators described in FIGS. 8A-8D. EX1001, 19:60-66; EX1009, ¶42. This intermediate stage 924 produces a first wavelength shift of the pump laser signal 922 before the subsequent Raman oscillator shifts it further. EX1001, 20:8-20; EX1009, ¶42.

FIG. 9B



Finally, FIG. 9C describes an embodiment where light generated by multiple pump lasers 942a and 942b at the same wavelength are combined via a multiplexer 944 (combiner) before being sent to the Raman oscillator. EX1001, 20:23-41; EX1009, ¶43.

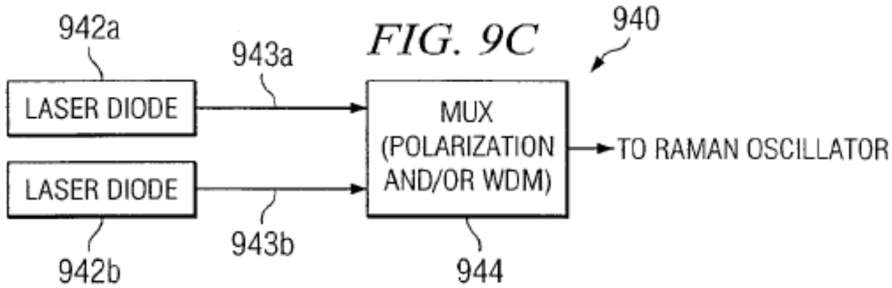


FIG. 9C

B. The '116 Patent Examination History

The '116 Patent was filed on March 30, 2004 and assigned U.S. Patent Application No. 10/812,608. The application included Claims 1-45. EX1002, pp. 149-52, 202-10.

The PTO issued an Office Action on August 28, 2007, rejecting the claims under 35 U.S.C. §112. EX1002, pp. 68-71. Applicant filed on November 8, 2007, a response amending the claims to address the §112 issues. EX1002, pp. 52-64. Notably, the independent claims were amended to recite that "the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal" and that "the first waveguide structure is substantially different than the second waveguide structure." EX1002, p. 53. Patent Applicant failed to state in its response where support for these claim limitations is found in the specification, nor is the phrase "substantially different" found anywhere in the specification. EX1002, pp. 155-201.

C. Person of Ordinary Skill in the Art ("POSITA")

A POSITA is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. Regarding the '116 Patent, a POSITA would have at least a Ph.D. in electrical engineering, optical engineering, or physics (or equivalent course work) and 3-4 years of experience in the areas of fiber optics and Raman scattering. EX1009, ¶31.

VI. CLAIM CONSTRUCTION

The Board only construes the claims when necessary to resolve the underlying controversy. *Toyota Motor Corp. v. Cellport Systems, Inc.*, IPR2015-00633, Paper 11 at 16 (PTAB Aug. 14, 2015). Other than the terms addressed below in Section VII,[3] Petitioners believe that no express constructions of the claims are necessary.

There are several claim terms of the '116 Patent that have been directly disputed or agreed to by the parties in district court, which Petitioners identify below. Any claim terms not addressed should be interpreted consistent with the *Phillips* standard. The challenged claims would have been obvious over the asserted prior art under all of the below constructions.

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[3] infrared light source, combiner, operable to combine the first pump signal and the second pump signal into a first optical signal, first optical signal, substantially different (multiple instances) coupled to, and shift.

VII. PETITIONERS HAVE A REASONABLE LIKELIHOOD OF PREVAILING

The purported invention of the ‘116 Patent is nothing more than the combination of well-known technologies and techniques yielding a predictable outcome. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

A. Claims 1-4, 9, 11-14, 16-25, and 30-35 are Anticipated by Shaw (Ground 1)

The following sections explain where each element of Claims 1-4, 9, 11-14, 16-25, and 30-35 is found in the prior art. EX1009, ¶¶72-73.

1. Claim 1 (Preamble): An infrared light source, comprising:

Both Petitioners and Patent Owner agree that this term means at least "a source of light that emits light with a wavelength between approximately 750 nm and 1 mm." EX1014. The '116 Patent describes this technology and each example falls within a wavelength ranging from 980 nm to 10 µm. EX1001, 14:54-64, 15:15-58, 16:16-20, 35-37, 55-57, 17:13-17, 53-60, 18:30-35, 64-65, 19:2-7, 20:15-16, 34-35; Claims 8, 28; FIGS. 6B, 7; EX1009, ¶74.

Patent Owner further construes this term as "a preamble term that does not exclude other wavelengths of light." EX1014. Petitioners assert that resolution of Patent Owner's additional language is not necessary to resolve the issues raised in this Petition.

Shaw states that it's "invention pertains to an ***optical device***…to amplify a pump light beam by means of stimulated Raman scattering" (EX1004, Abstract (emphasis added)) and "describes a new approach for achieving high efficiency Raman glass fiber lasers and amplifiers in the ***infrared region***" (EX1004, ¶[0020] (emphasis added)). EX1009, ¶77. Shaw further provides a specific example that emits light at 1.56 µm. EX1004, ¶[0041]; EX1009, ¶77.

To the extent that the preamble is limiting, Shaw discloses an infrared light source ("optical device" operating in "the infrared region"). EX1009, ¶78.

a. [1.1]: one or more combiners coupled to

The parties agreed to construe the term combiner as "an optical device that combines two or more separate incoming optical signals into an outgoing optical signal." EX1014. The parties also agreed to construe the term "coupled to" as "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another." EX1014.

Shaw's describes how his invention includes a 2x2 coupler (combiner), which is an optical device that combines two or more separate incoming signals into an outgoing signal. Shaw states that "[f]iber ***couplers***, WDM splitters, or dichroic beam splitters may also be utilized to ***combine pump beam and the signal beam for launching into and/or coupling out of the fiber***. EX1004, ¶[0027] (emphasis added); EX1009, ¶81. Thus, Shaw's couplers are combiners. EX1009, ¶81. Shaw's Example 1 has a 2x2 coupler 216 that combines light from two different laser sources: Continuum Mirage OPO[4] 212 and signal source 214. "The ***signal source 214*** was a 1.56 µm diode laser that was ***mixed*** with the ***pump laser*** using a ***2×2 coupler 216***." EX1004, ¶[0041] (emphasis added); EX1009, ¶82. This is illustrated in Shaw's FIG. 8 (an annotated version is shown below).

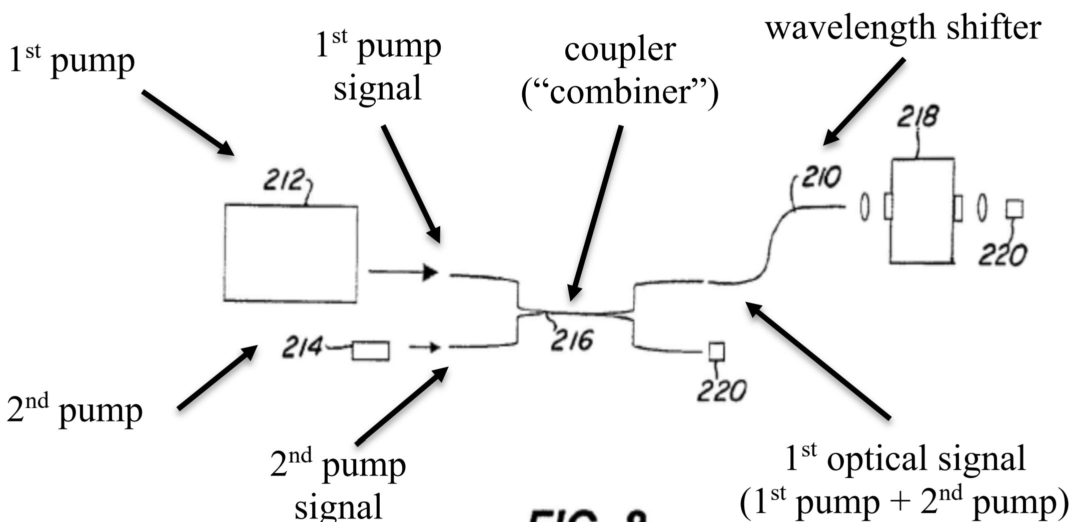

FIG. 8

EX1009, ¶82.

FIG. 6 of Shaw shows a similar, more generalized configuration with coupler 106 as the combiner. EX1004, ¶[0034]; EX1009, ¶83.

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[4] A Continuum Mirage OPO is an <u>o</u>ptical <u>p</u>arametric <u>o</u>scillator laser. EX1009, ¶82, n.1.

Claim 1 requires the one or more combiners to be coupled to first and second pump lasers. Shaw's coupler is coupled to (direct or indirect optical communication) its signal source and pump laser. EX1009, ¶84.

Shaw's coupler combines the two or more separate incoming optical signals into an outgoing optical signal. A 2x2 coupler is a device having two input ports and two output ports, which combines the incoming signals and transmits the combined signals to both output ports. EX1009, ¶85. A POSITA would have understood that Shaw's 2x2 coupler 216 is a combiner operable to combine a first signal generated by a first pump laser 212 with a second signal generated by a second pump laser 214 into a first optical signal and then to couple that combined signal to a subsequent optical element 210. EX1009, ¶85.

Thus, Shaw discloses one or more combiners (2x2 coupler 216) coupled to a first pump laser (Continuum Mirage OPO 212) and a second pump laser (signal source 214). EX1009, ¶86.

b. [1.2]: at least a first pump laser operable to generate a first pump signal and

Shaw's Example 1 and FIG. 8 describe an infrared light source having a pump laser (*e.g.*, Continuum Mirage OPO 212) generating a first pump signal. EX1009, ¶87. Shaw states that his IR light source "is pumped with Continuum Mirage OPO 212 at 1.5 μm with about 8 W of peak power in a 5 ns pulse." EX1004, ¶[0041]; EX1009, ¶87. Shaw refers to laser 212 as a "pump laser." EX1004, ¶[0041];

EX1009, ¶87. FIG. 6 also shows a first pump laser generating a first pump signal 110. EX1004, ¶[0034]; EX1009, ¶88. A POSITA would have understood Shaw's pump laser 212/110 to be a first pump laser operable to generate a first pump signal. EX1009, ¶89.

Thus, Shaw discloses at least a first pump laser (Continuum Mirage OPO 212 or 110) operable to generate a first pump signal (1.5 μm). EX1009, ¶90.

c. [1.3]: a second pump laser operable to generate a second pump signal,

Shaw's Example 1 and FIG. 8 describe an infrared light source having a laser diode source 214 generating a second pump signal. EX1009, ¶91. "The signal source 214 [is] a 1.56 μm diode laser that [is] mixed with the pump laser using a 2×2 coupler 216." EX1004, ¶[0041]; EX1009, ¶91. FIG. 6 shows a second pump laser 118 generating a second pump signal. EX1004, ¶[0034]; EX1009, ¶92. A POSITA would have understood that Shaw's laser diode 214/118 to be a second pump laser operable to generate a second pump signal. EX1009, ¶93.

Thus, Shaw discloses at least a second pump laser (signal source 214/118) operable to generate a second pump signal (1.56 μm). EX1009, ¶94.

d. [1.4]: the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal,

The parties agreed to construe "operable to combine the first pump signal and the second pump signal into a first optical signal" as "receive the first pump signal and the second pump signal and combine them into the first optical signal." EX1014. Petitioners construe the term "first optical signal" as "a combined optical signal that simultaneously contains both the first pump signal and the second pump signal propagating in the same direction."

