UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
SAMSUNG ELECTRONICS AMERICA, INC.,
FOSSIL GROUP, INC.,
FOSSIL STORES I, INC.,
FOSSIL PARTNERS, L.P.,
OURA HEALTH OY, AND
ONEPLUS TECHNOLOGY (SHENZHEN) CO., LTD.

Petitioners,

v.

OMNI MEDSCI, INC.,

Patent Owner.

Case IPR2025-01253

Patent No. 12,193,790

DECLARATION OF BRIAN W. ANTHONY IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 12,193,790

Executed this 5th day of August 2025, in Cambridge, Massachusetts

Brian W. Anthony

TABLE OF CONTENTS

Page

I. INTRODUCTION 1

II. QUALIFICATIONS 9

III. LEGAL UNDERSTANDING 13

IV. BACKGROUND OF THE TECHNOLOGY 20

V. THE '790 PATENT 22

A. '790 Patent Overview 22

B. The Prosecution History 24

VI. LEVEL OF ORDINARY SKILL IN THE ART 26

VII. CLAIM CONSTRUCTION 28

A. Board's Constructions in the Prior IPRs 28

1. "identify an object" limitation ([7.m]) 28

2. Additional Terms Discussed in '484 and '533 IPRs 29

B. Prior District Court Constructions 30

C. Terms at Issue in the Texas Case 31

VIII. GROUNDS OF UNPATENTABILITY 32

IX. SPECIFIC GROUNDS FOR CHALLENGE 32

A. GROUND 1: Lisogurski (Claim 7) 33

1. Overview of Lisogurski 33

2. Motivation to Modify Lisogurski 42

3. Invalidity of Claim 7 Over Lisogurski 57

B. GROUND 2: Lisogurski in further view of Carlson (Claim 7): 103

1. Overview of Carlson 103

2. Motivation to Combine 105

3. Invalidity of Claim 7 Over Lisogurski in view of Carlson 109

X. SECONDARY CONSIDERATIONS 112

XI. CONCLUSION 112

I. INTRODUCTION

1. My name is Brian W. Anthony and I am a Principal Research Scientist at the Massachusetts Institute of Technology (MIT). I have been retained on behalf of Samsung Electronics Co. Ltd. and Samsung Electronics America Inc. ("Samsung") to provide my opinions on certain issues related to U.S. Patent No. 12,193,790 ("the '790 patent") in connection with the above-captioned *inter partes* review ("IPR") proceeding. In particular, I have been asked to provide my insights, analysis, and opinions regarding whether claim 7 of the '790 patent ("the Challenged Claim") are obvious over the prior art references identified below.

2. I understand that the '790 patent is titled "Wearable devices comprising semiconductor diode light sources with improved signal-to-noise ratio," names as an inventor Mohammed N. Islam, and is currently owned by Omni Medsci Inc. I have considered the '790 patent. I understand that the '790 patent has been provided as Ex. 1001.

3. I understand that the file history of the '790 patent has been provided as Ex. 1002. I have considered this file history, and I will refer to it as "the '790 Patent File History" or by its exhibit number.

4. I understand that the '790 patent is a continuation of application No. 18/103,408, filed on Jan. 30, 2023, now Pat. No. 11,896,346, which is a continuation of application No. 17/514,778, filed on Oct. 29, 2021, now Pat. No. 11,564,577,

which is a continuation of application No. 17/078,771, filed on Oct. 23, 2020, now Pat. No. 11,160,455, which is a continuation of application No. 16/722,188, filed on Dec. 20, 2019, now Pat. No. 10,820,807, which is a continuation of application No. 16/506,885, filed on Jul. 9, 2019, now Pat. No. 10,517,484, which is a continuation of application No. 16/284,514, filed on Feb. 25, 2019, now abandoned, and a continuation of application No. 16/272,069, filed on Feb. 11, 2019, now abandoned, and a continuation of application No. 16/241,628, filed on Jan. 7, 2019, now Pat. No. 10,441,176, and a continuation of application No. 16/188,194, filed on Nov. 12, 2018, now Pat. No. 10,386,230, said application No. 16/272,069 is a continuation of application No. 16/029,611, filed on Jul. 8, 2018, now Pat. No. 10,201,283, said application No. 16/284,514 is a continuation of application No. 16/016,649, filed on Jun. 24, 2018, now Pat. No. 10,213,113, said application No. 16/241,628 is a continuation of application No. 16/015,737, filed on Jun. 22, 2018, now Pat. No. 10,172,523, said application No. 16/506,885 is a continuation of application No. 16/004,359, filed on Jun. 9, 2018, now Pat. No. 11,109,761, said application No. 16/188,194 is a continuation of application No. 16/004,154, filed on Jun. 8, 2018, now Pat. No. 10,126,283, said application No. 16/029,611 is a continuation of application No. 15/888,052, filed on Feb. 4, 2018, now Pat. No. 10,136,819, said application No. 16/016,649 is a continuation of application No. 15/860,065, filed on Jan. 2, 2018, now Pat. No. 10,098,546, said application No. 16/004,154 is a

continuation of application No. 15/855,201, filed on Dec. 27, 2017, now Pat. No. 9,995,722, which is a continuation of application No. 15/711,907, filed on Sep. 21, 2017, now Pat. No. 9,897,584, said application No. 15/860,065 is a continuation of application No. 15/686,198, filed on Aug. 25, 2017, now Pat. No. 9,861,286, said application No. 16/015,737 is a continuation of application No. 15/594,053, filed on May 12, 2017, now Pat. No. 10,188,299, said application No. 15/711,907 is a division of application No. 15/357,225, filed on Nov. 21, 2016, now Pat. No. 9,797,876, said application No. 15/686,198 is a continuation of application No. 15/357,136, filed on Nov. 21, 2016, now Pat. No. 9,757,040, said application No. 15/888,052 is a continuation of application No. 15/212,549, filed on Jul. 18, 2016, now Pat. No. 9,885,698, said application No. 15/594,053 is a continuation of application No. 14/875,709, filed on Oct. 6, 2015, now Pat. No. 9,651,533, said application No. 15/357,136 is a continuation of application No. 14/651,367, filed as application No. PCT/US2013/075736 on Dec. 17, 2013, now Pat. No. 9,500,635, said application No. 15/357,225 is a continuation of application No. 14/650,981, filed on Jun. 10, 2015, now Pat. No. 9,500,634, said application No. 15/212,549 is a continuation of application No. 14/650,897, filed as application No. PCT/US2013/075700 on Dec. 17, 2013, now Pat. No. 9,494,567, said application No. 16/004,359 is a continuation of application No. 14/109,007, filed on Dec. 17, 2013, now Pat. No 9,993,159, said application No. 14/875,709 is a continuation of

application No. 14/108,986, filed on Dec. 17, 2013, now Pat. No. 9,164,032. I have considered this file history.

5. I understand that the ’790 patent claims a priority date based on the following provisional patent applications: provisional application No. 61/754,698, filed on Jan. 21, 2013, provisional application No. 61/747,477, filed on Dec. 31, 2012, provisional application No. 61/747,472, filed on Dec. 31, 2012, provisional application No. 61/747,487, filed on Dec. 31, 2012, provisional application No. 61/747,553, filed on Dec. 31, 2012. For the purposes of rendering my opinions in this Declaration, I have been asked to assume that the Challenged Claim is entitled to the December 31, 2012 filing dates of the earliest filed provisional applications. I have not been asked to opine on whether the Challenged Claim of the ’790 patent is entitled to this priority date, and do not provide any opinion on that subject for the purpose of this Declaration. My opinions regarding the Challenged Claim remain the same as long as the identified prior art were still prior art.

6. My analysis and conclusions set forth in this declaration are based on my educational background and experiences in the field (Section II). I am qualified to opine concerning what a person of ordinary skill in the art would have known and understood during that time. Before December 31, 2012, my level of skill in the art was at least that of a person of ordinary skill. I am qualified to opine concerning what a person of ordinary skill in the art would have known and understood at the

time of the ’790 patent’s purported invention. My analysis and conclusions herein are from the perspective of a person of ordinary skill in the art as of December 31, 2012.

7. As part of my independent analysis for this declaration, I have considered the following: the background knowledge/technologies that were commonly known to persons of ordinary skill in the art during the time before the earliest claimed priority date for the ’790 patent; my own knowledge and experiences gained from my work experience in the field of the ’790 patent and related disciplines; and my experience in working with others involved in this field and related disciplines.

8. I have considered the following non-exhaustive list of references in preparing my declaration. I have been instructed to assume that each of these references qualifies as prior art.

- **U.S. Patent No. 9,241,676 (“Lisogurski”)** to Daniel Lisogurski et al., titled “Methods and systems for power optimization in a medical device,” filed on May 31, 2012, published on December 5, 2013 and granted on January 26, 2016. I understand that a copy of this reference has been designated as Exhibit 1025. Throughout my declaration, references to **Lisogurski** are to Exhibit 1025.
- **U.S. Patent Application Publication No. 2005/0049468 (“Carlson”)** to Sven-Erik Carlson et al., titled “Increasing the performance of an optical pulsoximeter,” filed on September 3, 2003 and published on March 3, 2005. I understand that a copy of this reference has been designated as Exhibit 1028. Throughout my declaration, references to **Carlson** are to Exhibit 1028.

9. I note that I previously submitted expert declarations in support of a prior IPR challenging limitations of Patent Nos. 9,651,533 (the "'533 patent") and 10,517,484 (the "'484 patent"), which I understand have been designated as Exhibits 1081 and 1082, respectively, on behalf of Petitioner Apple Inc. in IPR2019-00916 ("the prior '533 IPR") and IPR2021-00453 ("the prior '484 IPR"), which I understand have been designated as Exhibits 1004 and 1010, respectively. *See* Ex. 1004 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 9,651,533, herein "'533-Anthony"); 1010 (Declaration of Brian Anthony, Ph.D. Regarding U.S. Patent No. 10,517,484, herein "'484-Anthony"). As I discuss below, certain claim limitations challenged in those proceedings are identical and/or substantially identical to the Challenged Claim of the '790 patent. Accordingly, for purposes of this Declaration, I refer to my declaration submitted in the prior '533 IPR, as my "Prior '533 Declaration," and my declaration submitted in the prior '484 IPR as my "Prior '484 Declaration," as applicable. Additionally, in this Declaration, I refer to the Board's Final Written Decision in the prior '533 IPR as '533-FWD," which I understand has been designated as Exhibit 1008, and the Final Written Decision and Final Written Decision on Remand in '484 IPR as "'484-FWD" and "'484-RFWD," which I understand have been designated as Exhibits 1015 and 1016, respectively.

10. In my Prior '533 Declaration, I opined that claims 5, 7-10, 13, and

15-17 of the ’533 patent were obvious based on three independent grounds: **Lisogurski**; **Lisogurski** in view of **Carlson**, and; **Lisogurski** in view of **Carlson** and U.S. Patent No 5,746,206. ’533-Anthony, ¶¶87-204. I understand that the Board considered my Prior ’533 Declaration and ultimately held that all claims challenged in the prior ’533 IPR were unpatentable based on those three grounds. ’533-FWD, 50-51. I understand that the Federal Circuit, in its decision that I understand has been designated as Exhibit 1009, affirmed the Board’s decision holding these unpatentable, and those claims are now cancelled. *See* Ex. 1009 (*Omni MedSci, Inc. v. Apple Inc.*, No. 21-01229, ECF 69 (Fed. Cir. June 8, 2022)) (the Federal Circuit’s statement that it “AFFIRMED” the Board’s decision in the prior ’533 IPR). I understand that in the prior ’533 IPR, the Board relied on the embodiments of **Lisogurski** Figures 1 and 3, as modified (Section IX.A.2). Those are the embodiments I rely on in this declaration as set forth below.

11. In my Prior ’484 Declaration, I opined that claims 1-23 of the ’484 patent were obvious based on five independent grounds: (1) **Lisogurski** alone; (2) **Lisogurski** in view of **Carlson**; (3) **Lisogurski** in view of **Carlson** and **Tran**; (4) **Lisogurski** in view of **Carlson**, **Tran**, and U.S. Patent No. 8,725,226; and (5) **Lisogurski** in view of **Carlson**, **Tran**, U.S. Patent Publication No. 2012/0197093, with or without U.S. Patent No. 8,725,226. ’484-Anthony, ¶¶87-273. I understand that the Board considered my Prior ’484 Declaration and originally held that only

claims 1, 2, 7 15-23 challenged in the prior '484 IPR were unpatentable based on those five grounds. '484-FWD, 60-61. I understand that, following the Federal Circuit's remand, the Board ultimately found that all challenged claims 1-23 in the prior '484 IPR were unpatentable based on the same five grounds and in consideration of my opinion. '484-RFWD, 12-13. I understand that in the prior '484 IPR, the Board relied on the embodiments of Lisogurski Figures 1 and 3, as modified (Section IX.A.2). Those are the embodiments I rely on in this declaration as set forth below.

12. As I explain further below in Sections IX.A and IX.B, it is my opinion that (1) **Lisogurski** renders obvious Challenged Claim 7 of the '790 patent (Ground 1, see my discussion in Section IX.A), and (2) **Lisogurski** in view of **Carlson** renders obvious Challenged Claim 7 of the '790 patent (Ground 2, see my discussion in Section IX.B).