While the '116 Patent does not describe the two-differing-wavelength-pump system described in the claims, it does provide a single example in FIG. 9C of a two-pump system (albeit using two pumps of the same wavelength). In that case, the pump signals (943a, 943b) from the two pump lasers (942a, 942b) are sent to a combiner (944), merged into a single signal, and then sent to the Raman wavelength shifter/oscillator to shift its wavelength. EX1001, 20:21–41, FIG. 9C; EX1009, ¶96.

As a result, the "first optical signal" of Claim 1 must mean that it is an optical signal comprised of the first pump signal and the second pump signal and that those combined signals propagate together in the same direction after being combined so that they can be received by the first waveguide structure. EX1009, ¶97.

Patent Owner construes this term under its plain and ordinary meaning, or in alternative as "combined optical signal that contains at least a portion of the first pump signal and the second pump signal." EX1014. Petitioners assert that resolution of these different constructions is not necessary to resolve the issues raised in this Petition.

Shaw's Example 1 and FIG. 8 describe a 2x2 coupler (a "combiner" or "optical device"—*see* §VII(A)(1)(a))—operable to receive the first pump signal and the second pump signal and combine them into a first optical signal:

> The ***signal source 214*** was a 1.56 μm ***diode laser*** that was ***mixed*** with the ***pump laser*** using a 2×2 ***coupler*** 216.

EX1004, ¶[0041] (emphasis added); EX1009, ¶99.

An annotated version of Shaw's FIG. 8 is shown below.

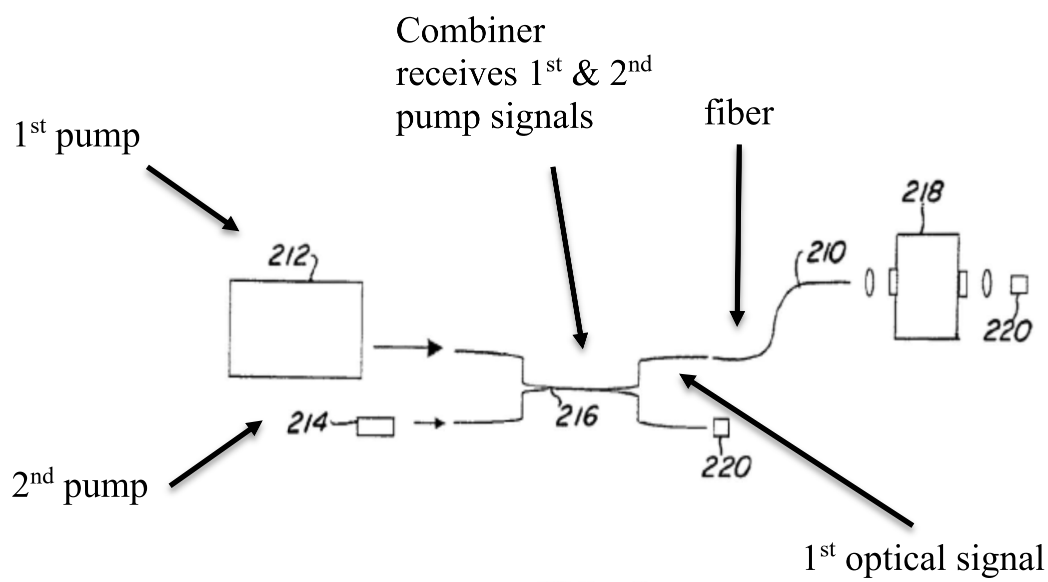

FIG. 8

EX1004, FIG.8; EX1009, ¶100. FIG. 6 shows a similar configuration. EX1004, ¶[0034]; EX1009, ¶100.

Shaw's system mixes the first and second pump signals so that they merge or "combine" into an optical signal that is fed to fiber 210. EX1009, ¶101. Each of the first pump signal and the second pump signal is an optical signal (*discussed supra*), and thus when they are mixed, they are combined into a "first optical signal." EX1009, ¶101. The first pump signal is at a first wavelength (1.5 µm) and the second pump signal is at a second wavelength (1.56 µm). EX1004, ¶[0041]; EX1009, ¶101. The 2x2 coupler 216 receives the first pump signal and the second pump signal and mixes them into a "first optical signal" that includes both the first wavelength (1.5 µm) and the second wavelength (1.56 µm). EX1004, ¶[0041]; EX1009, ¶101.

Thus, Shaw discloses the one or more combiners (2x2 coupler 216) operable to combine the first pump signal (1.5 µm) and the second pump signal (1.56 µm) into a first optical signal ("mixed" signal). EX1009, ¶102.

e. [1.5]: the first pump signal comprising at least a first wavelength and

In Shaw's Example 1, the first pump signal has a wavelength of 1.5 µm. EX1004, ¶[0041]; EX1009, ¶103.

Thus, Shaw discloses the first pump signal (1.5 µm) comprising at least a first wavelength (1.5 µm). EX1009, ¶104.

f. [1.6]: the second pump signal comprising at least a second wavelength,

In Shaw's Example 1, the second pump signal has a wavelength of 1.56 µm. EX1004, ¶[0041]; EX1009, ¶105.

Thus, Shaw discloses the second pump signal (1.56 µm) comprising at least a second wavelength (1.56 µm). EX1009, ¶106.

g. [1.7]: wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal; and

Petitioners asserted in the parallel district court proceeding that this term is indefinite because the '116 Patent provides no guidance as to how different the first and second wavelengths must be to be "substantially different." EX1014. Despite not providing a minimum difference, the '116 Patent does distinguish between light as close as 10 nm apart (1390 vs. 1400 nm). EX1001, 21:60-63. At the very least, a 10-nm difference in wavelength would seem to be "substantially different" within the meaning of the patent because the Patent Owner treats the two wavelengths as being different. EX1009, ¶107. Given the context of the specification, a POSITA would have understood that whatever the precise scope of the claim, a first wavelength has a wavelength that "substantially differs" from a second wavelength when it facilitates a significant shift of the wavelength on the order of tens of nanometers. EX1009, ¶108.

Petitioners acknowledge that in certain circumstances if a claim cannot be understood without resort to speculation, then other prior art grounds may not be able to be applied. *See, e.g., In re Steele,* 305 F.2d 859, 862 (CCPA 1962); *BlackBerry Corp. v. MobileMedia Ideas, LLC,* IPR2013-00036, Paper 65, slip op. at 19-20 (PTAB Mar. 7, 2014) (citing *Steele,* 305 F.2d at 862-63 for "the prior art grounds of unpatentability must fall, pro forma, because they are based on speculative assumption[s] as to the meaning of the claims" and reasoning that "an obviousness determination based on less than all of the claimed elements is speculative as to the meaning or scope of the claims"). However, the Board recognizes that this prohibition does not extend to cases where the prior art can be read against the claim in question, as is the case presently. The Board states that indefiniteness "does not necessarily preclude the Board from addressing the patentability of the claims on section 102 and 103 grounds." *See, e.g., PLR Worldwide Sales Limited v. Flip Phone Games, Inc.,* IPR2024-00200, Paper 9 (PTAB May 10, 2024), citing *Samsung Elecs. Am. Inc. v. Priusa Eng'g Corp.,* 948 F.3d 1342, 1355 (Fed. Cir. 2020); *Intel Corp. v. Qualcomm Inc.,* 21 F.4th 801, 813 (Fed. Cir. 2021) ("The indefiniteness of a limitation…precludes a patentability determination only when the indefiniteness renders it logically impossible for the Board to reach such a decision."). In *Target Corporation v. Proxicom Wireless, LLC,* IPR2020-00904, Paper 11 (PTAB Nov. 10, 2020), slip op. at 11-12, the Board correctly observes that "Petitioner's alternative pleading before a district court is common practice, especially where it concerns issues outside the scope of *inter partes* review." Notwithstanding Petitioners' view on the definiteness of this term, indefiniteness "does not necessarily preclude the Board from addressing the patentability of the claims on section 102 and 103 grounds." *Samsung Elecs.*, 948 F.3d at 1355; *Intel*, 21 F.4th at 813 ("The indefiniteness of a limitation…precludes a patentability determination only when the indefiniteness renders it logically impossible for the Board to reach such a decision.”). Here, as Patent Owner itself admits, there are differences in wavelength that a POSITA would understand to be substantial. Such differences not only include that which Patent Owner purports to be a substantial difference but also the difference in wavelength disclosed in the prior art Shaw. EX1009, ¶110.

Patent Owner construes this term as “wavelengths with an 80nm difference or more,” which coincidentally lies between the primary invalidity reference cited against the ’116 Patent (Shaw) (disclosing a 60-nm difference between the first and second pump wavelengths) and the products the Patent Owner accuses of infringement (allegedly having an 84-nm difference between the first and second pump wavelengths). The ’116 Patent is devoid of any specific wavelength range that constitutes a substantial difference, much less an 80-nm or more difference. Indeed, to the extent that the ’116 Patent discloses different wavelengths, it discloses wavelengths that a much closer, such as 10 nm apart. EX1001, 21:60–63; EX1009, ¶112. There is, simply put, no evidence to support the Patent Owner’s 80-nm now litigation-advanced construction.

In Shaw’s Example 1, the first wavelength is unquestionably ***different*** than the second wavelength (1.5 μm vs. 1.56 μm). EX1009, ¶113. Neither the ’116 Patent specification nor the examination history define the metes and bounds of how different these wavelengths must be to be "substantially different." EX1009, ¶113. However, given Patent Owner's contention that enumerated wavelengths differences in the specification are sufficient to be "substantially different" and the specification distinguishes between 1390 nm and 1400 nm, a difference of at least 10 nm would appear to be "substantially different" within the meaning of the claim even if the precise boundary between different and substantially different cannot be reasonably ascertained. EX1009, ¶114. The shift of 60 nm (0.06 μm) from the first wavelength to the second wavelength would correspond to a shift of six times the 10-nm difference described in the specification. EX1009, ¶114. Thus, a POSITA would have understood that a difference of wavelength from 1.5 μm to 1.56 μm is enough to be "substantially different." EX1009, ¶114.

Shaw, therefore, discloses the first wavelength (1.5 μm) of the first pump signal is substantially different (Δ0.06 μm—6× the minimum wavelength difference described in the specification) than the second wavelength (1.56 μm) of the second pump signal. EX1009, ¶115.

h. [1.8]: a wavelength shifter coupled to the one or more combiners, the wavelength shifter comprising

The parties also agreed to construe the term "coupled to" as "any direct or indirect optical communication between two or more elements, whether or not those elements are in physical contact with one another." EX1014.

The '116 Patent broadly defines wavelength shifters to refer to any device that shifts a signal to a longer wavelength, including optical fibers and gratings:

> "Raman wavelength shifter" refers to any device that uses the Raman effect to shift a shorter optical signal wavelength to a longer optical signal wavelength. The Raman wavelength shifters may comprise, for example, one or more reflectors, one or more gratings, an optical fiber, or a combination of these or other elements.

EX1001, 15:1-6; EX1009, ¶118.