13. I understand that there are pending district court litigations between Petitioners Samsung Electronics Co. Ltd., Samsung Electronics America Inc., Fossil Group, Inc., Fossil Stores I, Inc., Fossil Partners, L.P., Oura Health Oy, and OnePlus Technology (Shenzhen) Co., Ltd. and Omni Medsci, Inc. ("Texas Case") as well as Omni MedSci, Inc. and Whoop, Inc. involving the '790 patent. I also understand that the '484 patent, which is related to the '790 patent, is also subject to the following appeal: *Omni Medsci, Inc. v. Apple, Inc.*, No. 25-1646 (Fed. Cir.).

14. I am being compensated by Samsung at my standard hourly consulting rate of $500 for my time on this matter. My compensation is not dependent on the outcome of this proceeding or any other proceeding between the parties.

15. In forming my opinions, I relied on the documents cited in this declaration and the documents identified in the attached **Appendix B**. These documents comprise patents, file histories, printed publications, and other related documents. As I discuss below, each document is a type that experts in my field would have reasonably relied upon when forming their opinions. Further, experts in my field would have had access to each document either through the applicable patent offices and/or well-known libraries, conferences, or publications in the field. My opinions are also based upon my personal and professional experience.

II. QUALIFICATIONS

16. A detailed record of my professional qualifications, including a list of publications, awards, and professional activities, is set forth in my curriculum vitae attached to this report as **Appendix A**.

17. I am qualified by education and experience to testify as an expert in the field of physiological measurement system and devices. Additionally, the following overview of my background pertains to my qualifications for providing expert testimony in this matter. I am over the age of 18 and am competent to write this declaration. I have personal knowledge, or have developed knowledge, of these

technologies based upon education, training, or experience of the matters set forth herein.

18. I earned a Bachelor of Science in Engineering from Carnegie Mellon University in 1994 and a Master's degree in Engineering from MIT in 1998. My thesis topic related to anisotropic wave guides and acoustic non-destructive testing. In 2006, I earned my Ph.D. in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.

19. In 1997, I co-founded Xcitex Inc., a company that specialized in video-acquisition and motion-analysis software. I served as the Chief Technology Officer and directed and managed product development until 2006. Our first demo product was an optical ring for human motion measurement used to capture user hand motion in order to control the user's interaction with a computer. Many of the structural elements of our optical ring addressed the same system issues as those described and claimed in the patent at issue. For example, our optical ring included multiple light emitting diodes, multiple photodetectors, techniques for modulation and synchronization, noise reduction algorithms, and optical components for light blocking, light redirection, and light capture, and structural components for holding and geometrically arranging the various components. We estimated human hand-motion based on how that motion changed the detected light. In our application we did not try to eliminate motion artifact, we tried to measure it. In developing our

ring, we considered well-known problems such as ambient light and noise, which are, unsurprisingly, also mentioned in the patent at issue. Motion Integrated Data Acquisition System (MiDAS) was our flagship video and data acquisition product which relied upon precise synchronization of multiple clocks for optical sensor and video acquisition, data acquisition, and external illumination.

20. I joined MIT in 2006 and was the Director of the Master of Engineering in Advance Manufacturing and Design Program for over ten years. The degree program covers four main components: Manufacturing Physics, Manufacturing Systems, Product Design, and Business Fundamentals. Many of the courses, projects, and papers my students undertake involve technologies relevant to the patent at issue, for example, sensor devices including non-invasive optical biosensors.

21. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example, image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our

research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers. My experience with these devices is directly applicable to the technology in the patent at issue. For example, in one current project related to this work, we use a patient-mounted mobile near infrared (NIR) camera to image and characterize the surface and subsurface structures of the skin.

22. I am also the Associate Director of MIT.nano, MIT's new 200,000 sq-ft nanofabrication and characterization facility. One of the major research initiatives with MIT.nano focuses on sensors and sensing systems. Our research in sensing science and sensing engineering is targeting innovations in advanced manufacturing, healthcare, environmental remediation, smart infrastructure, and the creation of advanced machines and materials. I also co-founded the Center for Polymer Micro-fabrication at MIT. The Center's research focuses on polymer-based manufacturing processes and the large-scale commercialization of micro fluidic devices for chemical, biomedical, and photonic applications. My experience under these initiatives is directly applicable to the technology in the patent at issue. We develop optical sensors to noninvasively monitor soft flexible materials during the

manufacturing process.

23. Furthermore, my research focuses on computational instrumentation, including the development of instrumentation and measurement solutions for manufacturing systems and medical devices. Additionally, my teaching interests include the design and modeling of large-scale systems in a wide variety of decision-making domains and developing optimization algorithms and software for analyzing and designing such systems. I teach or have taught courses in Electrical Engineering, Controls, Optics, and Signal Processing, all pertinent subject matter to the patent at issue.

24. I have published over 100 papers, and have received a number of best paper and distinguished paper awards. I am a co-author of a number of papers that relate to the technology in the patent at issue.

III. LEGAL UNDERSTANDING

25. I am not an attorney and offer no legal opinions, but in the course of my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art.

26. I have been informed of certain legal concepts relevant to my opinions. In formulating my opinions, I have relied on my understanding of these legal concepts I have been provided with as set forth in this declaration.

27. I have been informed that in *inter partes* review proceedings, invalidity

must be shown under a preponderance of the evidence standard.

A. My Understanding of Claim Construction

28. I have been informed that patent claims are construed from the viewpoint of a person of ordinary skill in the art of the patent at the time of the invention. I have been informed that patent claims generally should be interpreted consistent with their plain and ordinary meaning as understood by a person of ordinary skill in the art in the relevant time period (i.e., at the time of the purported invention, or the so called "effective filing date" of the patent application), after reviewing the patent claim language, the specification, and the prosecution history (i.e., the intrinsic record).

29. I have further been informed that a person of ordinary skill in the art must read the claim terms in the context of the claim itself, as well as in the context of the entire patent specification. I understand that in the specification and prosecution history, the patentee may specifically define a claim term in a way that differs from the plain and ordinary meaning. I understand that the prosecution history of the patent is a record of the proceedings before the U.S. Patent and Trademark Office and may contain explicit representations or definitions made during prosecution that affect the scope of the patent claims. I understand that an applicant may, during the course of prosecuting the patent application, limit the scope of the claims to overcome prior art or to overcome an examiner's rejection, by

clearly and unambiguously arguing to overcome or distinguish a prior art reference, or clearly and unambiguously disavowing claim coverage.

30. In interpreting the meaning of the claim language, I understand that a person of ordinary skill in the art may also consider "extrinsic" evidence, including expert testimony, inventor testimony, dictionaries, technical treatises, other patents, and scholarly publications. I understand this evidence is considered to ensure that a claim is construed in a way that is consistent with the understanding of those of ordinary skill in the art at the time of the claimed invention. For example, this can be useful for a technical term whose meaning may differ from its ordinary English meaning. I understand that extrinsic evidence may not be relied on if it contradicts or varies the meaning of claim language provided by the intrinsic evidence, particularly if the applicant has explicitly defined a term in the intrinsic record.

B. My Understanding of Anticipation

31. I understand that a patent claim is invalid as "anticipated" if all the limitations of the claim are present, either expressly or inherently, in a single prior art publication or patent.

32. I also understand that a prior art reference can disclose a claimed feature because the feature is expressly described or because the feature is inherent in the disclosure. I have been informed that something is inherent in a prior art reference if the missing descriptive matter must necessarily be present, not merely probably or

possibly present, and it would be so recognized by a person of ordinary skill in the art as of the priority date of the patent. I understand that it is acceptable to examine evidence outside of the prior art reference (i.e., extrinsic evidence) in determining whether a feature, while not expressly discussed in the reference, is necessarily present in it.

33. I have further been informed that where a reference discloses multiple embodiments, the reference should not be limited to a preferred embodiment. Instead, each disclosed embodiment may anticipate.

34. Moreover, I have been informed that as part of an anticipation analysis, it is proper to take into account not only specific teachings of the reference, but also the inferences that one skilled in the art would reasonably be expected to draw therefrom. A reference can anticipate a claim even if it does not expressly spell out all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would at once envisage the claimed arrangement or combination.

C. My Understanding of Obviousness

35. I understand that a claim may be invalid if the subject matter described by the claim as a whole would have been obvious to a hypothetical person of ordinary skill in the art in view of a prior art reference or in view of a combination of references at the time the claimed invention was made. Therefore, I understand

that obviousness is determined from the perspective of a hypothetical person of ordinary skill in the art and that the asserted claims of the patent should be read from the point of view of such a person at the time the claimed invention was made. I further understand that a hypothetical person of ordinary skill in the art is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent in suit.

36. I have been informed that there are two criteria for determining whether prior art is analogous and thus can be considered prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the patentee's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the patentee is involved. I have also been informed that the field of endeavor of a patent is not limited to the specific point of novelty, the narrowest possible conception of the field, or the particular focus within a given field. I have also been informed that a reference is reasonably pertinent if, even though it may be in a different field from that of the patentee's endeavor, it is one which, because of the matter with which it deals, logically would have commended itself to a patentee's attention in considering their problem.

37. I have also been advised that an analysis of whether a claimed invention would have been obvious should be considered in light of the scope and content of

the prior art, the differences (if any) between the prior art and the claimed invention, and the level of ordinary skill in the pertinent art involved. I understand as well that a prior art reference should be viewed as a whole.

38. I have also been advised that in considering whether a claimed invention would have been obvious over a combination of prior art references, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a person of ordinary skill in the art. I understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a person of ordinary skill can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond their skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate

obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;

- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls whether the claim is obvious;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A person of ordinary skill in the art is also a person of ordinary creativity, and is not an automaton;
- A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a person of ordinary skill in the art would have had good reason to pursue the known options within his or her technical grasp; and
- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

39. I further understand that, in making a determination as to whether the claimed invention would have been obvious to a person of ordinary skill, the Board may consider certain objective factors if they are present, such as: commercial

success of products practicing the claimed invention; long-felt but unsolved need; teaching away; unexpected results; copying; and praise by others in the field. These factors are generally referred to as "secondary considerations" or "objective indicia" of nonobviousness. I understand, however, that for such objective evidence to be relevant to the obviousness of a claim, there must be a causal relationship (called a "nexus") between the claim and the evidence, and that this nexus must be based on a novel element of the claim rather than something in the prior art. I also understand that even when they are present, secondary considerations may be unable to overcome primary evidence of obviousness (such as motivation to combine with predictable results) that is sufficiently strong.

IV. BACKGROUND OF THE TECHNOLOGY

40. In my Prior '533 and '484 Declarations, I provided a discussion of the "Technical Background" for the '533 and '484 patents, both of which I incorporate by reference as if fully stated herein. *See* '533-Anthony, ¶¶37-56 (discussing "Photoplethysmography" and "Industry Trends"); '484-Anthony ¶¶37-56 (discussing the same).

41. As I discuss in Section V, the '790 patent is generally directed to a physiological measurement system comprising a wearable measurement device with light sources and detectors to generate an output signal with physiological parameters to be transmitted to a smart phone/tablet, and common techniques to

improve signal-to-noise ratio of such signals. ’790 patent, 21:7-28 (describing technique for “measuring a particular blood constituent” and “methods of improving the ability to discriminate between different constituents”), 35:47-37:19 (describing “the physiological measurement device that … communicate[s] over a first communication link … to a receiver in a smart phone[or] tablet cell phone,” “which … operate[s] through the use of one of many wireless technologies”), 58:24-45 (describing the advantages of “us[ing] … an active illuminator,” which includes, among other advantages, the benefit of “factor[ing] out” the “variations due to sunlight and time-of-day” as well as “us[ing] modulation and lock-in techniques” and “modulat[ing]” the light source so that “higher signal-to-noise ratios may be achieved”), 70:33-52, (same), 79:34-40 (describing that in order to “permit higher signal-to-noise levels,” a “higher intensity or brightness of light sources may be used”).

42. In my opinion, and as further discussed below, the ’790 patent recites claim limitations that are identical and/or substantially identical to those in the ’533 patent and the ’484 patent. Sections IX.A-B. As I opined in ’533 and ’484 IPRs, such wearable measurement system and devices were well known in the art prior to the ’790 patent’s priority date. ’533-Anthony, ¶¶37-56; ’484-Anthony, ¶¶37-56.

43. While the ’790 patent claim includes an additional limitation, it at most specifies that the tissue to which optical light is directed is skin

(Sections IX.A.3.e.[7.d], IX.B.3.a.[7.d]). For the reasons I have further discussed below, this additional limitation was well-known in the art (Sections IX.A.3.e.[7.d], IX.B.3.a.[7.d]).