Shaw explains how wavelength shifting occurs via the Raman effect in fibers. EX1004, ¶[0028]; EX1009, ¶119. Light at two different wavelengths is sent into a fiber, and light at one wavelength is amplified by transferring (shifting) energy from the other wavelength to it through stimulated Raman scattering:

> pump light beam 450 of wavelength λ_1 and signal light beam 452 of wavelength λ_2 of a lower intensity than the pump light beam 450 are launched into one end of glass fiber 454. Light beam 452 interacts with light beam 450 and the fiber 454 through stimulated Raman scattering and is amplified. At the opposite end of the fiber 454, depleted beam 456 at wavelength λ_1 and amplified light beam 458 at wavelength λ_2 issue forth.

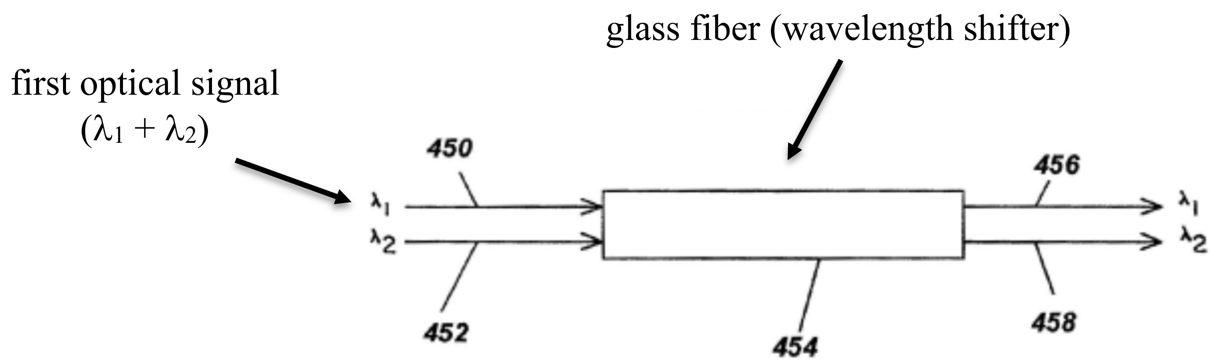

FIG. 4

EX1004, ¶[0028], FIG.4; EX1009, ¶119.

In Shaw's Example 1, 2x2 coupler 216 (the "combiner") combines the signals from lasers 212 and 214 (*i.e.*, light beams 450 and 452 from FIG. 4) into the first optical signal, which is then coupled to fiber 210 (*i.e.*, glass fiber 454 from FIG. 4), which operates as a wavelength shifter and shifts light from one wavelength (λ_1) to the other (λ_2). *Id.,* ¶[0041]; EX1009, ¶120. Coupler 106 in FIG. 6 similarly combines signals from lasers 110 and 118. EX1004, ¶[0034]; EX1009, ¶120.

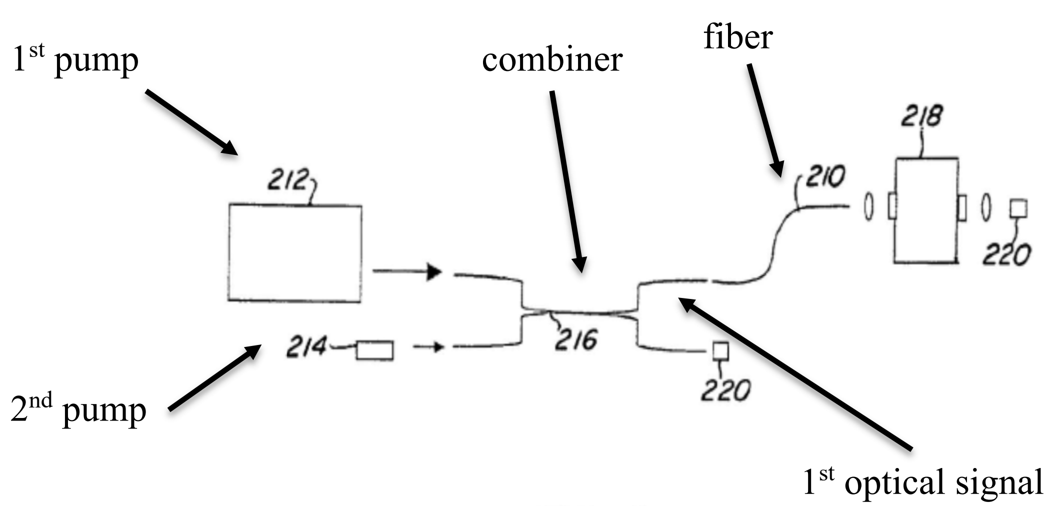

FIG. 8

EX1004, FIG.8; EX1009, ¶120.

Therefore, fiber 210 is a wavelength shifter coupled to (in direct or indirect optical communication with) the combiner (2x2 coupler 216). EX1009, ¶121.

The '116 Patent states that its "Raman wavelength shifter includes a gain fiber 804 operable to facilitate shifting pump signal 810 to a desired wavelength," and that its gain fiber can "comprise any waveguide structure capable of ***wavelength shifting pump signal*** 810 ***to a longer wavelength*** or a ***different Raman cascade order***." EX1001, 17:18-22 (emphasis added); EX1009, ¶122.

Shaw discloses:

> Other configurations of Raman fiber lasers include ring lasers and cascaded Raman fiber lasers….The latter embodiment involves ***cascading several Fabry-Perot cavities*** such that the output Stokes from one cavity is trapped in the next Fabry-Perot cavity that generates and amplifies a second Stokes at ***longer wavelength***. With this process, the ***initial pump beam may be shifted up in wavelength*** through several Stokes shifts to generate a high power beam at wavelengths corresponding to multiples of the Raman shift.

EX1004, ¶[0036]; EX1009, ¶123.

Shaw's Raman wavelength shifter, which is coupled to a combiner (2x2 coupler 216), includes a fiber 210 that shifts a pump signal to a desired wavelength. EX1009, ¶124. Its fiber incudes a waveguide structure capable of wavelength shifting the pump signal to a longer wavelength or a different Raman cascade order. EX1009, ¶124.

Thus, Shaw discloses a wavelength shifter (fiber 210) coupled to the one or more combiners (2x2 coupler 216). EX1009, ¶125.

i. [1.9]: a first waveguide structure and

The ’116 Patent states:

> The ***waveguide structure can comprise***, for example, an ***optical fiber***, a hollow tube waveguide, an air core waveguide, a planar waveguide, or a combination of these or other devices.

EX1001, 14:38-41 (emphasis added); EX1009, ¶126.

> [A]t least a portion of the ***Raman wavelength shifter can be implemented in a waveguide structure***.

EX1001, 16:43-45 (emphasis added); EX1009, ¶126.

> Raman wavelength shifter includes a gain fiber 804 operable to facilitate shifting pump signal 810 to a desired wavelength. ***Gain fiber 804 may comprise any waveguide structure capable of wavelength shifting*** pump signal 810 to a longer wavelength or a different Raman cascade order.

EX1001, 17:20-22 (emphasis added); EX1009, ¶126.

In Shaw’s Example 1, the As-Se fiber 210 is an optical fiber, which is one of the enumerated types of waveguide structures. EX1004, ¶[0041]; EX1009, ¶127.

Amplifier fiber 128 in FIG. 6 is also a waveguide structure. EX1004, ¶[0034]; EX1009, ¶127.

Thus, Shaw discloses the wavelength shifter (fiber 210) comprising…a first waveguide structure ("optical fiber"). EX1009, ¶128.

j. [1.10]: a second waveguide structure,

The '116 Patent provides an example of using two waveguide structures (*e.g.*, multiple fibers or Fabry-Perot cavities) in tandem to achieve multiple wavelength shifts. EX1001, 18:5-20; EX1009, ¶129. The second waveguide structure, therefore, could be a different Fabry-Perot cavity from the first waveguide structure. EX1009, ¶129.

As discussed above in §VII(A)(1)(i), Shaw discloses a first waveguide structure in the form of As-Se fiber 210. EX1004, ¶[0041]; EX1009, ¶130. Shaw further notes that additional fibers can be used in tandem with the first fiber to shift the wavelength through multiple Raman shifts, thereby achieving a longer overall wavelength shift than would be possible with a single fiber. EX1004, ¶[0036]; EX1009, ¶130. Shaw specifically shows such a configuration in FIG. 6 with fibers 132 and 138. EX1004, FIG.6; EX1009, ¶130.

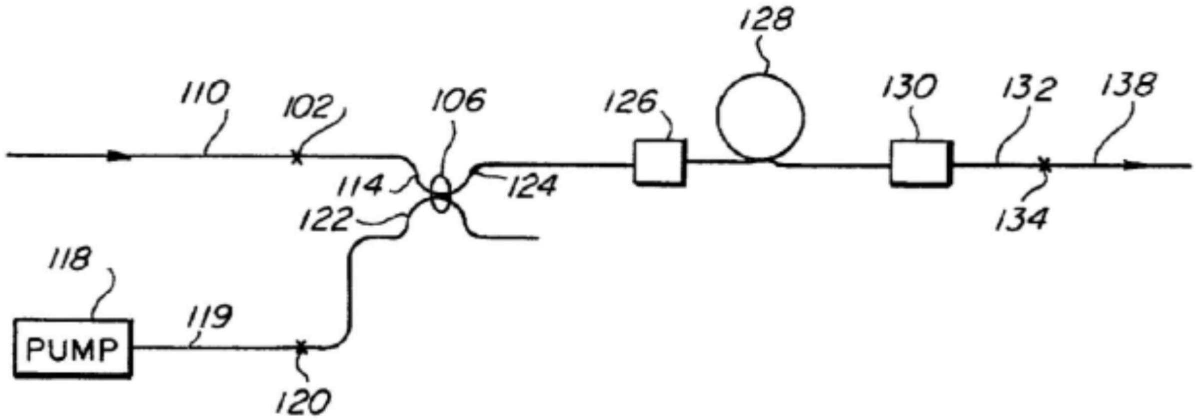

FIG. 6

Shaw further states that different fiber materials (*e.g.*, As-Se and As-S) have different Raman bandwidths, which would cause different shifting. EX1004, ¶¶[0024]-[0026],[0032], Fig. 3; EX1009, ¶131.

Shaw also explains that Fabry-Perot cavities can be made from fibers with a fiber-Bragg grating written into the fiber. EX1004, ¶[0035]; EX1009, ¶132. Shaw further notes that such a Bragg grating is uniquely tailored to the specific Stokes wavelength desired. EX1004, ¶[0035]; EX1009, ¶132. It will only be reflective at certain wavelengths and transmissive (or partially transmissive) at other wavelengths. EX1004, ¶[0035],[0037]; EX1009, ¶132. Thus, in the cascaded approach used by Shaw, each Fabry-Perot cavity necessarily will be different than the other because it will be designed to trap successively longer wavelengths as the light cascades from one cavity to the next. EX1004, ¶[0035]; EX1009, ¶132. This approach is the same as disclosed in the embodiment shown in FIG. 8C of the '116 Patent, which also uses multiple Fabry-Perot cavities. EX1001, 18:5-20; EX1009, ¶133. Accordingly, Shaw discloses a second, different waveguide structure via these other optical fibers. EX1009, ¶133. FIG. 6 shows how successive waveguide structures 132, 138 (fibers) can be coupled to prior waveguide structures 128. EX1004, FIG.6; EX1009, ¶133.

Thus, Shaw discloses the wavelength shifter (fiber 210) comprising…a second waveguide structure (different fibers or Fabry-Perot cavities). EX1009, ¶134.

k. [1.11]: the wavelength shifter operable to receive the first optical signal and

Shaw states: "Fiber couplers, WDM splitters, or dichroic beam splitters may also be utilized to combine pump beam and the signal beam [the combined beams forming the "first optical signal"—*discussed supra*] for launching into and/or coupling out of the fiber." EX1004, ¶[0027]; EX1009, ¶135. How the Shaw fiber 210 operates as a wavelength shifter is discussed above. *See* §VII(A)(1)(h); EX1009, ¶135. In the Shaw system, the fiber 210 (wavelength shifter) is operable to receive the first optical signal, as shown below. EX1009, ¶135.

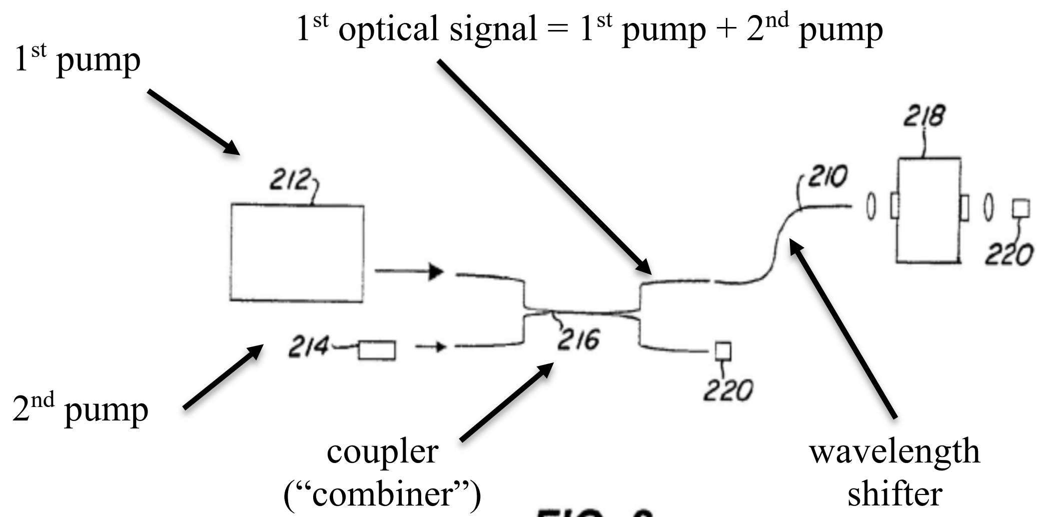

FIG. 8

FIG. 6 also shows a wavelength shifter 128. EX1004, ¶[0034]; EX1009, ¶135.

Thus, Shaw discloses the wavelength shifter (fiber 210) operable to receive the first optical signal ("mixed" signal). EX1009, ¶136.

l. [1.12]: to wavelength shift at least a portion of the first optical signal based at least in part on a Raman effect,

Petitioners construe the term "shift" as "to discretely move from one value to another without broadening." The '116 Patent never specifically defines the term "shift" in the patent, although the term (or the term "shifting") is used throughout the latter half of the specification. Every example involves a circumstance in which light is discretely shifted from one value to another: *See, e.g.,* EX1001, 14:67-15:3, 15:19-23,16:40-43,17:18-22; EX1009, ¶137. In no instance does the patent suggest that the invention is directed towards creating a broad continuum of wavelengths. EX1009, ¶137.

Patent Owner construes this term as "to change the wavelength of the light." Petitioners assert that resolution of these different constructions is not necessary to resolve the issues raised in this Petition.

In Shaw's Example 1, fiber 210 shifts at least a portion of the first optical signal (specifically the second pump signal portion to the first pump signal wavelength) using the stimulated Raman scattering effect. EX1004, ¶¶[0028],[0041]; EX1009, ¶139. Shaw states that the first pump signal (212 or 458) is amplified by depleting the second pump signal (214 or 450). EX1004, ¶¶[0028],[0041]; EX1009, ¶139. Shaw explains that amplification means that energy from the second pump signal is Raman-shifted to the first pump signal wavelength, which satisfies either construction. The light is either moved or changed from one wavelength (second pump signal) to another (first pump signal). EX1004, ¶[0029]; EX1009, ¶139.

Thus, Shaw discloses the wavelength shifter (fiber 210) operable to…wavelength shift (the first pump signal 212, 458 is amplified/shifted by depleting the second pump signal 214, 450) at least a portion of the first optical signal (1.5 μm) based at least in part on a Raman effect ("stimulated Raman scattering effect"). EX1009, ¶140.

m. [1.13]: wherein the wavelength shifter operates to wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure and

Shaw describes the concept of wavelength shifting using Raman scattering from a first wavelength λ_1 to a second wavelength λ_2 (an "intermediate" wavelength). EX1004, ¶[0028]; EX1009, ¶141. FIG. 4 is an illustration of a basic laser structure with first pump light beam 452 at wavelength λ_2 and a second pump light beam at wavelength λ_1 entering glass fiber 454. *Id*. Light from the second pump signal (λ_1) is then shifted to the first pump signal wavelength (λ_2) using stimulated Raman scattering. EX1004, ¶[0028]; EX1009, ¶141.

Shaw then describes an example of this technique (Example 1—EX1004, ¶[0041]) in which a signal from a Continuum Mirage OPO 212 at 1.5 µm is combined with a signal from a 1.56-µm signal source 214 in coupler 216 to form a first optical signal. EX1004, ¶[0041]; EX1009, ¶142.This "first optical signal" enters fiber 210, wherein 1.5-µm light is shifted to 1.56 µm through stimulated Raman scattering. EX1004, ¶[0028]; EX1009, ¶142. This shift occurs in Shaw's fiber 210, which includes the first waveguide structure (*discussed supra*). The claim requires another shift to occur in the second waveguide structure. As will be explained, Shaw discloses a system having a second waveguide structure within which another wavelength shift occurs. With two waveguide structures performing two different shifts, the first shift to the intermediate optical wavelength would occur in the first waveguide structure. EX1009, ¶142. Such a structure is also shown in FIG. 6. EX1004, ¶[0034]; EX1009, ¶142.

Thus, Shaw discloses the wavelength shifter (fiber 210) operates to wavelength shift (the first pump signal 212, 458 is amplified by depleting the second pump signal 214, 450) at least the first wavelength (1.5 μm) to an intermediate optical wavelength (1.56 μm) in the first waveguide structure ("optical fiber"). EX1009, ¶143.

n. [1.14]: to wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure;

Shaw's Example 1 further discloses that this intermediate optical wavelength can be further shifted using additional fibers (such as cascaded Raman fiber lasers) to shift the wavelength through several Stokes shifts. EX1004, ¶[0036]; EX1009, ¶144.

Cascading ***several*** Fabry-Perot cavities or fibers to shift through ***several*** Stokes shifts requires more than one wavelength shift—*e.g.*, a shift to one wavelength in the first fiber and then another shift in the next fiber and so on. EX1004, ¶[0036]; EX1009, ¶145. This is the same approach described in the embodiment shown in FIG. 8C of the '116 Patent. EX1001, 18:5-20; EX1009, ¶145.

Shaw further states that this process can be used to generate wavelengths of 1.91 μm, 5.4 μm, and up to 15 μm. EX1004, ¶[0042], Claim 10; EX1009, ¶146.

Because each Stokes shift in the subsequent waveguide structures shifts the wavelength of the signal to a longer wavelength, Shaw discloses a shift of the intermediate optical wavelength to a longer optical wavelength in a second waveguide structure (the subsequent Fabry-Perot cavity). EX1009, ¶147. Alternatively, separate waveguide structures (132, 138) can be connected in series, as shown in FIG. 6 of Shaw. EX1004, FIG.6; EX1009, ¶147.

Thus, Shaw discloses wherein the wavelength shifter (fiber 210) operates to…wavelength shift (the first pump signal 212, 458 is amplified by depleting the second pump signal 214, 450) the intermediate optical wavelength (1.56 µm) to a longer optical wavelength ("the initial pump beam may be shifted up in wavelength through several Stokes shifts") in the second waveguide structure ("Fabry-Perot cavities"). With two waveguide structures performing two different shifts, the second shift to the longer optical wavelength would occur in the second waveguide structure. EX1009, ¶148.

o. [1.15]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and

In Shaw's Example 1, the fiber 210 shifts 1.5-µm light (first wavelength) to 1.56 µm (intermediate wavelength). EX1004, ¶[0028],[0041]; EX1009, ¶149. 1.56 µm is an optical wavelength greater than a 1.5 µm. EX1009, ¶149.

Thus, Shaw discloses wherein at least a portion of the intermediate optical wavelength (1.56 μm) is greater than the first wavelength (1.5 μm). EX1009, ¶150.

p. [1.16]: wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength; and

Shaw states that his cascaded Raman fiber laser embodiment will cause multiple wavelength shifts, each to a longer wavelength than the previous. EX1004, ¶[0036]; EX1009, ¶151.

By cascading an additional Fabry-Perot cavity to fiber 210 (or using additional fibers), Shaw can shift the 1.56 μm light (the intermediate optical wavelength) to a longer optical wavelength (up to 15 μm). EX1004, ¶¶[0020],[0034], FIG.6; EX1009, ¶152.

Thus, Shaw discloses at least a portion of the longer optical wavelength (up to 15 μm via "several Stokes shifts") is greater than the intermediate optical wavelength (1.56 μm). EX1009, ¶153.

q. [1.17]: wherein the first waveguide structure is substantially different than the second waveguide structure.

Petitioners have asserted in the district court that this term as indefinite because there is no explanation in the '116 Patent regarding how different the first and second waveguide structures must be to be "substantially different." EX1014. As mentioned with respect to Claim element 1.7, prohibitions against challenging indefinite claim does not extend to cases where the prior art can be read against the claim in question, as is the case presently. Here, given the context of the specification, a POSITA would have understood the first and second waveguide structures to operate at wavelengths that differ from one another. EX1009, ¶155. For instance, the ’116 Patent provides an example with two different waveguide structures (Fabry-Perot cavities) that cause multiple wavelength shifts, and that these fibers were selected because they work at different wavelengths. EX1001, 18:5-20; EX1009, ¶156. In another example, the ’116 Patent describes the two waveguide structures as being comprised of different materials—fused silica and different chalcogenide glass—that enable multiple shifts in wavelengths. EX1001, 15:14-24; EX1009, ¶156. A POSITA would have understood that whatever the precise scope of this term “substantial” it at least includes differences in the wavelengths for which the first and second waveguide structures are optimized. EX1009, ¶157.

Patent Owner construes this term as “a waveguide having a different material, shape, or size greater than standard tolerances.” But the ’116 Patent is devoid of any reference to waveguide shape or size. EX1009, ¶158. There is nothing about use of one size or shape for a first waveguide structure and use of another for a second waveguide structure. The ’116 Patent is further devoid of any discussion related to standard tolerances or why a deviation from standard tolerances is desired. There is also no discussion of any baseline waveguide structure to use as a standard. As a result, there is no support for the Patent Owner's proposed construction. *Id.*

As discussed above, the '116 Patent specification provides one example of an embodiment with two different waveguide structures (Fabry-Perot cavities) that cause multiple wavelength shifts. EX1001, 18:5-20; EX1009, ¶159. The patent states that these fibers were selected because they work at different wavelengths. EX1001, 18:5-20; EX1009, ¶159.