V. THE '790 PATENT

A. '790 Patent Overview

44. Figure 24 of the '790 patent, annotated and reproduced below, shows an embodiment of the physiological measurement system to which the '790 patent is directed:

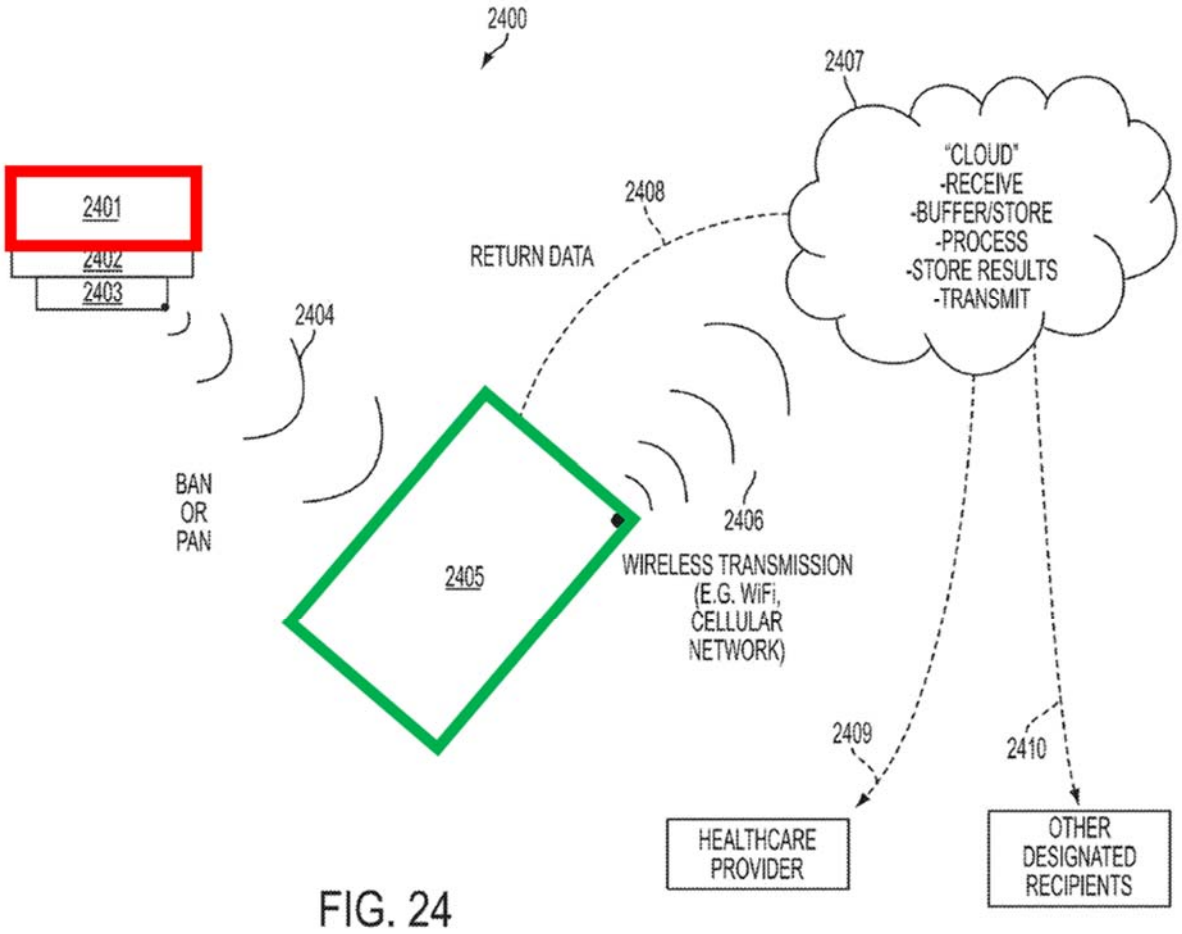


FIG. 24

'790 patent, 35:47-37:19 (describing "a particular embodiment 2400" of "the physiological measurement device"). The wearable **physiological measurement device 2401** comprises "a processor 2402" to "process some of the physiological data" and "a transmitter 2403 to communicate over a first communication link 2404 … to a receiver in a **smart phone[or] tablet cell phone … 2405**." '790 patent, 35:47-67.

45. The **wearable device 2401** "measure[s] one or more physiological parameters," can be placed on a user's body (i.e., "placed on a wrist placed on a wrist or a hand dorsal of a user") and includes a plurality of semiconductor sources such as LEDs that generate an output optical light with a plurality of optical wavelengths. '790 patent, 8:35-45. The **wearable device 2401** further comprises "one or more lenses" that receives and directs or delivers light from the semiconductor sources to a targeted region of the user's tissue, and a detection system that receives the light reflected from the user's tissue and generates an output signal having a signal-to-noise ratio. '790 patent, 8:45-52. In one embodiment, the light source is configured to generate optical wavelengths of between 700 nanometers (nm) and 2500 nm. '790 patent, 9:4-12. The detection system includes detectors that are spatially separated from each other. '790 patent, 8:52-56. The wearable device is configured to identify an object. '790 patent, 9:1-3. For example, the '790 patent describes "methods for identify[ing] the blood constituents of interest" in the user's blood, such as

"triacetin," "ascorbate," "lactate," "alanine," "urea," and "glucose" by applying various algorithms and mathematical methods to data when the wearable device operates using short wave infrared (SWIR) optical light. '790 patent, 18:2-24.

46. The '790 patent describes several common and well-known techniques to improve signal to noise ratio, including using increased light intensity, modulation, lock-in, and dark subtraction techniques. For example, the '790 patent describes that using a "higher light level or intensity [of light] may improve the signal-to-noise ratio for the measurements." '790 patent, 21:11-13; *see also* '790 patent, 79:34-40 (disclosing that using "higher intensity or brightness of light sources" to "permit higher signal-to-noise levels"). As another example, the '790 patent describes "improv[ing] the signal-to-noise ratio" by "us[ing] modulation and lock-in techniques," which may include "modulat[ing] the light source," using "narrow band filtering around the modulation frequency … to reject noise outside the modulation," and "differenc[ing]" the signal captured with the light source on and the signal captured with the light source off. '790 patent, 58:24-45; *see also* '790 patent, 70:33-52.

B. The Prosecution History

47. In formulating my opinions, I considered the contents of the '790 Patent File History, a copy of which I understand has been designated as Exhibit 1002.

48. The '790 patent issued from U.S. Pat. App. 18/438,144, which was filed

on February 9, 2024. The Applicant filed a terminal disclaimer on August 20, 2024 in view of in view of several patents, including U.S. Patent Nos. 11,896,346, 9,494,567, 9,993,159, 10,441,176, 11,564,577, 9,500,635, 9,164,032, 9,500,634. '790FH, 263-65. This Terminal Disclaimer was filed one day after an Examiner-initiated interview where, according to meeting notes, the Applicant's representative was told that "the application would be in condition for allowance," if the Applicant were to "file the terminal disclaimer." '790 Patent File History, 271. The pending claims were then allowed (i.e., the Examiner issued a Notice of Allowance) on September 4, 2024, without any amendments to the claims or any Office Actions. '790 Patent File History, 301-302.

49. In the Notice of Allowance, the Examiner provided a statement of reasons for allowance, noting that the prior art does not disclose or render obvious: (1) "detection system is configured to be synchronized to the light source"; (2) "detection system comprises a plurality of detectors that are spatially separated from each other"; (3) "at least one analog to digital converter is coupled to at least one the plurality of detectors;" (4) "output signal is indicative of the one or more of the physiological parameters"; (5) "configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of semiconductor diodes from an initial light intensity"; (6) the detection system further configured to: "generate a first signal responsive to light received while the semiconductor diodes

are off," "generate a second signal responsive to light received while at least one of the semiconductor diodes is on," "increase the signal-to-noise ratio by comparing the first signal and the second signal"; and (7) "wearable device is at least in part configured to identify an object." '790 Patent File History, 307.

50. For the reasons I discuss in more detail below, **Lisogurski** alone or in view of **Carlson** discloses each such limitations (Sections IX.A-B).

VI. LEVEL OF ORDINARY SKILL IN THE ART

51. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person having ordinary skill in the art at the time of the alleged invention. I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field, the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a person having ordinary skill in the art is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a person having ordinary skill in the art would also have knowledge from the teachings of the prior art including the art cited below.

52. I have been asked to assume the Challenged Claim is entitled to the December 31, 2012 priority date for the purposes of this declaration only. Upon

consideration of the relevant factors listed above, in my opinion, on or before the priority date, a person of ordinary skill in the art, at the time the application that matured into the ’790 patent was filed, would have had a good working knowledge of optical sensing techniques and their applications, and some familiarity with optical system design and signal processing techniques. That knowledge would have been gained via an undergraduate education in engineering (electrical, mechanical, biomedical or optical) or a related field of study, along with relevant experience in studying or developing physiological monitoring devices (e.g., non-invasive optical biosensors) in industry or academia. This description is approximate; varying combinations of education and practical experience also would be sufficient.

53. This is the same level of ordinary skill in the art as I opined for the ’484 and ’533 patents in the prior ’533 and ’484 IPRs, which the Board adopted. ’484-Anthony, ¶35; ’533-Anthony, ¶35; ’533-FWD, at 8-9; ’484-Inst., at 7-8; ’484-FWD, at 11 n.7.

54. Well before December 31, 2012, my level of skill in the art was at least that of a person having ordinary skill. I am qualified to opine concerning what a person having ordinary skill in the art would have known and understood at the time of the ’790 patent’s purported invention. My analysis and conclusions herein are from the perspective of a person having ordinary skill in the art as of December 31,

2012. A different priority date would not change my opinions as long as the identified prior art were still prior art.

VII. CLAIM CONSTRUCTION

55. I have been instructed that the Challenged Claim of the ’790 patent is to be given its ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the alleged invention in light of the specification and the prosecution history pertaining to the patent, except as provided below. I have followed these principles in my analysis set forth in this document. I reserve the right to supplement my opinions in this declaration to the extent that any parties later propose claim constructions for any claim terms in the ’790 patent.

A. Board’s Constructions in the Prior IPRs

1. “identify an object” limitation ([7.m])

56. In the ’484 patent final written decision, I understand that the Board construed “identify an object” to mean “to recognize or establish an object as being a particular thing.” ’484-FWD, 8-10; ’484-RFWD, 3. For the purposes of this Declaration, I have been instructed to adopt the Board’s construction. For the reasons I discuss below, the prior art discloses this limitation under the Board’s construction, which is also consistent with the plain and ordinary meaning of the term (Section IX.A.3.n.[7.m]).

2. Additional Terms Discussed in ’484 and ’533 IPRs

57. In the prior ’533 IPR, I opined that a person of ordinary skill in the art would have understood the term “a plurality of lenses” to mean “a plurality of transparent surfaces used to collimate (make parallel) or focus rays of light” in the context of the ’533 patent. ’533-Anthony, ¶65.

58. In the prior ’533 IPR, I further opined that a person of ordinary skill in the art would have understood the term “pulse rate” to mean “number of pulses of light per unit of time.” ’533-Anthony, ¶66.

59. I understand that in the prior ’533 IPR, the petitioner proposed construing “plurality of lenses,” and “pulse rate,” which the Board declined to construe. ’533-FWD, 9-10.

60. In the prior ’484 IPR, I did not opine on the meaning of “plurality of lenses,” however I opined that a person of ordinary skill in the art would have understood the term “optical light” to mean “photons or light transmitted to a particular location in space” in the context of the ’484 patent. ’484-Anthony, ¶64.

61. In the prior ’484 IPR, I understand that the petitioner proposed construing “optical light,” and informed the Board of its proposed construction for “lens” in a parallel district court case, Patent Owner did not propose constructions for these terms, and the Board declined to construe them. ’484-FWD, 7-8.

62. The Board in ’533 and ’484-IPRs did not construe any other claim

present in the ’790 patent.

63. For the purposes of this Declaration, I have been instructed to adopt plain and ordinary meanings of those terms. Regardless, for the reasons I discuss below, the prior art discloses these limitations both under the plain and ordinary meaning of the terms and under the constructions that I proposed previously to the extent there is any difference between them and the plain and ordinary meaning. (Sections IX.3.d-f.[7.c]-[7.e]).

B. Prior District Court Constructions

64. I understand that prior to the Board’s ’533-FWD, in two Eastern District of Texas cases—*Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00134 (E.D. Tex.), and *Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00429 (E.D. Tex.)—involving related patents to the ’790 patent, including the ’533 patent, the district court (in its decisions that I understand have been designated as Exhibits 1018 and 1019, respectively) determined that the term “lenses” should be given its “plain and ordinary meaning without the need for further construction.” Ex. 1018, at 10-13 (construing “lenses” to have “its plain and ordinary meaning without the need for further construction.”); Ex. 1019, at 12-15 (construing “lens” and “lenses” to have their “plain and ordinary meanings without the need for further construction”).

65. For the purposes of this Declaration, and consistent with the Board’s prior decision not to construe the term, I have been instructed to adopt the plain and

ordinary meaning of those terms for my analysis. For the reasons I discuss below, the prior art discloses this limitation under the plain and ordinary meaning of the terms (Sections IX.3.e-f.[7.d]-[7.e]).

C. Terms at Issue in the Texas Case

66. I understand that, in their Invalidity and Subject Matter Eligibility Contentions served in the Texas Case between Petitioners and Patent Owner, which I understand has been designated as Exhibit 1023, Defendants (including Petitioners) identified the following limitations of Challenged Claim 7 as potentially indefinite:

- "a plurality of detectors that are spatially separated from each other"
- "increase the signal-to-noise ratio by comparing the first signal and the second signal"
- "wherein the wearable device is at least in part configured to identify an object"
- "wherein the detection system is configured to be synchronized to the light source."

Ex. 1023, at 243-244.

67. For the purposes of this Declaration, I do not take a position on whether these terms are indefinite. And, regardless of the outer bounds of these limitations, for the reasons discussed below in Section IX.A.3, these limitations are still disclosed and rendered obvious by the prior art because the prior art discloses and

renders obvious embodiments within the indisputable scope of these limitations.

VIII. GROUNDS OF UNPATENTABILITY

68. As I explain above in Section IV, physiological measurement systems were well-known in the art.

69. In this section, I will explain why the teachings or combinations of teachings from the following references render obvious each limitation of the Challenged Claim:

Name	Ex.	Publication	Filed	Published/ Issued
Lisogurski	1025	US 9,241,676	5/31/2012	1/26/2016
Carlson	1028	US 2005/0049468	9/3/2003	3/3/2005

I have been instructed to assume that each of these references qualifies as prior art.

70. As I explain below, the Challenged Claim is invalid based upon the following prior art grounds:

- **Ground 1**: Challenged Claim 7 of the ’790 patent is rendered obvious by **Lisogurski**.
- **Ground 2**: Challenged Claim 7 of the ’790 patent is rendered obvious by **Lisogurski** further in view of **Carlson**.

IX. SPECIFIC GROUNDS FOR CHALLENGE

71. It is my opinion that Challenged Claim of the ’790 patent is unpatentable as explained below. As I explain above in Section IV, although the ’790 patent purports to have invented a physiological measurement system, such

devices were well-known in the art. As described below, the cited prior art provides these teachings.

72. In this section, I explain why claim 7 of the ’790 patent is rendered obvious by the teachings of **Lisogurski** and **Carlson**. Regarding both Grounds, **Lisogurski** teaches a physiological measurement system that is worn by a user and is for use with a smart phone or tablet, the measurement system including a light source that outputs light having multiple wavelengths, lenses, and detection system, and where the measurement system includes means for improving signal-noise-ratios, as well as means for identifying an object. Regarding Ground 2, **Carlson** further teaches the use of lenses in a physiological monitoring system.

73. I note that in this discussion, I may focus on the particular language in the specific claim limitations, but it should be understood that my analysis applies to the corresponding elements of the Challenged Claim containing identical or substantially identical language.

A. GROUND 1: Lisogurski (Claim 7)

1. Overview of Lisogurski

74. **Lisogurski** discloses a “medical device,” specifically a “physiological monitoring system [that] monitor[s] one or more physiological parameters of a patient[by] … using one or more physiological sensors.” Lisogurski, 3:44-46. The physiological parameters may include “a patient’s pulse rate and blood pressure.”

Lisogurski, 4:3-5. The physiological sensors may include a pulse oximeter with a "light sensor that is placed at a site on a patient, typically a fingertip, toe, forehead, [ ] earlobe, … or … a foot." Lisogurski, 4:6-7. '533-FWD, 12-13; '484-FWD, 13. A person of ordinary skill in the art would have understood such disclosures as being consistent with standard, established physiological monitoring techniques and sensor placements.

75. Figure 1 of **Lisogurski** is reproduced below:

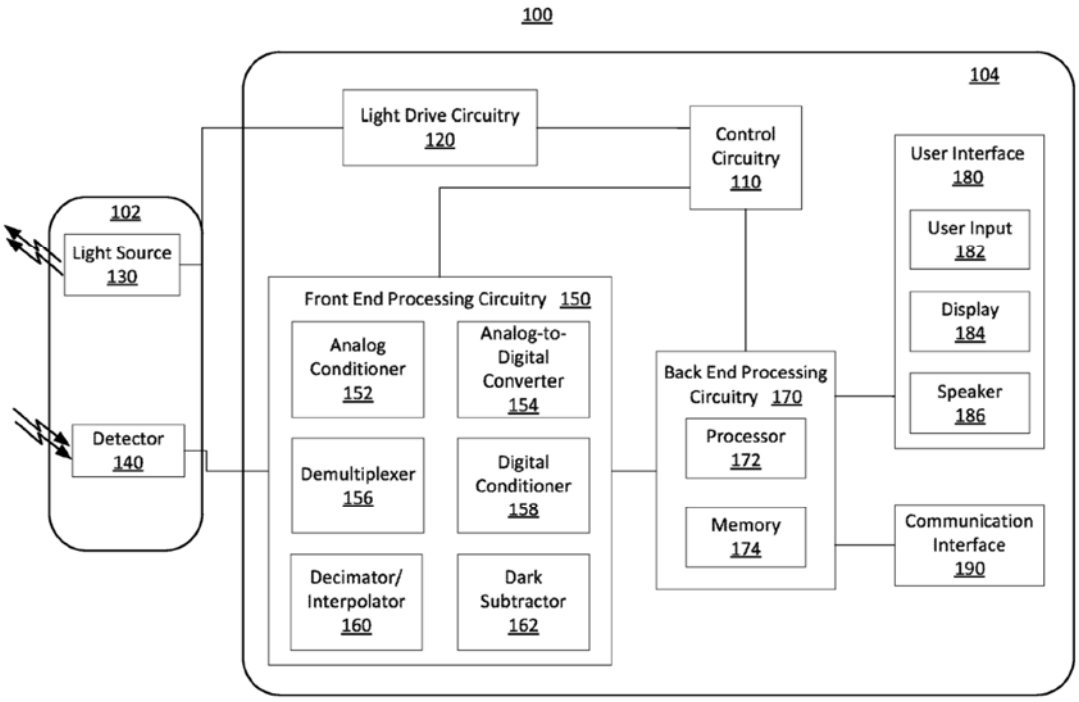


FIG. 1

76. **Lisogurski's** Figure 1 is a "block diagram of an illustrative physiological monitoring system in accordance with some embodiments of the present disclosure." Lisogurski, 2:11-13. The system includes "sensor 102," which

has "light source 130 and detector 140," and "monitor 104" for "generating and processing physiological signals of a subject." Lisogurski, 10:44-49. Light source 130 "emit[s] photonic signals having one or more wavelengths of light," including red light and IR light, "into a subject's tissue." Lisogurski, 10:49-52. Light source 130 includes "a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs)." Lisogurski, 10:52-56. The "Red wavelength" is "between 600 nm and about 700 nm" and the "IR wavelength" is "between about 800 nm and about 1000 nm." Lisogurski, 10:52-11:8. Spatially separated detectors 140 "detect the intensity of light," for example, "the intensity of light at the Red and IR wavelengths," after the light "pass[es] through the subject's tissue." Lisogurski, 11:9-14. After detectors 140 receive the light, they then "convert[ ]" them to an electrical signal, and "send the detection signal to monitor 104, where the detection signal [is] … processed [to determine] physiological parameters." Lisogurski, 11:14-23. The light that is received by the detectors is "directly related to the absorbance and/or reflectance of light in the issue," such that "when more light at a certain wavelength is absorbed or reflected, less light of that wavelength is received from the tissue by detector[s] 140." Lisogurski, 11:16-20; *see also* Lisogurski, 17:40-45 ("One or more detector 318 may also be provided in sensor unit 312 for detecting the light that is reflected by or has traveled through the subject's tissue."). '533-FWD, 15-16; '484-FWD, 15-16. A person of ordinary skill

in the art would have understood that **Lisogurski's** configuration is consistent with a common pulse oximeter system widely adopted in the field of non-invasive physiological monitoring at the priority date of the '790 patent. A person of ordinary skill in the art would have been familiar with the well-established physical principle underlying pulse oximetry—that is, changes in absorption and reflection of selected wavelengths correlate with physiological parameters like oxygen saturation levels in arterial blood. Furthermore, the conversion of the detected optical signals into electrical signals, and their subsequent processing to yield relevant physiological parameters, are routine operations and align with conventional designs in wearable medical sensors used at the time.

77. Monitor 104 includes several components, including "user interface 180," "communication interface 190," and various circuitry components, such as "control circuitry 110," "light drive circuitry 120," "front end processing circuitry 150," and "back end processing circuitry 170." Lisogurski, 11:28-32. "Control circuitry 110" controls "light drive circuitry 120." Lisogurski, 11:33-36 (disclosing that control circuitry 110 is "coupled" to light drive circuitry 120 and that it is "configured to control [its] operation"). '533-FWD, 16; '484-FWD, 16.

78. "Light drive circuitry 120 … generate[s] a light drive signal, which may be used to turn on and off light source 130, based on timing control signals." Lisogurski, 11:38-54. "Light drive circuitry 120" also controls the intensity of light

source 130. Lisogurski, 11:50-54. ’533-FWD, 16; ’484-FWD, 16.

79. “Front end processing circuitry 150” (1) operates “synchronously with light drive circuitry 120,” (2) “receive[s] a detection signal from detector 140,” (3) “processes the output signal of detector 140,” (4) provide[s] one or more processed signals to back end processing circuitry 170,” and (5) “synchronize[s] the operation of an analog-to-digital converter … with the light drive signal based on the timing control signals.” Lisogurski, 11:40-46, 12:42-48. ’533-FWD, 16; ’484-FWD, 16. A person of ordinary skill in the art would have recognized the synchronization of front-end processing circuitry, particularly the analog-to-digital conversion and initial signal conditioning, with the operation of the optical source drive circuitry as common practice. Such synchronization significantly enhances accuracy and repeatability by ensuring consistent timing alignment between optical emission and measurement acquisition.

80. “[B]ackend processing circuitry 170” includes “processor 172 and memory 174.” Lisogurski, 14:56-57. “[B]ackend processing circuitry 170” “receive[s] and process[es] physiological signals received from front end processing circuitry 150” to “determine one or more physiological parameters based on the received physiological signals.” Lisogurski, 14:56-64. Moreover, backend processing circuitry 170 is “communicatively coupled [to] use[r] interface 180 and communication interface 190.” Lisogurski, 15:16-18. **Lisogurski’s** backend

processing circuitry 170 is consistent with the standard practice supporting user interactions and data integration with other systems.

81. "User interface 180" includes various components, including "user input 182, display 184, and speaker 186," and may include "a keyboard, a mouse, a touch screen, buttons, switches, [and] a microphone[,] … or any other suitable input device." Lisogurski, 15:19-22. '533-FWD, 17; '484-FWD, 16-17.

82. "Communication interface 190" allows "monitor 104 to exchange information with external devices," and includes "one or more receivers, transmitters, transceivers, antennas, plug-in connectors, ports, communication buses, communication protocols, device identification protocols, any other suitable hardware or software, or any combination thereof" to allow "wireless communication." Lisogurski, 15:43-57. '533-FWD, 17; '484-FWD, 16-17.

83. **Lisogurski** further discloses that "the components of physiological monitoring system 100 that are shown and described as separate components … for illustrative purposes only" and that: (1) "the functionality of some of the components may be combined in a single component" and (2) "the functionality of some of the components ... may be divided over multiple components." Lisogurski, 15:66-16:9. **Lisogurski** goes on to explain that: "For example, some or all of the functionality of control circuitry 110 may be performed in front end processing circuitry 150, in back end processing circuitry 170, or both." Lisogurski, 16:9-12. As another example,

"all of the components of physiological monitoring system 100 can be realized in processor circuitry." Lisogurski, 16:14-16. '533-FWD, 15; '484-FWD, 17. A person of ordinary skill in the art would have recognized that **Lisogurski's** disclosure of combining and dividing functionality among electronic components (such as control, front-end processing, and backend-processing) was a common practice, based on design engineering considerations such as power management, miniaturization, reliability, and manufacturability.

84. **Lisogurski's** Figure 3, reproduced below, is "a perspective view of an embodiment of a physiological monitoring system." Lisogurski, 2:23-25. The system includes several components, such as "sensor unit 312," "monitor 314," and a "multi-parameter physiological monitor 326" ("MPPM"). Lisogurski, 17:35-36, 18:44-45.

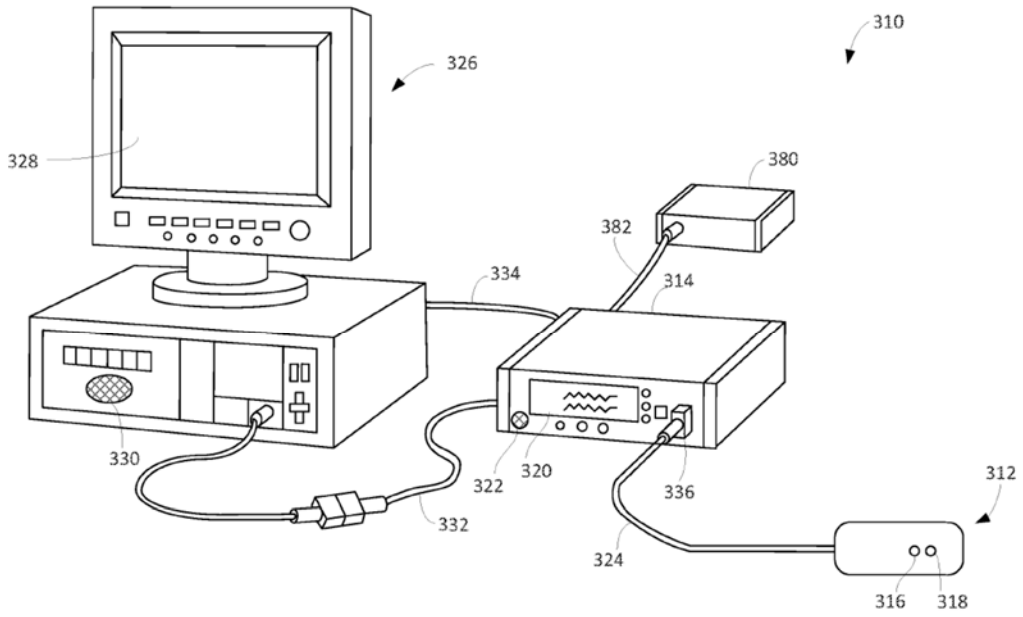


FIG. 3

85. **Lisogurski** discloses several embodiments of its physiological monitoring system, two of which are depicted in the block diagram of Figure 1 (Lisogurski, 2:11-13; element labelled "100") and the perspective view of Figure 3 (Lisogurski, 2:23-25; element labelled "310"). Figure 3 is an exemplary application of the embodiment shown in Figure 1 and, therefore, a person of ordinary skill in the art would have understood that the disclosures in Figure 3 apply to the corresponding components or features in Figure 1. '533-FWD, 13-15; '484-FWD, 13-15.