Shaw notes that the Fabry-Perot cavity/fiber can be formed with Bragg gratings written into the fiber. EX1004, ¶[0035]; EX1009, ¶160. Because the gratings would be tailored to the specific output wavelength, they must be different if the wavelengths are different. EX1004, ¶[0035]; EX1009, ¶160. Shaw uses the same approach described in the embodiment shown in FIG. 8C of the '116 Patent. EX1001, 18:5-20; EX1009, ¶160. Shaw also discloses that different compositions of fibers can be used to cause different shifts in wavelengths. EX1004, ¶¶[0022],[0025],[0026],[0032], FIG. 3; EX1009, ¶160. Claims 19 and 20 in Shaw identify a variety of different types of waveguide structures that work in the infrared to mid-infrared range. EX1009, ¶160. A POSITA would have recognized that the specific type of second fiber/waveguide structure would be tailored differently than the first waveguide structure in order to shift the signal to higher wavelengths. EX1009, ¶160.

Thus, Shaw discloses that the second waveguide structure is substantially different from the first waveguide structure because it comprises a different type of fiber that works at a different wavelength. EX1009, ¶161.

As stated above, Patent Owner construes this term as a waveguide having a different material, shape, or size greater than standard tolerances. Shaw also discloses that different compositions of fibers (*e.g.*, entirely different materials) can be used to cause different shifts in wavelengths. EX1004, ¶¶[0022],[0025],[0026], FIG. 3; Claims 19 and 20; EX1009, ¶162. A POSITA would have understood to use a material composition, concentration, etc. for the first waveguide structure that is entirely different from the material composition, concentration, etc. of the second waveguide structure so as to have two waveguide structures that substantially differ. EX1009, ¶162.

Thus, Shaw discloses wherein the first waveguide structure ("optical fiber") is substantially different than the second waveguide structure ("Fabry-Perot cavities")—Fabry-Perot cavities/fibers can be formed with or by different Bragg gratings, different compositions of fibers, etc. to effectuate different shifts. EX1009, ¶163.

2. Claim 2: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a continuous wave laser and a pulsed laser.

As stated above in §VII(A)(1)(b), laser 212 is the first pump laser in Shaw's Example 1. Shaw specifically notes that pump laser 212 is pulsed—"The device was pumped with Continuum Mirage OPO 212 at 1.5 μm with about 8 W of peak power in a 5 ns ***pulse***." EX1004, ¶[0041] (emphasis added); EX1009, ¶164.

Thus, Shaw discloses the first pump laser (Continuum Mirage OPO 212) is selected from the group consisting of…a pulsed laser ("in a 5 ns pulse"). EX1009, ¶165.

3. Claim 3: The infrared light source of claim 1, wherein the first pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber.

The Continuum Mirage OPO 212 of Shaw's Example 1 is a solid-state laser. EX1009, ¶166. OPO lasers use solid nonlinear crystals as their gain medium. EX1009, ¶166.

Thus, Shaw discloses the first pump laser (Continuum Mirage OPO 212) is selected from the group consisting of…a solid state laser (OPO lasers are solid state lasers). EX1009, ¶167.

4. Claim 4: The infrared light source of claim 1, wherein the second pump laser is selected from the group consisting of a solid state laser, a Nd:YAG laser, a Nd:YLF laser, laser diodes, a semiconductor laser, and a cladding pump fiber.

As stated above in §VII(A)(1)(c), laser 214 is the second pump laser in Shaw's Example 1, which is a laser diode. EX1004, ¶[0041] ("The signal source 214 was a 1.56 μm diode laser…"); EX1009, ¶168.

Thus, Shaw discloses the second pump laser (signal source 214) is selected from the group consisting of…laser diodes ("signal source 214 was a 1.56 μm diode laser"). EX1009, ¶169.

5. Claim 9: The infrared light source of claim 1, wherein the longer optical wavelength comprises a pulsed optical signal having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz.

In Example 1, Shaw's first pump laser 212 is a Continuum Mirage OPO. EX1004, ¶[0041]; EX1009, ¶170. A Continuum Mirage OPO operates at 10 Hz, as evidenced by "*Raman Amplification in As-Se Fiber*," SPIE Vol. 4628, published in 2002. EX1013; EX1009, ¶170.

Thus, Shaw discloses the longer optical wavelength (1.56 μm) comprises a pulsed optical signal ("Continuum Mirage OPO 212…in a 5 ns pulse") having a pulse repetition rate in the range of two (2) hertz to one hundred (100) megahertz (Continuum Mirage OPO operates at 10 Hz). EX1009, ¶171.

6. Claim 11: The infrared light source of claim 1, wherein a variation of the first wavelength of the first pump signal causes a variation in the longer optical wavelength.

Neither the '116 Patent nor the examination history provides any guidance as to what Patentee envisioned the technical effect of a variation of the first wavelength would cause on the longer optical wavelength. EX1009, ¶172. A POSITA would have understood that changing the first wavelength would change the subsequent longer wavelength due to how the Raman process works, however. EX1009, ¶172. For instance, Shaw discloses that starting with a different wavelength leads to different shifts—*e.g.*, using a 1.83-μm pump to shift to 1.91 μm; using a 5.4-μm pump to shift to 6.2 μm. EX1004, ¶[0042]; EX1009, ¶172.

Thus, Shaw discloses a variation of the first wavelength of the first pump signal causes a variation in the longer optical wavelength—Shaw discloses that starting with a different wavelength leads to different shifts (*e.g.*, using a 1.83-μm pump to shift to 1.91 μm; using a 5.4-μm pump to shift to 6.2 μm). EX1009, ¶173.

7. Claim 12: The infrared light source of claim 1, wherein the one or more combiners are selected from the group consisting of a wavelength division multiplexer and a power coupler.

The 2x2 coupler 216 of Shaw's Example 1 is a power coupler. EX1009, ¶174. In addition, Shaw states: "Fiber couplers, WDM[5] splitters, or dichroic beam splitters

[5] "WDM" stands for wavelength division multiplexer. EX1009, ¶174, n.2.

may also be utilized to combine pump beam and the signal beam for launching into and/or coupling out of the fiber" EX1004, ¶[0027]; EX1009, ¶174.

Thus, Shaw discloses the one or more combiners (2x2 coupler 216) are selected from the group consisting of a wavelength division multiplexer ("WDM splitters"). EX1009, ¶175.

8. Claim 13: The infrared light source of claim 1, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber.

Shaw states that its waveguide structure is an "As-Se fiber 210." EX1004, ¶[0041]; EX1009, ¶176. And Shaw classifies such a fiber as a "chalcogenide As-Se glass fiber." EX1004, ¶[0032] EX1009, ¶176.

Thus, Shaw discloses the first waveguide structure ("optical fiber") is selected from the group consisting of…chalcogenide fiber ("chalcogenide As-Se glass fiber"). EX1009, ¶177.

9. Claim 14: The infrared light source of claim 1, wherein at least a portion of the first waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.

The fiber 210 of Shaw's Example 1 is an optical fiber. EX1004, ¶[0041]; EX1009, ¶178.

Thus, Shaw discloses at least a portion of the first waveguide structure ("optical fiber") is selected from the group consisting of an optical fiber ("optical fiber"). EX1009, ¶179.

10. Claim 16: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is selected from the group consisting of an optical fiber, a hollow tube waveguide, an air core waveguide, and a planar waveguide.

Shaw teaches use of multiple waveguides to achieve larger wavelength shifts—*i.e.*, the Shaw fiber 210 can include a second waveguide structure via additional fiber Bragg gratings written into optical fibers. *See* §VII(A)(1)(j); EX1004, ¶[0035]; EX1009, ¶180.

Thus, Shaw discloses at least a portion of the second waveguide structure ("optical fiber") is selected from the group consisting of an optical fiber ("optical fiber"). EX1009, ¶181.

11. Claim 17: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure comprises an optical fiber, wherein the optical fiber is selected from the group consisting of a mid-infrared optical fiber, a chalcogenide fiber and a ZBLAN fiber.

Shaw teaches that at least a portion of the second waveguide structure comprises an optical fiber. *See* §VII(A)(10); EX1009, ¶182. Shaw further discloses use of chalcogenide glass fibers to achieve a wavelength shift. EX1004, ¶[0020] ("The approach involves utilizing Stimulated Raman Scattering (SRS) in infrared transmissive chalcogenide glass fibers to frequency shift a shorter wavelength pump beam to a longer wavelength Stokes beam"), ¶[0022]; EX1009, ¶182.

Thus, Shaw discloses at least a portion of the second waveguide structure ("optical fiber") comprises an optical fiber ("optical fiber"), wherein the optical fiber is selected from the group consisting of…a chalcogenide fiber ("chalcogenide As-Se glass fiber"). EX1009, ¶183.

12. Claim 18: The infrared light source of claim 1, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride.

Shaw teaches that its second waveguide structure comprises a chalcogenide optical fiber. *See* §VII(A)(11); EX1009, ¶184. Shaw further discloses use of optical waveguides comprising sulfide, selenide, or telluride. EX1004, ¶[0022] ("Chalcogenide glasses comprise at least one of the chalcogenide elements sulfur (S), selenium (Se), and tellurium (Te)…"); EX1009, ¶184.

As-Se is the chemical name for arsenic selenide. EX1009, ¶185. Thus, Shaw discloses that its second waveguide structure comprises an optical waveguide comprising selenide. EX1009, ¶185.

Thus, Shaw discloses at least a portion of the second waveguide structure ("optical fiber") is an optical waveguide ("optical fiber") comprising a material selected from the group consisting of…selenide ("Chalcogenide glasses comprise at least one of the chalcogenide elements sulfur (S), selenium (Se), and tellurium (Te)…”). EX1009, ¶186.

13. Claim 19: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more.

Shaw teaches that its technique can create Raman shifts up to 15 µm. EX1004, ¶[0020] (“Raman lasers and amplifiers can be utilized to generate or amplify light in the wavelength region of about 1-15 µm”); EX1009, ¶187. Further, Shaw’s Example 2 shows how wavelengths of at least 6.2 µm can be obtained using the disclosed technique. EX1004, ¶[0042]; EX1009, ¶187. Accordingly, Shaw discloses that its technique can generate the longer optical wavelength having a wavelength of approximately 1.7 microns or more. EX1009, ¶187.

Thus, Shaw discloses the longer optical wavelength (“amplify light in the wavelength region of about 1-15 µm”) comprises a wavelength of approximately 1.7 microns or more (Example 2—wavelengths of at least 6.2 µm can be obtained). EX1009, ¶188.

14. Claim 20: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns.

Shaw teaches that its technique can “generate or amplify light in the wavelength region of about 1-15 µm.” *See* §VII(A)(13); EX1009, ¶189.

Thus, Shaw discloses the longer optical wavelength ("amplify light in the wavelength region of about 1-15 µm") comprises a wavelength in the range of two (2) microns to ten (10) microns (Example 2—wavelengths of at least 6.2 µm can be obtained). EX1009, ¶190.

15. Claim 21: The infrared light source of claim 1, wherein the longer optical wavelength comprises a wavelength in the range of five (5) microns to seven (7) microns.