86. **Lisogurski** further discloses that the system 310 in Figure 3 includes "one or more components of physiological monitoring system 100 of [Figure] 1," such that a person or ordinary skill in the art would have understood (or at least found it obvious) that the analysis for other limitations relying on Figure 1 of **Lisogurski**

applies equally to **Lisogurski's** exemplary application shown in Figure 3. Lisogurski, 17:30-35. Indeed, **Lisogurski** explicitly discloses that "one or more components of physiological monitoring system 310 [depicted in Figure 3] may include one or more components of physiological monitoring system 100 [depicted in Figure 1]." Lisogurski, 17:30-35, 18:13-14. For example, monitor 314 (depicted in Figure 3) may be implemented as monitor 104 (depicted in Figure 1). Lisogurski, 17:30-35, 18:13-14. Sensor 312 and monitor 314 also include similar configurations as sensor 102 and monitor 104, respectively. Lisogurski, 17:37-62, 18:3-10, 19:25-27. '533-FWD, 13-15; '484-FWD, 13-15.

87. Monitor 314 is "communicatively coupled to" and "communicate[s] wirelessly" with MPPM 326. Lisogurski, 18:58-65. MPPM 326 "calculate[s] physiological parameters," "provide[s] a display 328 for information from monitor 314," is "coupled to a network to enable the sharing of information with servers or other workstations (not shown)." Lisogurski, 18:49-52, 18:62-65. The remote network servers "determine[s] physiological parameters" and "display[s] the determined physiological parameter[s]" on display 320 of monitor 314 (depicted in Figure 3), or display 328 of MPPM 326 (also depicted in Figure 3). Lisogurski, 20:53-58. '533-FWD, 13-15; '484-FWD, 13-15.

88. **Lisogurski** further discloses various methods for improving signal-to-noise ratio. For example, **Lisogurski** discloses: (1) modulating the light drive signal

to have a "period the same as or closely related to the period of [a] cardiac cycle, thus generating a cardiac cycle modulation," (2) using a dark subtraction process to remove noise from the ambient light by "subtract[ing] the background or dark level from the levels received during red 'on' portion 286 and IR 'on' period 290", and (3) varying parameters related to the light drive signal, including "drive current or light brightness, duty cycle, firing rate, modulation parameters, other suitable parameters, or any combination thereof." Lisogurski, 6:7-19, 9:46-60, 13:60-14:10, 16:33-54, 17:8-10, 25:49-55. '533-FWD, 17; '484-FWD, 17. A person of ordinary skill in the art would have understood these disclosed methods (cardiac-cycle modulation, dark subtraction, varying drive parameters) as common and well-understood strategies for improving signal-to-noise ratio and accuracy in photoplethysmography-based physiological wearable or ambulatory monitoring systems.

2. Motivation to Modify Lisogurski

89. A person of ordinary skill in the art would have been motivated to modify **Lisogurski's** "physiological monitoring system 100" in order to place several components located within monitor 104—namely, **control circuitry 110**, **light drive circuitry 120**, and **front end processing circuitry 150**—to sensor 102, where **light source 130** is located. Figure 1 is reproduced below with annotations highlighting some of the components I've described.

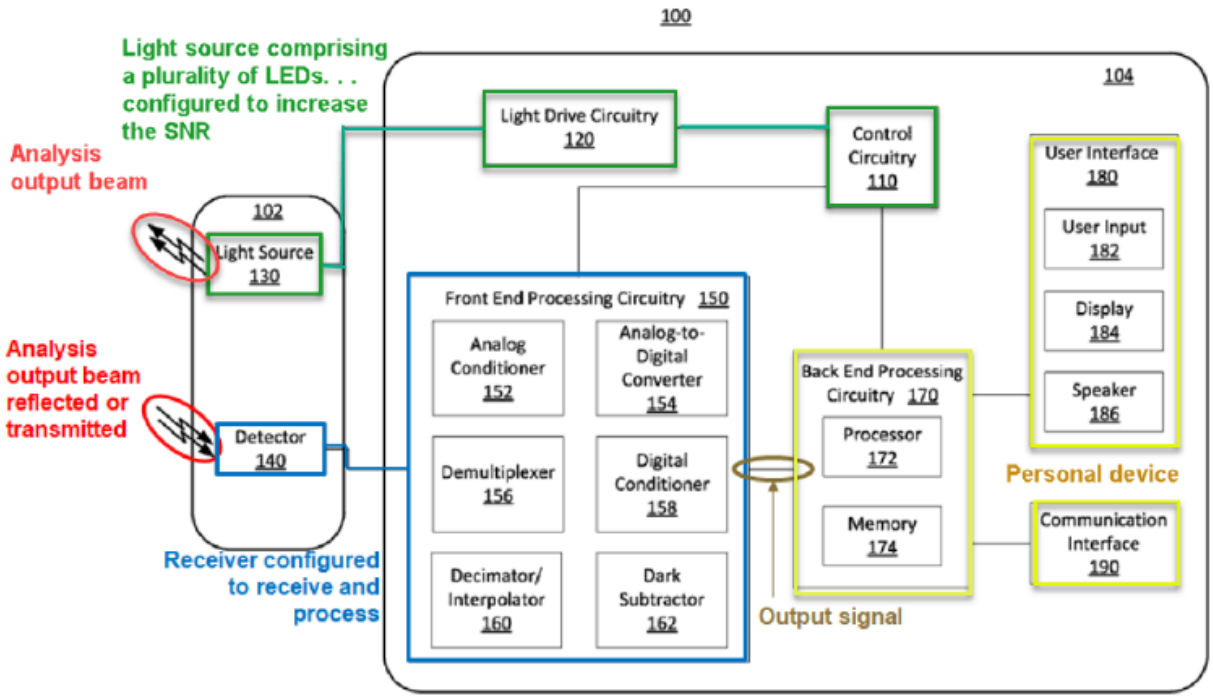


FIG. 1

90. As an initial matter, **Lisogurski** states that, even though the "components of physiological monitoring system 100 … are shown and described as separate components are shown and described as such for illustrative purposes only," such as in Figure 1, "the functionality of some of the components may be combined in a single component." Lisogurski, 15:66-16:4. A person of ordinary skill in the art would have understood that this disclosure explicitly states that the functionality attributed to these separate components can, in practice, be integrated into a single combined unit. **Lisogurski** further discloses that "the functionality of some of the components of monitor 104 shown and described herein may be divided over multiple components." Lisogurski, 16:6-9. A person of ordinary skill in the

art would have understood **Lisogurski's** disclosure of both integration and distribution allows customization and optimization of the system depending on specific design or implementation requirement considerations, such as portability, computational power, signal processing capabilities, or manufacturability.

91. As the Board found, "Lisogurski expressly suggests the modification by teaching embodiments in which 'the functionality of some of the components may be combined in a single component' and embodiments in which 'the functionality of some of the components of monitor 104…may be divided over multiple components.'" '533-FWD, 23 (quoting Lisogurski, 16:2-4, 16:7-9). As the Board further found, "numerous industry trends motivate the modification," which "include improving the capabilities of wearable sensors for use in sports and personal fitness applications and wirelessly connecting wearable sensors to networks to remotely monitor patient health." '533-FWD, 23. This is consistent with my opinions provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶48-56, 98-103, 138, 142-146.

92. Further, in the prior '484 IPR, I understand that the Board agreed with Petitioner's argument that "[although] Lisogurski depicts front end processing circuitry 104 as separate from wearable sensor 102, … incorporating the front end processing circuitry into the same device with the detector would have been consistent with Lisogurski's teaching that the functionality of some components of

monitor 104 can be divided over multiple components and is an obvious modification to a person of ordinary skill." '484-FWD, 24-27. This is consistent with my opinions provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶48-56, 123-127, 160-164.

93. Consistent with **Lisogurski's** disclosures, ***first***, a person of ordinary skill in the art would have been motivated to combine the functionality of at least both **control circuitry 110** and **light drive circuitry 120** into a single device—specifically, within the device where **light source 120**, the LEDs, are located (i.e., sensor 102). This is because the **control circuity 110** and light drive circuitry 120 are coupled and work in tandem with the **light source 130**: the control circuitry 110 sends timing control signals to direct the **light drive circuitry 120** to generate a light drive signal, and this signal is the electric current provided to the **light source 130** to, for example, turn the light source on and off and to regulate their brightness. Lisogurski, 11:38-41, 11:50-54, 25:52-55. It would have been obvious to include **control circuitry 110** and **light drive circuitry 120** in sensor 102, where the LEDs are located, because the electrical current cannot be transferred wirelessly from monitor 104 to sensor 102. Because these circuits work together to generate and apply the electric current to the LEDs, a person of ordinary skill in the art would have understood that it was at least obvious to include the **control circuitry 110** and **light drive circuitry 120** to be located alongside the **light**

source 130 within sensor 102. '533-Anthony, ¶101 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55); '484-Anthony, ¶162 (citing Lisogurski, 11:38-41, 11:50-54, 25:52-55). A person of ordinary skill in the art would have further understood that integrating control and drive circuitry directly with the LEDs is advantageous to maintaining precise synchronization and optimal signal integrity. Indeed, given the limitations in transmitting accurate electrical signals without introducing noise or timing errors, a person of ordinary skill in the art would have found such integration technically and practically advantageous.

94. Moreover, a person of ordinary skill in the art would have understood that adding the **light drive** and **control circuitry** directly to sensor 102 would not have negatively impacted the operation of **Lisogurski's** system. For example, a person of ordinary skill in the art would have appreciated that modern electronic components such as control and drive circuits are designed with compactness, power efficiency, and ease of integration in mind, making them well-suited for integration within the form factor of a wearable sensor. Their small size would not add significant bulk or weight, and their efficient power consumption helps maintain the device's overall battery life. As a result, a person of ordinary skill in the art would have found the integration of the light drive circuitry and control circuitry into sensor 102 both practical, feasible and advantageous, enhancing both performance and usability in physiological monitoring applications without compromising system

performance. ’533-Anthony, ¶102 (citing Lisogurski, 16:2-9); ’484-Anthony, ¶163 (citing Lisogurski, 16:2-9).

95. Lastly, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components. Integrating **control circuitry 110** and **light drive circuitry 120** into a single device, sensor 102, is consistent with these teachings.

96. Additionally, as the Board further found, a person of ordinary skill in the art would have been motivated to modify monitor 104 to be a personal device “includ[ing] only backend processing circuitry 170, user interface 180, and communication interface 190.” ’533-FWD, 39-40 (citing ’533-Pet., 49-53; Lisogurski, Fig. 1). As the Board explained, and as I noted above, “Lisogurski’s express suggestion and the industry trend to make wireless sensors for personal fitness tracking that transmit monitored physiological parameters to a personal device.” ’533-FWD, 39-40 (citing ’533-Pet., 49-53; Lisogurski, Fig. 1). This is consistent with my opinions provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶150-153.

97. ***Second***, a person of ordinary skill in the art would have been further motivated to combine the functionality of **front end processing circuitry 150** into the same device where the **detector 140** is located. A person of ordinary skill in the

art would have been motivated to do so for three reasons. **One**, **Lisogurski** discloses that its sensor "preprocess[es]" a signal before transmitting the processed signal to the monitor. Lisogurski, 11:25-27. Accordingly, a person of ordinary skill in the art would have been motivated to combine components that perform the same functionality together in a single device to substantially minimize latency, improve signal fidelity, and simplify overall system architecture by reducing signal travel distances and potential points of interference or noise. **Two**, **Lisogurski** teaches that the sensor may be a separate device from monitor. Lisogurski, 17:55-57 (stating that as opposed to "draw[ing] power from monitor 314," "[s]ensor unit 312 may be powered by an internal power source, e.g., a battery."). Accordingly, a person of ordinary skill in the art would have understood that **front end processing circuity 150**, although it is depicted in **Lisogurski's** Figure 1 as part of monitor 104, can be a separate component from monitor 104. Indeed, **Lisogurski** explicitly teaches that "the functionality of some of the components of monitor 104 shown and described herein may be divided over multiple components." Lisogurski, 16:6-9. A person of ordinary skill in the art would have recognized this as strong evidence supporting the feasibility and desirability of placing the **front-end processing circuitry 150** within the sensor device itself, further validating a self-contained, independently powered sensor architecture that integrates detection and preprocessing functions. **Three**, **Lisogurski** teaches that the sensor may be

wirelessly connected to the monitor. Lisogurski, 17:57-59 ("[T]he sensor may be wirelessly connected to monitor 314."); *see also* Lisogurski, 18:23-25, 18:16-31. A person of ordinary skill in the art would have understood that even though the front end processing circuitry can be arranged to be located within the sensor rather than monitor 104, it would still be capable of communicating with components—such as back end processing circuitry 170—located within monitor 104. *E.g.,* Lisogurski, 11:46-49 ("[T]he back end processing circuitry 170 may use the timing control signals to coordinate its operation with front end processing circuitry 150."). Accordingly, a person of ordinary skill in the art would have at least found it obvious to configure **Lisogurski's** system such that the **front end processing circuitry** is wirelessly configured to monitor 104, allowing the two components to transmit signals wirelessly to each other, even though such wireless configuration is not depicted in Lisogurski's figures. This arrangement helps ensure that high-quality, digitized signals are transmitted wirelessly, rather than raw, low-level analog signals that are more susceptible to interference and degradation. '533-Anthony, ¶143 (citing Lisogurski, 11:20-27, 17:55-59, 18:16-31); '484-Anthony, ¶124 (citing Lisogurski, 11:20-27, 17:55-59, 18:16-31).

98. Lastly, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components and integrating **front end processing circuitry**

150 into the same device where the **detector 140** is, thus, consistent with these teachings. A person of ordinary skill in the art would have understood that integrating front end signal processing circuitry directly into the sensor with the detector offers clear technical benefits, including improved signal integrity, reduced latency, simplified system architecture, and enhanced reliability of wireless communications. Furthermore, given the explicit teaching in **Lisogurski** regarding the possibility and benefit of separating and integrating different components, a person of ordinary skill in the art would have found it straightforward and logical to physically locate the front-end processing and detection functions within the sensor device. This would enhance performance and robustness of the overall physiological monitoring system and be used as part of natural design, manufacturing, and usability trade-off consideration.

99. ***Third***, a person of ordinary skill in the art would have been further motivated to combine the functionality of **front end processing circuitry 150** into sensor 102 so that the sensor could process the detected signal before wirelessly transmitting it to the monitor. A person of ordinary skill in the art would have understood that for information contained in an analog signal output from the detector to be wireless transmitted effectively, it would have to be converted to digital form. The analog-to-digital conversion is performed by the **front-end processing circuitry**. A person of ordinary skill in the art would have understood

that preprocessing signals (such as amplification, filtering, and particularly analog-to-digital conversion) near the point of detection is technically beneficial because it substantially enhances signal fidelity and accuracy. Performing analog-to-digital conversion at the sensor level significantly reduces signal degradation and interference that typically accompany analog signal transmission, especially over wireless links or extended cables. This integration also enables precise and rapid tuning of signal parameters such as gain values and filtering conditions, thereby improving measurement reliability and responsiveness. A person of ordinary skill in the art would have understood that measurement accuracy would be improved by performing the analog-to-digital conversion prior to wireless transmission of digital bits instead of analog amplitudes, and by being able to tune the measurement process by, for example, adjusting any gain values (e.g. for matching the signal amplitude to the dynamic range of the analog to digital conversion). Accordingly, it would have been obvious to include the **front-end processing circuitry** in the sensor. Adding the **front end processing circuity** to the sensor would not have negatively impacted the operation of **Lisogurski's** system. These circuits are compact and designed to be power-efficient, making them well-suited for integration within the form factor of a wearable sensor. Their small size would not add significant bulk or weight, and their efficient power consumption helps maintain the device's overall battery life. Moreover, as I explained above, **Lisogurski** explicitly teaches that the functionality

of its components may be integrated into a single component or separated into multiple components. From this explicit teaching, a person of ordinary skill in the art would have recognized that the sensor's architecture naturally lends itself to integrating front-end processing circuitry, since independent powering inherently supports local signal processing. This self-contained design enhances the sensor's versatility, allowing it to perform critical signal processing tasks without requiring continuous wired power or cable communication connections, making the sensor especially suitable for mobile, wearable, and ambulatory applications. As a result, a person of ordinary skill in the art would have found the integration of the front end processing circuitry into sensor 102 both practical and feasible without compromising system performance. '533-Anthony, ¶144; '484-Anthony, ¶125. Additionally, a person of ordinary skill in the art would have understood that integrating the **control circuitry**, **light drive circuitry**, and **front-end processing circuitry** directly with the sensor significantly enhances the system's efficiency by reducing noise, signal degradation, and latency. Such integration aligns with standard industry practices in wearable sensor technologies, commonly used to ensure compact, energy-efficient, and responsive physiological monitoring solutions. A person of ordinary skill would also have understood that integrating front-end analog-to-digital conversion circuitry directly within or closely adjacent to sensors is a conventional approach, designed to minimize noise, reduce data

transmission losses, and ensure accurate, real-time signal capture and analysis. In sum, a person of ordinary skill in the art would have understood that the close integration of **front-end processing circuitry** and the detector in a sensor is highly advantageous for multiple reasons: it enhances signal integrity, reduces noise and signal degradation, improves data reliability and accuracy, simplifies sensor-to-monitor communication, and ensures system responsiveness. Given the explicit teachings from **Lisogurski** about flexibility and wireless operation, a person of ordinary skill in the art would have found the integration obvious, practical, technically straightforward, and consistent with industry standards in physiological monitoring technologies.

100. The desire to relocate the **control circuitry 110**, **light drive circuitry 120**, and **front-end processing circuitry 150** from **Lisogurski's** monitor 104 to the sensor 102 aligns with common practices at the time aimed at improving signal fidelity and reliability. **Lisogurski** itself supports this arrangement, suggesting explicitly that functionalities can be combined or distributed flexibly. Lisogurski, 15:66-16:9.

101. A person of ordinary skill would have understood this relocation as an obvious step, consistent with established industry practices for design, manufacturing, function, and usability. Integrating light drive circuitry and associated control components directly into sensor assemblies minimizes

interference, enhances operational efficiency, improves manufacturability, and optimizes device compactness and usability. A person of ordinary skill in the art would have been familiar with numerous examples in the field where integration of control and drive circuitry with the sensor components is a known solution for achieving optimal performance, signal clarity, and reliability. This well-established approach underscores the practicality and technical desirability of this integration in physiological monitoring devices; this concept was widely adopted by industry as early as the early 2000s, as illustrated by, e.g., U.S. Patent No. 8,050,703 and U.S. Patent Pub. No. 2011/0237911, which I understand have been designated as Exhibits 1031 and 1033, respectively, as further discussed below. Ex. 1031, 14:12-26, Fig. 18; Ex. 1033, [0052], Fig. 4.

102. Additionally, as I explained above, **Lisogurski** explicitly teaches that the functionality of its components may be integrated into a single component or separated into multiple components and integrating **front end processing circuitry 150** into sensor 102 is consistent with these teachings.

103. Moreover, a person of ordinary skill in the art would have found the integration of the control and light drive circuitry components and front end processing components into sensor 102, where light sources are located, as routine and straightforward. Indeed, it was common for **light sources** to include **light drive circuitry** and **control circuitry**, and for a **detector** to include a **front end**

processing circuitry.

104. For example, U.S. Patent Pub. No. 2011/0237911 (Ex. 1033) discloses, as depicted in Figure 4, front end analog signal conditioning circuitry 330 ("330") and analog to digital conversion circuit 332 located within sensor 300 ("300"). Ex. 1033, [0052], Fig. 4. And, as disclosed in U.S. Pat. No. 5,592,124, which I understand has been designated as Exhibit 1036, a "photodiode structure" "could be provided on an integrated circuit wafer circuitry other than transimpedance amplifier 2 and output buffer 8[, such as] signal processing circuitry." Ex. 1036, 11:7-33 ("signal processing circuitry integrated onto the same semiconductor chip as photodiode structure"), Fig. 3 (depicting the same). Further, as U.S. Pat. No. 5,942,749, which I understand has been designated as Exhibit 1034, discloses, a "photodetector with a signal processing capability" was well known in the art. Ex. 1034, 2:66-4:20 ("photodetector is also operable as a ternary circuit."), Figs. 7-9. U.S. Pat. No. 5,822,473, which I understand has been designated as Exhibit 1035, also discloses an "integrated smart sensor," which includes "LED 14" as well as "processing circuitry 20." Ex. 1035, 3:37-52, Fig 2 (depicting a top view of the integrated smart sensor). Similarly, U.S. Pat. No. 8,050,730 (Exhibit 1031) discloses an "apparatus" for "pulse oxygen measurement[s]" that includes collectively a "single chip data processing unit"; a "probe unit" having a red and infrared light sources and light driver circuitry; and signal processing circuitry. Ex. 1031, 14:12-

26, Fig. 18.

105. Additionally, as to the **control circuitry 110** and **light drive circuitry 120**, because they work together to output the electric current that is applied to the light source, a person of ordinary skill in the art would have understood or at least found it obvious to include the circuitry in the same device as the light source. *See* '533-FWD, 23 (citing '533-Pet., 32-34). As to the **front-end processing circuitry 150,** because it performs analog-to-digital conversion and other initial processing of the signal, the Board also agreed that a person of ordinary skill in the art would have understood or at least found it obvious to include it in the sensor where the signal is captured. *See* '533-FWD, 23 (citing '533-Pet., 47-48). Indeed, it was common for light sources to include light drive circuitry and control circuitry, and for a detector to include a front end processing circuitry. *See, e.g.*, Ex. 1031, 14:12-26, Fig. 18 (light drive circuit in probe); Ex. 1033, [0052], Fig. 4 (showing front end analog signal conditioning circuitry 330 in sensor 300); Ex. 1034, Abstract ("a photodetector with a signal processing capability"); Ex. 1035, 2:21-23 ("an embodiment of the present invention is simple integration of the sensor with other circuits such as a signal processor.").

106. Moreover, integrating the various circuitry components, detector, and light sources into one device is consistent with a growing industry trend toward integrating additional features into wearable sensors—particularly in applications

like personal fitness and sports—to enable remote monitoring of a user's physiological state. '533-Anthony, ¶¶48-56; '484-Anthony, ¶¶48-56.

3. Invalidity of Claim 7 Over Lisogurski

107. As I discuss below, Claim 7 is rendered obvious by **Lisogurski**. In addition to my discussion in Sections IX.A.1-2, the following discussion identifies example disclosures that each disclose Challenged Claim 7.

a. Element [7.pre]

108. Element [7.pre] recites: "**An optical system, comprising.**" This element is met by **Lisogurski**.

109. Regarding a substantially identical limitation in the prior '484 IPR reciting "**system** for measuring one or more physiological parameters," I understand that the Board determined that the petitioner demonstrated "Lisogurski [] disclos[es] a system for measuring one or more physiological parameters for use with a smart phone or tablet…," and that the Board relied on **Lisogurski's** disclosure of "an optical physiological monitoring system." '484-FWD, 13, 23, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶89-95 (citing Lisogurski, 1:10-25, 3:43-46, 3:61-4:5, 4:6-20, 4:22-25, 4:52-62, 15:19-42, 15:49-56, 17:55-59, 18:65-66, Figs. 1 & 3).

110. Regarding a substantially identical limitation in the prior '533 IPR

reciting "A measurement **system comprising**," I understand that the Board determined that "[p]etitioner demonstrates that Lisogurski's "system 100/310, including sensor 102/312 for measuring blood oxygen saturation, meets this limitation," and that "[s]ensor 102/312 is a pulse oximeter." '533-FWD, 25. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶88 (citing Lisogurski, Abstract, 3:43-46, 3:61-4:3, 4:52-62, Figs. 1 & 3).

111. '790 patent element [7.pre] is substantially identical to the corresponding limitation in the claim 1 of the '484 patent on which I previously opined, and which recites: "**system** for measuring one or more physiological parameters." Both limitations recite a "system." Moreover, the '484 patent limitation is directed to specifically an optical system and, as the later portions of claim 1 specify, includes "light emitting diodes configured to generate an output optical light." '484 patent, claim 1. Any differences between these claim limitations do not change my analysis. Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.pre]. '484-Anthony, ¶¶89-95.

112. A portion of the '790 patent element [7.pre] is also substantially identical to the corresponding limitation in claims 5 and 13 the '533 patent on which I previously opined, which recites: "A measurement **system comprising**." Both

limitations recite a "system." Moreover, later portions of both claims 1 and 13 of the '533 patent specify that it includes "light emitting diodes configured to generate an output optical beam," where the use of "optical beam" is a term to describes the general propagation (radiation-pattern or directional-shape) of light, confirming that the system is directed to an optical system. '533 patent, claims 1, 13. Any differences between these claim limitations do not change my analysis. Thus, my opinions regarding the '533 patent term apply equally to '790 patent element [7.pre]. '533-Anthony, ¶88.

113. As further support for this limitation, **Lisogurski** discloses that its "sensor unit 312 may be connected to monitor 314 as shown," and "may be powered by an internal power source, e.g., a battery" or "may draw power from monitor 314." Lisogurski, 17:55-59.

b. Element [7.a]

114. Element [7.a] recites: "**a wearable device for measuring one or more physiological parameters.**" This element is met by **Lisogurski**.

115. Regarding a substantially identical limitation in the prior '533 IPR reciting "**a wearable** measurement **device for measuring one or more physiological parameters**," I understand that the Board determined that the petitioner demonstrated **Lisogurski** discloses that "[s]ensor 102/312 is a pulse oximeter that … [is] mounted on a user's fingertip, toe, earlobe, wrist, or thigh," and

that **Lisogurski's** system, which "include[es] sensor 102/312 [is] for measuring blood oxygen saturation." '533-FWD, 25. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶89-94 (citing Lisogurski, 1:10-25, 3:43-46, 3:61-4:20, 4:22-25, 4:52-62, 15:30-35, 17:55-59, Figs. 1 & 3).

116. Regarding a substantially identical limitation in the prior '484 IPR "**a wearable device**…," I understand that the Board determined that the petitioner demonstrated "Lisogurski [] disclos[es] a system for measuring one or more physiological parameters for use with a smart phone or tablet," and that "the system may be placed on a user's ear or wrist." '484-FWD, 23, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶96-97 (citing Lisogurski, 4:6-20).

117. '790 patent element [7.a] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: "**a wearable** measurement **device for measuring one or more physiological parameters**." The only difference between the two limitations is the '533's use of a "wearable <u>measurement</u> device … for measuring" as opposed to the '790's use of a "wearable device … for measuring." A person of ordinary skill in the art would

have understood that a wearable device used to measure physiological parameters—like **Lisogurski's** wearable device (Section IX.A.3.c.[7.b])—is itself, a wearable measurement device. *See, e.g.*, Lisogurski, 37:2-5 (describing that its "system may detect the physiological condition using information obtained through measurements"). This difference between these claim limitations does not change my analysis. Thus, my opinions regarding the '533 patent term apply equally to '790 patent element [7.a]. '533-Anthony, ¶¶89-94.