Shaw teaches that its technique can "generate or amplify light in the wavelength region of about 1-15 µm." *See* §VII(A)(13); EX1009, ¶191.

Thus, Shaw discloses the longer optical wavelength ("amplify light in the wavelength region of about 1-15 µm") comprises a wavelength in the range of five (5) microns to seven (7) microns (Example 2—wavelengths of at least 6.2 µm can be obtained). EX1009, ¶192.

16. Claim 22: The infrared light source of claim 1, further comprising a wavelength separator coupled to the wavelength shifter and capable of transmitting at least a portion of a selected wavelength from the wavelength shifter.

In Shaw's Example 1, a wavelength separator 218 is used after the Raman amplifier (*e.g.*, coupled to fiber 210) to remove the unwanted light and only transmit the shifted light:

> The signal source 214 was a 1.56 µm diode laser that was mixed with the pump laser using a 2×2 coupler 216. The amplified 1.56 µm signal ***was spectrally separated from***

the pump by a Jarrel-Ash ¼ meter monochromator 218 and detected with an InGaAs detector 220.

EX1004, ¶[0041]) (emphasis added); EX1009, ¶193.

An annotated version of Shaw's FIG. 8 is shown below to illustrate this feature.

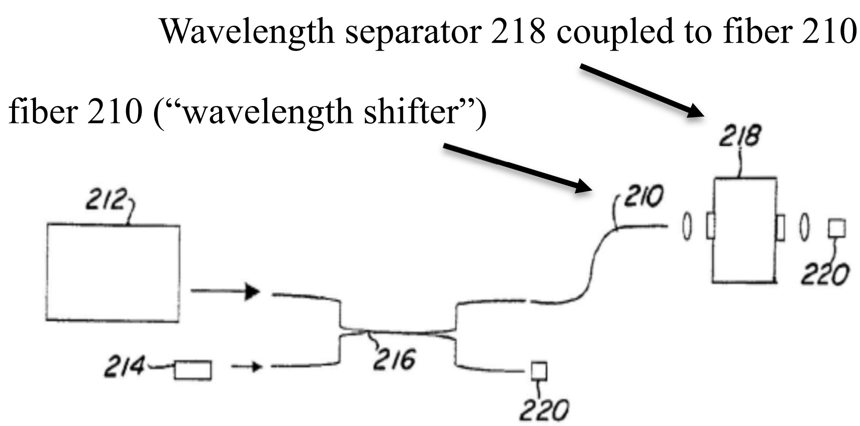

FIG. 8

EX1009, ¶194.

Shaw also describes how the Fabry-Perot cavity (*see* §VII(A)(1)(j)) uses a partially transmissive Bragg grating 156 to transmit part of the shifted light 155 out of the cavity 158, which therefore acts as a wavelength separator:

FIG. 7 is an illustration of a basic laser structure with pump light beam 150 at wavelength λ_1 entering glass fiber 152. Glass fiber 152, having at both ends thereof mirrors or other reflectors 151, 153, is provided with a pair of spaced

> fiber Bragg gratings 154, 156 at ends of the fiber creating cavity 158 between the spaced gratings….Gratings 154, 156 reflect light 155 at wavelength λ_2 back and forth in cavity 158 and every time the light at wavelength λ_2 is reflected, it interacts with pump light beam 150 and extracts energy through stimulated Raman scattering….Since grating 156 is designed so that its reflectivity is not 100%, some of light 155 at wavelength λ_2 in cavity 158 escapes through grating 156 and issues out of fiber 152 as laser light beam 160 at wavelength λ_2.

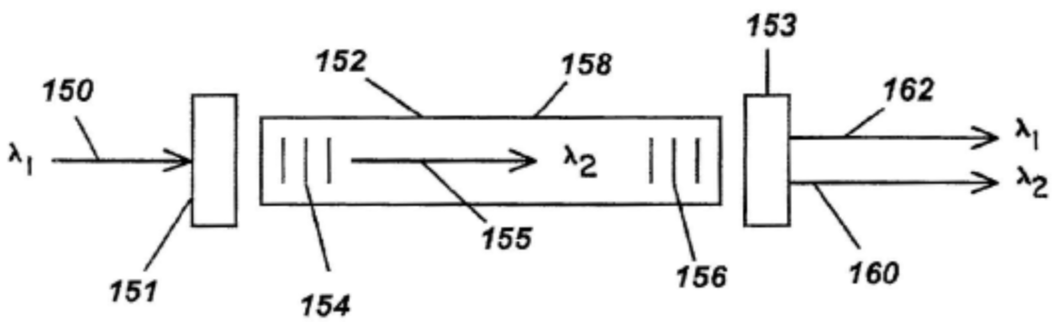

FIG. 7

EX1004, ¶[0037], FIG.7; EX1009, ¶195.

The ’116 Patent describes its wavelength separator as a device “capable of transmitting at least a portion of the desired wavelength from Raman wavelength shifter 800.” EX1001, 17:37-40; EX1009, ¶196. A POSITA would have understood that Shaw's monochromator 218 or partially transmissive grating 156 operate to select and transmit a portion of a desired wavelength, and that monochromators and gratings were commonly used as separators in a manner prescribed by Claim 22. EX1009, ¶196.

Thus, Shaw discloses a wavelength separator (monochromator 218/grating 156) coupled to the wavelength shifter (fiber 210) and capable of transmitting ("amplified 1.56 μm signal was spectrally separated from the pump by a Jarrel-Ash ¼ meter monochromator 218," "[s]ince grating 156 is designed so that its reflectivity is not 100%, some of light 155 at wavelength λ_2 in cavity 158 escapes through grating 156") at least a portion of a selected wavelength from the wavelength shifter (fiber 210). EX1009, ¶197.

17. Claim 23: The infrared light source of claim 22, wherein the wavelength separator is selected from the group consisting of a demultiplexer, one or more partially transmissive gratings, one or more partially transmitting mirrors, one or more Fabry Perot filters and one or more dielectric gratings.

Shaw's Fabry-Perot cavities include a partially transmissive grating 156 that separates and transmits a portion of the shifted wavelength 155 out of the laser. *See* §VII(A)(16); EX1004, ¶[0037], FIG.7; EX1009, ¶198.

Thus, Shaw discloses wherein the wavelength separator (partially transmissive grating 156) is selected from the group consisting of…one or more partially transmissive gratings. EX1009, ¶199.

18. Claim 24: The infrared light source of claim 1, further comprising at least a third waveguide structure coupled to the wavelength shifter, wherein a coupling loss between the third waveguide structure and the wavelength shifter comprises no more than five (5) decibels.

Shaw teaches use of multiple waveguides (Fabry-Perot cavities) to achieve larger wavelength shifts. *See* §VII(A)(1)(j); EX1009, ¶200. Thus, Shaw's device can include a third waveguide structure (or more). EX1009, ¶200.

A POSITA would have recognized that fibers were routinely coupled together at the time with losses less than 5 decibels. EX1015, p. 888 (noting a loss of "only 0.05 db when we spliced these fibers" in a cascaded Raman fiber laser using ~1.0-1.5-µm light); EX1009, ¶201. Moreover, Shaw's Example 1 demonstrates a that "the fiber loss was about 0.7 dB/m at 1.5 µm." EX1004, ¶[0041]; EX1009, ¶201. Given that the fiber length was 1 meter, this corresponds to a loss of only 0.7 dB. EX1009, ¶201. Accordingly, Shaw discloses that a third waveguide structure can be coupled to the wavelength shifter that has a coupling loss of no more than 5 decibels. EX1009, ¶201.

Thus, Shaw discloses at least a third waveguide structure ("Fabry-Perot cavities") coupled to the wavelength shifter (fiber 210), wherein a coupling loss between the third waveguide structure ("Fabry-Perot cavities") and the wavelength shifter (fiber 210) comprises no more than five (5) decibels ("fiber loss was about 0.7 dB/m"). EX1009, ¶202.

19. Claim 25: A method of shifting an optical wavelength to a longer optical wavelength, comprising:

See Claim 1 (Preamble); EX1009, ¶203.

a. [25.1]: combining a first pump signal generated by a first pump laser and a second pump signal generated by a second pump laser into a first optical signal, the first pump signal comprising at least a first wavelength and the second pump signal comprising at least a second wavelength, wherein the first wavelength of the first pump signal is substantially different than the second wavelength of the second pump signal;

See Elements [1.1];[1.2];[1.3];[1.4];[1.5];[1.6];[1.7]; EX1009, ¶204.

b. [25.2]: receiving the first optical signal at a wavelength shifter, the wavelength shifter comprising a first waveguide structure and a second waveguide structure, wherein the first waveguide structure is substantially different than the second waveguide structure;

See Elements [1.8];[1.9];[1.10];[1.11];[1.17]; EX1009, ¶205.

c. [25.3]: shifting at least the first wavelength to an intermediate optical wavelength using the first waveguide structure based at least in part on a Raman effect;

See Elements [1.12];[1.13]; EX1009, ¶206.

d. [25.4]: shifting the intermediate optical wavelength to a longer optical wavelength using the second waveguide structure; and

See Element [1.14]; EX1009, ¶207.

e. **[25.5]: wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength.**

See Elements [1.15];[1.16]; EX1009, ¶208.

20. **Claim 30: The method of claim 25, wherein the longer optical wavelength comprises a wavelength of approximately 1.7 microns or more.**

See Claim 19; EX1009, ¶209.

21. **Claim 31: The method of claim 25, wherein the longer optical wavelength comprises a wavelength in the range of two (2) microns to ten (10) microns.**

See Claim 20; EX1009, ¶210.

22. **Claim 32: The method of claim 25, further comprising transmitting at least a portion of a selected wavelength from the wavelength shifter into a third waveguide structure.**

See Claim 24; EX1009, ¶211.

23. **Claim 33: The method of claim 25, wherein the first waveguide structure is selected from the group consisting of a dispersion compensating fiber, a dispersion shifted fiber, a single mode fiber, a chalcogenide fiber, and a fused silica optical fiber.**

See Claim 13; EX1009, ¶212.

24. **Claim 34: The method of claim 25, wherein the second waveguide structure is selected from the group consisting of a chalcogenide fiber and a ZBLAN fiber.**

See Claim 17; EX1009, ¶213.

25. Claim 35: The method of claim 25, wherein at least a portion of the second waveguide structure is an optical waveguide comprising a material selected from the group consisting of ZBLAN, sulfide, selenide, and telluride.

See Claim 18; EX1009, ¶214.

B. Claims 1-4, 9, 11-14, 16-25, 30-35 Would Have Been Obvious in View of Shaw (Ground 2).

As indicated above, Shaw discloses each of the features of the challenged claims and thus anticipates the challenged claims. However, to the extent Patent Owner asserts that there are differences such differences would have been minor and thus obvious to a POSITA. EX1009, ¶216. For instance, a POSITA would understand how to combine the disclosures in FIGS. 4, 6, and 8, as well as ¶¶[0026]-[0032],[0034]-[0037],[0040]-[0043] to achieve each of the requirements of the challenged claims and would have been motivated to do so to create a longer wavelength light source. EX1004, ¶[0002]; EX1009, ¶216. As Shaw notes, there was significant interest at that time in generating longer infrared wavelength sources (e.g., 2–12 μm) for high atmospheric transmission, chemical fingerprinting, remote sensing, infrared countermeasures, surgery, and biomedical applications, among other things. EX1004, ¶[0002]; EX1009, ¶216.

Anticipation is the "ultimate or epitome of obviousness." *In re Kalm*, 378 F.2d 959, 962 (CCPA 1967). Thus, Claims 1-4, 9, 11-14, 16-25, and 30-35 would have been obvious in view of Shaw. EX1009, ¶217.

C. Claims 1-4, 9, 11-14, 16-25, 30-35 Would Have Been Obvious Over Shaw in View of Islam (Ground 3).

The following sections explain where each element of Claims 1-4, 9, 11-14, 16-25, and 30-35 are found in the prior art.

Claims 1-4, 9, 11-14, 16-25, and 30-35 would have been obvious over Shaw in view of Islam. EX1009, ¶218. Patent Owner may argue that one or more of the claimed features are not exactly disclosed. Any such argument is untenable but to the extent that there are any minor differences such differences would have been obvious, as discussed below. EX1009, ¶220.

Each of the ’116 Patent (EX1001, Abstract), Shaw (EX1004, Abstract, ¶¶[0010],[0020]), and Islam (EX1005, Abstract; 1:63-65,2:44-62,7:64-67,9:27-35,12:32-33) is directed toward an infrared light source that wavelength shifts light via a Raman effect. EX1009, ¶¶51-71,221. Each of the ’116 Patent (EX1001, 16:63-17:17, FIGS. 8A-8D,9A-9C), Shaw (EX1004, ¶[0041], FIG.8), and Islam (EX1005, 3:49-53,7:64-67,9:15-19,10:5-8, FIGS. 9,9a,9b,9c,10) has configurations where two laser pumps generate two different pump signals at different wavelengths, which are combined by a combiner into an optical signal. EX1009, ¶222. Each of the ’116 Patent (EX1001, 14:38-41,17:20-23,19:60-20:5), Shaw (EX1004, ¶¶[0036],[0041]), and Islam (EX1005, 9:17-24,9:64-10:4,10:16-19,10:24-35, FIGS. 9,10,11) send their optical signal to a fiber (“wavelength shifter”) that wavelength shifts via a Raman effect. EX1009, ¶223. The wavelength shifting in each of the ’116 Patent

(EX1001, 14:38-41,17:20-23,19:60-20:5), Shaw (EX1004, ¶¶[0021],[0030]-[0041]), and Islam (EX1005, 4:56–58,9:25–33,14:29–32,12:32–34, FIG. 9B) includes shifting the first wavelength to an intermediate wavelength in a first waveguide structure of the wavelength shifter, and shifting the intermediate wavelength to a longer wavelength in a second waveguide structure of the wavelength shifter. EX1009, ¶224.

The '116 Patent purports that its wavelength shifting technology can be used in a medical device to generate an optical signal in the infrared wavelength range to prevent or reduce damage to tissue during surgical procedures. EX1001, 14:35-15:53; EX1009, ¶225. Shaw's wavelength shifting technology is used to improve Raman fiber lasers and amplifiers operating in the infrared spectrum, which can be used for laser surgy applications or telecommunication applications. EX1004, ¶¶[0002],[0003],[0010],[0038]; EX1009, ¶226. Islam's wavelength shifting technology is used to improve broadband nonlinear polarization amplifiers by broadening the bandwidth of the fiber amplifiers so they can accommodate a larger number of channels, which can be used for telecommunication applications. EX1005, Abstract, 1:17-23,1:63-65,2:44-62; EX1009, ¶227.

1. Islam suggests and teaches "the one or more combiners operable to combine the first pump signal and the second pump signal into a first optical signal," as recited by Element [1.4]

Patent Owner may argue that Shaw does not describe its coupler forming a first optical signal that includes both the first wavelength of the first pump signal and the second wavelength of the second pump signal. Such an argument is untenable. EX1009, ¶228.

Shaw discloses that its "signal source 214 was a 1.56 μm diode laser that was mixed with the pump laser [1.5 μm] using a 2×2 coupler 216" to generate a first optical signal which is feed to a fiber for wavelength shifting, and therefore Shaw's first optical signal includes both wavelengths. *See* §VII(A)(1)(d); EX1004, ¶[0041]; EX1009, ¶229.

Islam discloses use of wavelength-division multiplexing (WDM) couplers as combiners in its system to generate a first optical signal from two pump sources. EX1004, 10:14-16, FIG.10; EX1009, ¶230.

At a minimum, it would have been obvious to supplant the Shaw coupler with Islam's WDM combiner to generate such a first optical signal as the substitution of a known equivalent, especially since Shaw discloses that a WDM coupler can be used in its system in a similar way. EX1004, ¶[0036]; EX1009, ¶231. It was well understood by a POSITA that WDM facilitates combining multiple optical signals for subsequent separation of them—*i.e.*, a WDM combines optical input signals to generate an optical output signal that includes both wavelengths of the input signals. EX1009, ¶232. A POSITA would have been motivated to use the Islam WDM as the Shaw combiner to ensure that the first optical signal includes a first wavelength from the first pump signal and a second wavelength from the second pump signal at least because when operating the Shaw system one would want to ensure that "pump light beam 450 of wavelength λ_1 and signal light beam 452 of wavelength λ_2…[are] launched into one end of glass fiber 454…[so that] "[l]ight beam 452 interacts with light beam 450…." EX1004, ¶[0028]; EX1009, ¶232.

Shaw contemplates use of a WDM coupler and both Shaw and Islam discuss optical amplification in telecommunications as a practical application of their respective technologies, and therefore a POSITA would have readily applied the teachings of Islam to modify the Shaw system to accommodate the Islam WDM. To the extent Shaw does not expressly disclose generating such a first optical signal, there would have been motivation to modify Shaw with Islam because a WDM coupler is a standard fiber device to combine signals, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses it to combine signals. EX1009, ¶233.

2. Islam suggests and teaches "a second waveguide structure,…wherein the first waveguide structure is substantially different than the second waveguide structure." as recited by Elements [1.10],[1.17]

Patent Owner may argue that Shaw does not disclose a second waveguide structure, or that if it does then it fails to disclose its first waveguide structure being substantially different from its second waveguide structure. Such an argument is untenable. EX1009, ¶234.

Shaw discloses a wavelength shifter including a second waveguide structure—*e.g.*, "The latter embodiment involves cascading ***several Fabry-Perot cavities***." *See* §VII(A)(1)(j); EX1004, ¶¶[0022],[0030]-[0031],[0036],[0041]; EX1009, ¶235. Also, Shaw's first waveguide structure is substantially different from its second waveguide structure. *See* §VII(A)(1)(q); EX1004, ¶¶[0022],[0025],[0026],[0035], FIG. 3; EX1009, ¶235.

Islam's FIG. 9b (annotated version is shown below) illustrates an exemplary wavelength shifter (*e.g.*, a fiber) having a first waveguide structure and a second waveguide structure (EX1005, 9:17-24,9:64-10:4; EX1009, ¶236:

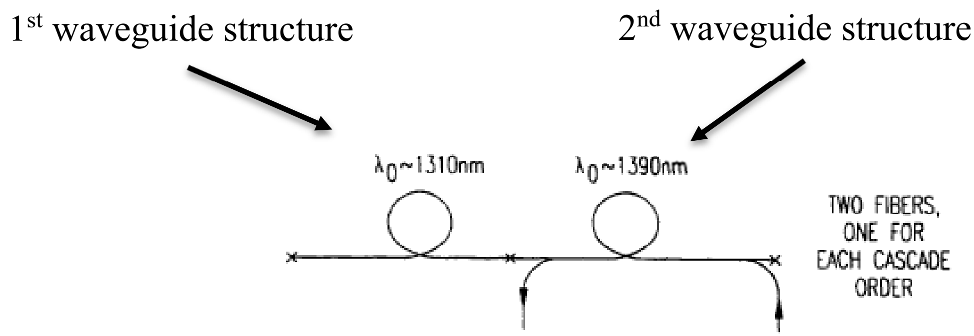

FIG.9b

Fiber (λ_0~1310nm) constitutes a first waveguide structure, and fiber (λ_0~1390nm) constitutes a second waveguide structure:

> [D]istributed gain medium comprises first and second optical fibers spliced together, and said optical fibers are used for two different cascaded Raman orders….

EX1005, 14:29–32; EX1009, ¶237.

Fiber (λ_0~1310nm) and fiber (λ_0~1390nm) are two separate and distinct fibers—*e.g.*, they are substantially different from each other. EX1009, ¶238.

At a minimum, it would have been obvious to use the multiple fibers configuration of Islam as the multiple waveguides in Shaw's system, especially since Shaw discloses multiple waveguides to achieve larger wavelength shifts. *See* §VII(A)(1)(j); EX1004, ¶[0035]; EX1009, ¶239. It was well understood by a POSITA to use different fibers to generate different wavelength shifting and/or to use multiple fibers to generate larger wavelength shifts. EX1009, ¶240. Islam discloses such a use of multiple fibers for multiple wavelength shifts. EX1005, 9:9-

51, FIG.9b; EX1009, ¶240. Shaw discloses that different compositions of fibers can be used to cause different shifts in wavelengths—*e.g.*, Shaw contemplates use of more than one fiber as multiple waveguide structures. *See* §VII(A)(1)(q); EX1009, ¶240. A POSITA would have been motivated to use the two-fiber configuration of Islam in the Shaw system for at least the purpose of providing "successively longer wavelengths." EX1004, ¶[0035]; EX1009, ¶241. Shaw discusses that it may be favorable in some applications to provide "amplification over the entire telecom band" which would motivate a POSITA to use more than one fiber to achieve such amplification. EX1004, ¶[0003]; EX1009, ¶241. As Shaw contemplates use of more than one fiber as multiple waveguide structures (*see* §VII(A)(1)(q); EX1009, ¶240), and both Shaw and Islam discuss optical amplification in telecommunications as a practical application of their respective technologies, a POSITA would have readily applied the teachings of Islam to modify the Shaw system to accommodate the Islam two fiber configuration. EX1009, ¶241. To the extent Shaw does not expressly disclose a wavelength shifter comprising a first waveguide structure and a second waveguide structure, there would have been motivation to modify Shaw with Islam because additional fibers provide additional shifting to other desirable wavelengths, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses additional fibers. EX1009, ¶242.

3. Islam suggests and teaches "wherein the wavelength shifter operates to wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure and to wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure; wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength and wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength; and" as recited by Elements [1.13]-[1.16]

Patent Owner may argue that Shaw does not disclose its wavelength shifter operating to: i) wavelength shift at least the first wavelength to an intermediate optical wavelength in the first waveguide structure; ii) wavelength shift the intermediate optical wavelength to a longer optical wavelength in the second waveguide structure; iii) wherein at least a portion of the intermediate optical wavelength is greater than the first wavelength; iv) wherein at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength.

The prior art discussed below illustrates why that position is incorrect.

Shaw's fiber shifts light from the first pump signal (at 1.5 µm—the first wavelength) to the second wavelength (at 1.56 µm—the intermediate wavelength), and this shift occurs in a first waveguide structure. *See* §VII(A)(1)(m); EX1004, ¶¶[0023]-[0024],[0036]-[0041]; EX1009, ¶245. Shaw's intermediate optical wavelength (the second wavelength at 1.56 µm) is shifted to a longer wavelength than the first optical wavelength, and this occurs in a second waveguide structure. *See* §VII(A)(1)(n); EX1009, ¶245. Notably, the intermediate optical wavelength

(1.56 µm) is longer ("greater") than the first wavelength (1.5 µm). EX1009, ¶245. Shaw's use of a second waveguide structure shifts the wavelength of the intermediate optical wavelength to a longer optical wavelength, and thus the output (the longer optical wavelength) from the second waveguide is at a longer ("greater") wavelength than the input (the intermediate optical wavelength) to the second waveguide. *See* §VII(A)(1)(p); EX1009, ¶245.

Islam states that an option is to have "two fibers spliced together with one fiber having a zero-dispersion wavelength at about 1310 nm (first cascade) and the other at 1390 nm (second cascade)." EX1005, 9:30–33; EX1009, ¶246. Islam's first fiber is the first waveguide structure, and the second fiber is the second waveguide structure. EX1009, ¶246. Accordingly, the first cascade happens in the first fiber, and the second cascade happens in the second fiber. Islam states that the "first pumping light cascades through said first distributed gain medium a plurality of Raman orders including an intermediate order." EX1005, 12:32–34; EX1009, ¶246. This is taught as a preferred embodiment.

Islam explains "[t]he pumping light cascades through the distributed gain medium a plurality of Raman orders including an intermediate order having a wavelength λ_r, at a close proximity to the zero-dispersion wavelength λ_0…." EX1005, 10:49-54; EX1009, ¶247. This intermediate order of the Raman cascade constitutes an intermediate optical wavelength in the first waveguide structure. EX1009, ¶247.

Islam explains that "[c]ascading is the mechanism by which optical energy at the pump wavelength is transferred, through a series of nonlinear polarizations, to an optical signal at a longer wavelength.…" (EX1005, 5:14-19; EX1009, ¶248), and that "pumping light cascades through said second distributed gain medium a plurality of Raman orders including an intermediate order" (EX1005, 12:52-54; EX1009, ¶248). Therefore, the wavelength is shifted to a longer wavelength by a second Raman cascade in the second fiber. EX1009, ¶248.

Islam continues to explain how at least a portion of the intermediate optical wavelength is greater than the first wavelength and how least a portion of the longer optical wavelength is greater than the intermediate optical wavelength:

> To obtain gain between 1430 nm and 1520 nm, the pump is operated between 1090 nm and 1140 nm, and five cascaded Raman orders are used to reach the desired wavelength. To make use of the broadening from PA or 4WM, a pumping scheme is selected in the middle of this range, i.e., starting with a pump wavelength of 1117 nm. Then, the various Raman orders land at approximately 1175 nm, 1240 nm, 1310 nm, 1390 nm and finally 1480 nm.

EX1005, 8:43–57; EX1009, ¶249.

In addition, Table 1 of the Islam provides a list of various Raman orders when pumping between 1060 and 1140 nm. EX1005, 8:5-42; EX1009, ¶250.

Therefore, at least a portion of the intermediate optical wavelength is greater than the first wavelength, and at least a portion of the longer optical wavelength is greater than the intermediate optical wavelength. EX1009, ¶251.

At a minimum, it would have been obvious to use the multiple fibers of Islam with Shaw's system to perform the wavelength shifting scheme prescribed by Elements [1.13]-[1.17], especially since Shaw discloses such wavelength shifting scheme. *See* §§VII(A)(1)(m)-(p); EX1009, ¶252. A POSITA would have found it obvious to use the two-fiber arrangement of Islam in the Shaw system for the enhanced shifting. *See* EX1009, ¶253. It was well understood by a POSITA to configure optical systems to wavelength shift light to a first order and a second order via first and second waveguide structures, respectively. EX1009, ¶253. A POSITA would have been motivated to use the two-fiber configuration of Islam in the Shaw system for at least the purpose of providing two separate and distinct waveguide structures to facilitate a first wavelength shift occurring in the first waveguide structure and a second wavelength shift occurring the second waveguide structure. EX1009, ¶254. A POSITA would have obtained guidance from Islam's discussion of Raman cascade through intermediate order(s) via its first and second fibers (first and second waveguide structures) to incorporate the same into a Shaw-Islam two-fiber system. EX1009, ¶255. To the extent Shaw does not expressly disclose the wavelength shifting scheme prescribed by Elements [1.13]-[1.17], there would have been motivation to modify Shaw with Islam because using different fibers optimized for different wavelengths was a well-known approach to cascading Raman shifts to reach longer wavelengths, and a POSITA would have had a reasonable expectation of success given that Shaw expressly teaches such modifications and uses cascaded Raman shifting. EX1009, ¶255.

4. Claims 2-4, 9, 11-14, 16-25, 30-35

Clams 1-4, 9, 11-14, 16-25, and 30-35 have been shown to be anticipated by Shaw. *See* §§VII(A)(1)-(25); EX1009, ¶256.

Regarding independent Claim 1, to the extent Shaw may not explicitly disclose a feature recited by independent Claim 1, it has been demonstrated that a Shaw-Islam combination would render said feature obvious. *See* §§VII(C)(1)-(3); EX1009, ¶257. While independent Claim 25 is not identical to independent Claim 1, the obviousness analysis presented for independent Claim 1 is similarly applicable to independent Claim 25. EX1009, ¶257. Therefore, to the extent Shaw does not explicitly disclose a feature recited by independent Claim 25, it has been demonstrated that a Shaw-Islam combination would render said feature obvious. EX1009, ¶257.

Regarding dependent Claims 2-4, 9, 11-14, 16-24, and 30-35, each feature recited by these claims is disclosed by Shaw. *See* §§VII(A)(1)-(25); EX1009, ¶258. None of the features required by these claims would, when applied to a Shaw-Islam combination of the independent claim from which they depend, frustrate the motivation to combine Islam with Shaw, detract from a POSITA's reasonable expectation of successfully combining Shaw with Islam to generate a predictable result, or render Shaw or Islam inoperable for its intended purpose. EX1009, ¶258.

For instance, Claims 2-4 specify which type of pump lasers are required. Islam specifically identifies the pump lasers as being cladding-pumped fiber lasers or semiconductor lasers. EX1005, 7:64-67,9:38-42; EX1009, ¶259. Claims 9 and 30-31 specify optical characteristics of the longer optical wavelength. Claim 11 requires a variation of the first wavelength to cause a variation in the longer optical wavelength. Claim 12 specifies which type of combiner is required. Claims 13-14, 16-18, and 33-35 specify which type of waveguide structure(s) is/are required. Claim 22 requires the system to include a wavelength separator, and Claim 23 specifies the type of separator required. Claims 24 and 32 require the system to include a third waveguide structure. Each of these claims requires features that were well known and commonly used in optical systems at the time, or merely recite inherent properties of elements required by the claims. EX1009, ¶259. Implementing them in the Shaw-Islam combination would not require undue experimentation on a part of a POSITA or require a modification to the Shaw-Islam system beyond which has already been discussed. EX1009, ¶259. Thus, Shaw's disclosure of these features set forth in Ground 1 is applicable to the Shaw-Islam combination set forth in Ground 3 to render Claims 2-4, 9, 11-14, 16-24, and 30-35 obvious. EX1009, ¶260.

VIII. OTHER CONSIDERATIONS

A. Any Purported Secondary Considerations Evidence Does Not Overcome the Strong Evidence of the Obviousness of the Claims

All elements of Claims 1-4, 9, 11-14, 16-25, and 30-35 are known in the art, and any differences between the claims of the '116 Patent and the prior art would have been obvious to a POSITA based on the disclosures of the applied references and the knowledge in the art. EX1009, ¶261.

Petitioners are not aware of any secondary considerations evidence bearing any nexus to the purported claimed invention.

B. Discretionary Denial Under 35 U.S.C. §314(a) and §325(d)

Under the *Advanced Bionics* two-part framework, the same or substantially the same art previously was ***not*** presented to the Office, and the same or substantially the same arguments previously were ***not*** presented to the Office. Neither Shaw nor Islam were considered during examination of the '116 Patent, nor has the Office previously considered the specific arguments or combinations of references presented in this Petition.

To the extent that Patent Owner asserts any argument for discretionary denial on institution, Petitioner will follow the bifurcated approach outlined in Acting Under Secretary Stewart's memorandum entitled "Interim Processes for PTAB Workload Management" dated March 26, 2025. Such response will come in the form of an opposition brief consistent with 37 C.F.R. §42.24 following the submission of any, if any, motion by Patent Owner.

IX. CONCLUSION

For at least the foregoing reasons, Claims 1-14, 16-28, 30-35, 38-40, and 43-45 of the '116 Patent are unpatentable. Since Petitioners have shown the claims to be *prima facie* obvious, Petitioners have also shown a likelihood of success on the merits. Therefore, this Petition should be granted, and the Board should institute trial.

Respectfully submitted,

Date: April 11, 2025

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APPENDIX A—LIST OF EXHIBITS

EXHIBIT	DESCRIPTION
1001	U.S. Patent No. 7,433,116, issued on October 7, 2008
1002	File History of U.S. Patent Application No. 10/812,608, filed on March 30, 2004
1003	U.S. Provisional Application No. 60/408,025, filed November 18, 2005
1004	U.S. Patent Publication No. 2003/0012491 ("Shaw")
1005	U.S. Patent No. 6,239,903 ("Islam")
1006	Comparison of U.S. Provisional Application No. 60/408,025 disclosure with U.S. Patent No. 7,433,116 disclosure
1007	U.S. Patent Application No. 09/906,010, filed July 12, 2001 ("Original Shaw Filing")
1008	Comparison between the Original Shaw Filing and U.S. 20030012491 A1
1009	Declaration of Dr. Scott Diddams
1010	*Curriculum Vitae* of Dr. Scott Diddams
1011	Declaration of Dr. Sylvia Hall-Ellis
1012	*Curriculum Vitae* of Dr. Sylvia Hall-Ellis
1013	P.A. Thielen, et al., "*Raman Amplification in As-Se Fiber*," Proceedings of SPIE Vol. 4628, p. 74, published in 2002
1014	Joint Claim Construction and Prehearing Statement (Docket No. 83) in *Omni Continuum LLC v. NKT Photonics Inc. et al.,* Civil Action No. 1:24-cv-11007-IT, U.S. District Court for the District of Massachusetts

EXHIBIT	DESCRIPTION
1015	V.I. Karpov et al., "*Laser-diode-pumped phosphosilicate-fiber Raman laser with an output power of 1 W at 1.48 μm,*" Optics Letters, Vol. 24, No. 13, p. 887, published July 1, 1999

CERTIFICATE OF COMPLIANCE WITH 37 C.F.R. §42.24

I hereby certify that the word count for the foregoing Petition totals 13,979 words, excluding the parts which are exempted by 37 C.F.R. §42.24(a)(1).

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that on this 11th day of April, 2025, a true and correct copy of the foregoing **PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 7,433,116 B2 UNDER 35 U.S.C. §§311–19 and 37 C.F.R. §42.100 *et seq*., POWERS OF ATTORNEY,** and **EXHIBITS 1001-1015** are being served upon the Patent Owner at the following correspondence address of record for U.S. Patent No. 7,433,116 via UPS as follows:

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