118. '790 patent element [7.a] is also substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: "**a wearable device** …." Both limitations recite "a wearable device." Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.a]. '484-Anthony, ¶¶96-97.

c. Element [7.b]

119. Element [7.b] recites: "**the wearable device adapted to be placed on a wrist of a user**." This element is met by **Lisogurski**.

120. Regarding a substantially identical limitation in the prior '484 IPR reciting "a **wearable device adapted to be placed on a wrist** or an ear **of a user**," I understand that the Board determined that the petitioner demonstrated that "Lisogurski [ ] disclos[es a] system [that] may be placed on a user's ear or wrist." '484-FWD, 23, 26-27. This is consistent with my opinions regarding this '484

limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶96-97 (citing Lisogurski, 4:6-20).

121. ’790 patent element [7.b] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, which recites: “a **wearable device adapted to be placed on a wrist** or an ear **of a user**.” A person having ordinary skill in the art would have understood that **Lisogurski** discloses placing its sensor on either the wrist or ear of a user (Lisogurski, 4:6-20), and thus is sufficient to satisfy element [7.b] of the ’790 patent. The differences between the two terms do not change my analysis, and thus my opinions regarding the ’484 patent term apply equally to ’790 patent element [7.b]. ’484-Anthony, ¶¶96-97.

122. As further support for this limitation, **Lisogursk**i discloses that embodiments of its system include wearable device (“sensor 102” or “sensor 312”) which are placed, for example, on the ear of a patient. Lisogurski, 4:6-20, 10:44-46, 17:30-36. As I discussed above (Section IX.A.1), Lisogurski Figure 3 is an exemplary application of **Lisogurski** Figure 1 and “one or more components of physiological monitoring system 310 [of FIG. 3] may include one or more components of physiological monitoring system 100 of FIG. 1.” Lisogurski, 17:30-35. Thus, **Lisogurski’s** “sensor 102” could be implemented as “sensor 312,” and vice versa, and can both be worn on a patient.

d. Element [7.c]

123. Element [7.c] recites: "**the wearable device including a light source comprising a plurality of semiconductor diodes that are configured to generate an output optical light having one or more optical wavelengths, wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers.**" This element is met by **Lisogurski**.

124. Regarding a substantially identical limitation in the prior '533 IPR reciting "**including a light source comprising a plurality of semiconductor sources that are** light emitting diodes, the light emitting diodes **configured to generate an output optical beam** with **one or more optical wavelengths, wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers**," I understand that the Board determined that the "[p]etitioner demonstrate[d] how Lisogurski's sensor 102/312 meets this limitation," and that **Lisogurski's** "[s]ensor 102/312 can contain multiple LEDs that emit and direct light toward a subject's tissue, including an LED that emits red light, and an LED that emits infrared light having a wavelength between 800 and 1000 nm." '533-FWD, 25-26. A person of ordinary skill in the art would have understood that IR light with 800 nm to 1000 nm of wavelength falls within the near-infrared region, and this is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by

reference as if fully set forth herein. ’533-Anthony, ¶¶92-94 (citing Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-64, 17:37-45, 19:25-31, Figs. 1 & 3).

125. Regarding a substantially identical limitation in the prior ’484 IPR reciting “**including a light source comprising a plurality of semiconductor sources that are** light emitting diodes, each of the light emitting diodes **configured to generate an output optical light having one or more optical wavelengths**,” I understand that the Board determined that the petitioner demonstrated that **Lisogurski** disclosed “a plurality of LED light sources generating photonic signals having one or more wavelengths configured to direct light into a subject’s tissue.” ’484-FWD, 23, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶98-101 (citing Lisogurski, 4:42-45, 7:38-8:3, 10:48-52, 10:56-64, 17:37-45, 19:25-31, Figs. 1 & 3).

126. ’790 patent element [7.c] is substantially identical to the corresponding limitation in the ’533 patent on which I previously opined, which recites: “**including a light source comprising a plurality of semiconductor sources that are** light emitting diodes, the light emitting diodes **configured to generate an output optical beam** with **one or more optical wavelengths, wherein at least a portion of the one or more optical wavelengths is a near-infrared wavelength between 700 nanometers and 2500 nanometers**.” Aside from differing turns of phrases, the

main differences between the two limitations are (i) the ’533 patent’s additional use of “semiconductor sources that are light emitting diodes” (as opposed to the ’790 patent’s use of “semiconductor sources”) and (ii) that “each of the light emitting diodes is configured to generate an output optical light” (as opposed to the ’790 patent’s use of “semiconductor sources that are configured to generate an output optical light”). However, these differences are immaterial because a person of ordinary skill in the art would have understood that the term “semiconductor sources” encompasses “light emitting diodes,” as LEDs are well-known types of semiconductor sources as shown in U.S. Patent No. 8,079,735, which I understand has been designated as Exhibit 1039. *E.g.*, Ex. 1039, 2:6-9 (“The LED is a semiconductor diode that emits incoherent narrow-spectrum light….”). These differences between these claim limitations do not change my analysis. Thus, my opinions regarding the ’533 patent term apply equally to ’790 patent element [7.c]. ’533-Anthony, ¶¶92-94.

127. Similarly, ’790 patent element [7.c] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, which recites: “**including a light source comprising a plurality of semiconductor sources that are** light emitting diodes, each of the light emitting diodes **configured to generate an output optical light having one or more optical wavelengths**.” The only differences between the two limitations are (i) the ’484 patent’s additional

use of "semiconductor sources that are light emitting diodes" (as opposed to the '790 patent's use of "semiconductor sources") and (ii) that "each of the light emitting diodes is configured to generate an output optical light" (as opposed to the '790 patent's use of "semiconductor sources that are configured to generate an output optical light"). However, these differences are immaterial because a person of ordinary skill in the art would have understood that the term "semiconductor sources" encompasses "light emitting diodes," as LEDs are well-known types of semiconductor sources. *E.g.*, Ex. 1039, 2:6-9 ("The LED is a semiconductor diode that emits incoherent narrow-spectrum light…."). These differences between these claim limitations do not change my analysis. Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.c]. '484-Anthony, ¶¶98-101. As further support for this limitation, **Lisogurski** discloses that its "light source 130 may include a Red light emitting light source and an IR light emitting light source, e.g., Red and IR light emitting diodes (LEDs), for emitting light into the tissue of a subject to generate physiological signals." Lisogurski, 10:52-56.

e. Element [7.d]

128. Element [7.d] recites: "**the wearable device comprising one or more lenses configured to receive at least a portion of the output optical light and to deliver a lens output light to tissue comprising skin.**" This element is met by **Lisogurski**.

129. Regarding a substantially identical limitation in the prior ’533 IPR reciting “**the wearable** measurement **device comprising** a plurality of **lenses configured to receive a portion of the output optical** beam **and to deliver** an analysis output beam to a sample,” I understand the Board determined that “[p]etitioner demonstrate[d] how Lisogurski’s wireless sensor 102/312, when combined with the knowledge of a person of ordinary skill in the art … meets this limitation,” and that (1) “a person skilled in the art would have known that LEDs are often covered by lensing encapsulants, and would have selected such LEDs for wireless sensor 102/312 in order to ‘direct more of the light produced by the LED outward toward the tissue,’ thereby improving the efficiency of wireless, battery-powered, sensor 102/312’”; and (2) “a person skilled in the art, knowing ‘a lens is a “basic building block” of an optical sensor,’ would have included lenses in Lisogurski’s wireless sensor 102/312.” ’533-FWD, 35-36. This is consistent with my opinions regarding this ’533 limitation provided in my Prior ’533 Declaration, which I incorporate by reference as if fully set forth herein. ’533-Anthony, ¶¶123-129 (citing Lisogurski, 7:38-8:3, 10:53-56; Ex. 1037, 97-98, 191-99, 266-67; Ex. 1038, 765).

130. Regarding a substantially identical limitation in the prior ’484 IPR reciting “**the wearable device comprising one or more lenses configured to receive** a portion of at least one **of the output optical lights and to** direct **a lens**

output light to tissue," I understand the Board determined that the petitioner demonstrated that "a person of ordinary skill would have understood that glass encapsulating LEDs serves as a lens, i.e., a basic building block of an optical sensor, to receive the LED's light and transmit that light to a particular location…." '484-FWD, 23-24, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶102-109 (citing Lisogurski, 7:38-8:3,10:53-56; Ex. 1037, 97-98, 191-99, 266-67; Ex. 1038, 765).

131. '790 patent element [7.d] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: "**the wearable** measurement **device comprising** a plurality of **lenses configured to receive a portion of the output optical** beam **and to deliver** an analysis output beam to a sample."

132. Aside from differing turns of phrases, the main differences between the two limitations are: (i) the '533 patent's use of "the wearable <u>measurement</u> device" as opposed to the '790 patent's use of "the wearable device," (ii) the '533 patent's use of "output optical <u>beam</u>" or "output <u>beam</u>" as opposed to the '790 patent's use of "output optical <u>light</u>" or "output <u>light</u>," (iii) the '533 patent's use of "to deliver an <u>analysis</u> output" as opposed to the '790 patent's use of "to deliver a <u>lens</u> output, and (iv) the '533 patent's use of "to deliver … to <u>a sample</u>" as opposed to the '790

patent's use of "deliver … to tissue comprising skin."

133. **First**, as I discussed above regarding claim element [7.a] (Section IX.A.3.b.[7.a]), a person of ordinary skill in the art would have understood that a wearable device used to measure physiological parameters—like **Lisogurski's** wearable device—is itself, a wearable measurement device. *See, e.g.*, Lisogurski, 37:2-5 (describing that its "system may detect the physiological condition using information obtained through measurements"). **Second**, a person of ordinary skill in the art would have understood that the '533 patent's use of "optical beam" describes the general propagation (radiation-pattern or directional-shape) of light, as does the '790 patent's use of "optical light." **Third**, a person of ordinary skill in the art would have understood that in the context of the '533 patent claims the term "an analysis output" refers to the light that is received by the lenses and then directed by the lens to another component or location and that '790 patent recitation of "a lens output" refers to the same such light. *See* '533 patent, 4:54-58, 5:15-18 ("…a[n] … apparatus [comprising a plurality of lenses is] configured to receive a received portion of the output optical beam and to deliver to a sample an analysis output beam, ***which is a delivered portion of the output optical beam***") (emphasis my own). **Fourth**, a person of ordinary skill in the art would have understood that the term "sample" refers to specifically a tissue sample because the optical systems described in both the '790 and the '533 patents are used to interact with and collect data from

biological tissue in order to analyze physiological parameters. Section IX.A.3.b.[7.a]. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the ’533 patent term apply equally to ’790 patent element [7.d]. ’533-Anthony, ¶¶123-129.

134. ’790 patent element [7.d] is also substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, which recites: “**the wearable device comprising one or more lenses configured to receive** a portion of at least one **of the output optical lights and to** direct **a lens output light to tissue**.”

135. The main differences between the two limitations are: (i) the ’790 patent’s use of “receive <u>at least a portion</u> of the output optical light” as opposed to the ’484 patent’s use of “receive <u>a portion of at least one of</u> the output optical light<u>s</u>,” and (ii) the ’790 patent’s use of “<u>deliver</u> a lens output light to tissue” as opposed to the ’484 patent’s use of “<u>direct</u> a lens output light to tissue.” **First**, a person of ordinary skill in the art would have understood that both “receive at least a portion of the output optical light” and “receive a portion of at least one of the output optical lights” describe the same general operation of receiving some of the emitted light. **Second**, a person of ordinary skill in the art would have understood that a lens’ delivering and directing light refer to the same operation of receiving and guiding the received light towards the tissue in a controlled manner. Thus, the differences

between the two terms do not change my analysis, and my opinions regarding the ’484 patent term apply equally to ’790 patent element [7.d]. ’484-Anthony, ¶¶102-109.

136. Accordingly, for the reasons discuss above, **Lisogurski** discloses “**the wearable device comprising one or more lenses configured to receive at least a portion of the output optical light and to deliver a lens output light to a tissue**,” and, **Lisogurski** also discloses that the **tissue** is **tissue comprising skin** (*e.g.*, “fingertip, toe, forehead, forehead, or earlobe, or…a foot”). As explained above regarding claim element [7.b] (Section IX.A.3.c.[7.b]), **Lisogurski** discloses a wearable device, specifically, that its “light sensor [ ] is placed at a site on a patient, typically a fingertip, toe, forehead or earlobe, or in the case of a neonate, across a foot.” Lisogurski, 4:6-11. **Lisogurski** further teaches that its sensor uses a light source that generates and “pass[es] light through blood perfused tissue and photoelectrically sense[s] the absorption of the light in the tissue.” Lisogurski, 4:6-11. **Lisogurski** also discloses that its device detects the amount of light reflected or transmitted after the light has passed through a subject’s tissue. Lisogurski, 10:48-56 (describing “emitting light into the tissue of a subject to generate physiological signals”), 11:13-25 (stating that “light may enter detector 140 after passing through the subject’s tissue”), 12:9-22 (teaching that “red light may be absorbed and scattered more than IR light when passing through perfused tissue at

certain oxygen saturations"), 17:37-42 (describing "detecting the light that is reflected by or has traveled through the subject's tissue"), 19:48-50 (describing attenuation of light because of tissue), 22:58-60 (describing how "light intensity signal … is indictive of more received light, or less blood in the sampled tissue"), 26:34-36 (describing that "attenuation of the light may depend on the wavelength of the light and the tissue with which the light interacts"). A person or ordinary skill in the art would have understood that **Lisogurski's** multiple repeated references to "tissue" specifically includes skin. For example, **Lisogurski** discloses "[r]ed and IR light emitting diodes (LEDs), for emitting light into the tissue of a subject to generate physiological signals," and explains that the emitted light enters the user's tissue by first passing through the skin, and that the intensity of the reflected light depends on the amount of light attenuated which varies based on skin pigmentation: "red waveforms may be 25% of the intensity of the IR waveforms, as may occur in patients with dark ***skin*** pigmentation." Lisogurski, 10:52-56, 44:43-45 (emphasis my own). Thus, and from **Lisogurski's** multiple, repeated references to tissue and specific reference to skin, a person of ordinary skill in the art would have understood that **Lisogurski** discloses tissue comprising skin. Such understanding is fully consistent with explicit teachings, and common technical knowledge at the relevant time.

f. Element [7.e]

137. Element [7.e] recites: "**the wearable device further comprising a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio.**" This element is met by **Lisogurski**.

138. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated "Lisogurski [] disclos[es] the recited detection system in the form of a sensor with one or more detectors connected to front-end processing circuitry that may receive a detection signal, i.e., light that is reflected by or has traveled through the subject's tissue, from detector 140, and provides processed signals, i.e., electrical signals based on the intensity of the reflected light, to back-end circuitry 170," and (2) "the processed signals originate from detection signals that have a signal-to-noise ratio." '484-FWD, 23-24, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶115-117 (citing Lisogurski, 11:9-10, 11:14-17, 11:20-27, 12:42-45, 14:49-50, 17:40-42, Figs. 1 & 3). Indeed, a person of ordinary skill in the art would have understood that the described front-end processing circuitry integrated with optical detectors in a physiological monitoring system represents standard and well-known industry practice. Such circuitry was commonly used for

receiving and processing optical signals captured from patient tissue.

139. Regarding a substantially identical limitation in the prior ’533 IPR reciting “**the wearable** measurement **device further comprising a** receiver **configured to receive** and process **at least a portion of the** analysis output beam **reflected** or transmitted **from the** sample **and to generate an output signal**,” I understand the Board determined that, regarding “[p]etitioner’s proposed modification of sensor 102 to include front end processing circuitry 150 from monitor 104,” that “[p]etitioner demonstrate[d] why a person skilled in the art would have modified Lisogurski’s wireless sensor 102/312 to include front end processing circuitry 150,” and that a person of skill in the art would have done so because of “Lisogurski’s express suggestion, the industry trend to make wireless sensors for remote healthcare and personal fitness tracking, and the need to convert ‘the analog signal output from the detector … to digital form for wireless transmission. … in the sensor where the signal is captured.’” ’533-FWD, 37-38. Moreover, I understand that the Board determined that “[p]etitioner demonstrates how Lisogurski’s receiver (i.e., detector 140/318 and front end processing circuitry 150) meets the ‘receiver’ limitations,” and that (1) “receiver receives and processes the output beam because it includes detector 140/318, which ‘detect[s] the light that is reflected by or has traveled through the subject’s tissue’ and ‘convert[s] the intensity of the received light into an electrical signal’”; and (2) “[t]he receiver generates an output signal

because front end processing circuitry 150 'receive[s] a detection signal from detector 140 and provide[s] one or more processed signals to back end processing circuitry 170.'" '533-FWD, 38-39. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶136-146 (citing Lisogurski, 2:1-2, 11:9-10, 11:14-17, 11:20-27, 11:41-46, 12:42-44, 13:6-60, 16:2-9, 16:58-62, 17:40-42, 17:55-59, 18:16-31, 19:17-19, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Figs. 1 & 3).

140. **Lisogurski's** detectors and the front-end processing circuitry, each depicted in the annotated Figure 1 below, are collectively the claimed "detection system." **Lisogurski** discloses "[o]ne or more detector 318… for detecting the light that is reflected by or has traveled through the subject's tissue." '533-Anthony, ¶136.

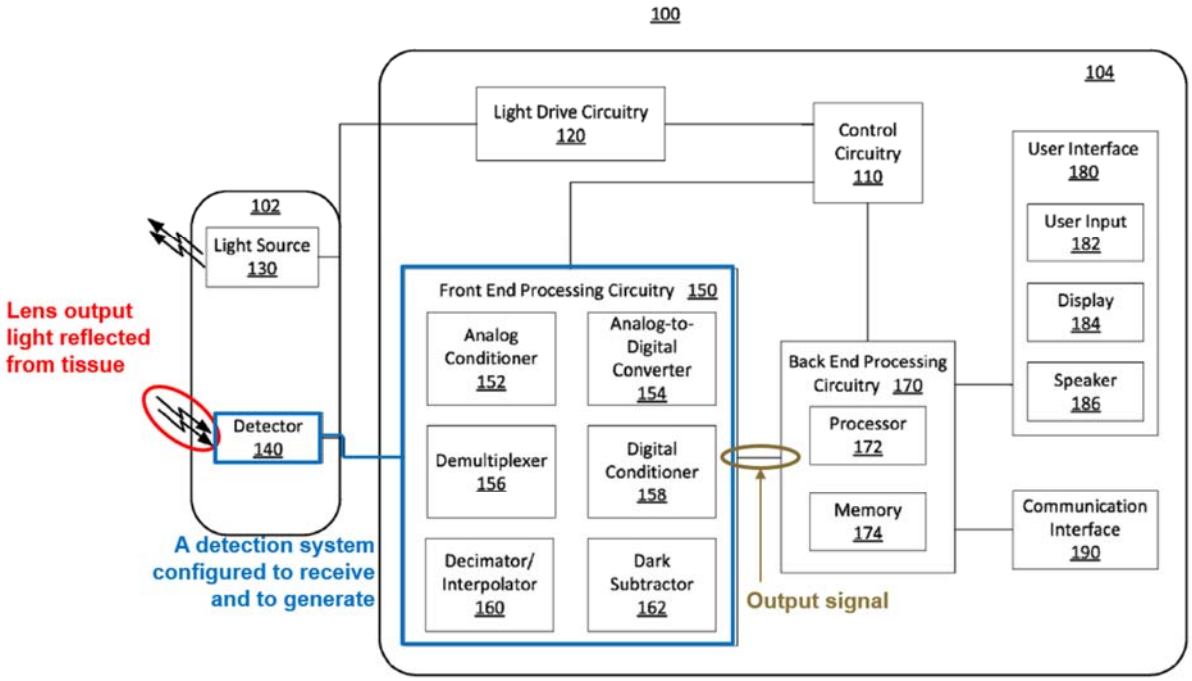


FIG. 1

Lisogurski, Figure 1; '533-Anthony, ¶138.

141. '790 patent element [7.e] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**the wearable device further comprising a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio**." Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.e]. '484-Anthony, ¶¶115-117.

142. '790 patent element [7.e] is substantially also identical to the corresponding limitation in the '533 patent on which I previously opined, which

recites: "**the wearable** measurement **device further comprising a** receiver **configured to receive** and process **at least a portion of the** analysis output beam **reflected** or transmitted **from the** sample **and to generate an output signal**." Aside from differing turns of phrases, the main differences between the two limitations are as listed, and each is immaterial to my analysis: (i) the '533 patent's use of "wearable measurement device" as opposed to the '790 patent's use of "wearable device"; (ii) the '533 patent's use of "comprising a receiver configured to receive and process" as opposed to the '790 patent's "comprising a detection system configured to receive; (iii) the '533 patent's use of "at least a portion of the analysis output beam" as opposed to the '790 patent's use of "at least a portion of the lens output light"; and (iv) the '533 patent's additional use of "reflected or transmitted" as opposed to the '790 patent's use of "reflected."

143. **First**, as I explained above regarding claim element [7.a] (Section IX.A.3.b.[7.a]), a person of ordinary skill in the art would have understood that a wearable device used to measure physiological parameters—like **Lisogurski's** wearable device—is itself, a wearable measurement device. **Second**, a person of ordinary skill in the art would have understood that the terms "receiver" and "detection system" refer to components configured to perform at least the same functionality: receiving optical signals or light. Further, a person of ordinary skill in the art would have understood that the "detection system" of '790 patent

element [7.e], just like "receiver" in the '533 patent, is used to "process" the "portion of the lens output light" as it "generate[s] an output signal" based on this light. **Third**, as I noted above, a person of ordinary skill in the art would have understood that a "beam" is one term to describe the general propagation (radiation-pattern or directional-shape) of light and that the claim terms "analysis output" and "lens output" refer to the light that is received by the lenses. **Fourth**, a person of ordinary skill in the art would have understood that light that is received by a tissue or a sample can undergo both reflection and transmission—standard aspects of optical interactions with biological tissue. Thus, the inclusion of the term "or transmitted" in the '533 patent merely expands upon an aspect of the same optical interaction already covered by the '790 patent's reference to "reflected" light. A person of ordinary skill in the art would have recognized that the identified wording differences between the '790 and '533 patent limitations do not represent substantial technical distinctions. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '790 patent element [7.e]. '533-Anthony, ¶¶136-146.

g. Element [7.f]

144. Element [7.f] recites: "**wherein the detection system is configured to be synchronized to the light source**." This element is met by **Lisogurski**.

145. Regarding an identical limitation in the prior '484 IPR, I understand the

Board determined that the petitioner demonstrated that "Lisogurski [] disclos[es] front end processing circuitry 150 operating synchronously with light drive circuitry 120, e.g., by synchronizing the sampling rate of an analog to digital converter to a modulated LED firing rate to provide, e.g., one or more samples to be averaged per period." '484-FWD, 24-27. Further, in the prior '484 IPR, I understand that the Board agreed with the petitioner's argument that "[although] Lisogurski depicts front end processing circuitry 104 as separate from wearable sensor 102, … incorporating the front end processing circuitry into the same device with the detector would have been consistent with Lisogurski's teaching that the functionality of some components of monitor 104 can be divided over multiple components and is an obvious modification to a person of ordinary skill." '484-FWD, 24-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶118-127 (citing Lisogurski, 2:1-2, 11:20-27, 11:41-46, 16:2-9, 16:67-17:2, 17:55-59, 18:16-31, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Fig. 1).

146. Regarding a substantially identical limitation in the prior '533 IPR reciting "**wherein the** receiver **is configured to be synchronized to the light source**," I understand the Board determined that "[p]etitioner demonstrate[d] how Lisogurski's receiver (i.e., detector 140/318 and front end processing circuitry 150) meets the 'receiver' limitations," and that **Lisogurski's** receiver is "synchronized to

the light source's pulses of light because the 'front end processing circuitry may use the timing control signals to operate synchronously with light drive circuitry 120,' i.e., the circuitry that drives **Lisogurski's** LED-based light source." '533-FWD, 37-39. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶136-146 (citing Lisogurski, 2:1-2, 11:9-10, 11:14-17, 11:20-27, 11:41-46, 12:42-44, 13:6-60, 16:2-9, 16:58-62, 17:40-42, 17:55-59, 18:16-31, 19:17-19, 27:44-52, 33:47-49, 35:17-19, 35:27-31, Figs. 1 & 3), 171.

147. '790 patent element [7.f] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**wherein the detection system is configured to be synchronized to the light source**." Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.f]. '484-Anthony, ¶¶118-127.

148. '790 patent element [7.f] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: "**wherein the** receiver **is configured to be synchronized to the light source**." The main difference between the two limitations is the '790 patent's use of "<u>receiver</u>" as opposed to the '484 patent's use of "<u>detection system</u>." As I discuss above regarding claim limitation [7.e] (Section IX.A.3.f.[7.e]), a person having ordinary skill in the art would have understood that the terms "receiver" and "detection system" refer to

components configured to perform at least the same functionality: receiving optical signals or light and processing the same. Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '790 patent element [7.f]. '533-Anthony, ¶¶136-146, 171.

149. As further support for this limitation, **Lisogurski** discloses that its system includes "light drive circuitry 120 [] configured to generate a light drive signal that is provided to light source 130 of sensor 102," and that the "light drive signal may…control the intensity of light source 130 and the timing of when light source 130 is turned on and off." Lisogurski, 11:50-54. To this end, **Lisogurski** teaches that the drive cycle of the light source includes a sequence of "on" and "off" portion to implement a dark subtraction technique, which removes background noise caused by ambient light or sensor-generated artifacts. Lisogurski, 6:16-19, 16:48-54, 16:66-17:2. This technique entails generating two signals. Lisogurski, 6:16-19, 16:48-54. The first signal generated during the "off" ("dark") portion, which captures the contribution of ambient light, noise, or dark current. Lisogurski, 6:16-19, 16:48-54. The second signal is generated during the "on" period, which includes the signal and the (non-signal or noise) contribution from ambient light, noise, and dark current. Lisogurski, 6:16-19, 16:48-54. The signal from the "off" phase is then subtracted from the signal from the "on" phase. Lisogurski, 6:16-19, 16:48-54. Thus, a person of ordinary skill in the art would have understood that

Lisogurski's detection system would have to be synchronized to the turning on/off of the light source in order to generate separate "on" and "off" signals to subtract. A person of ordinary skill in the art would further have understood from **Lisogurski's** explicit disclosures and widely recognized standard industry practices that synchronization between the detection system and the timing of the optical source would ensure accurate separation of physiological signals from background noise and artifacts.

150. As I discussed above, a person of ordinary skill in the art would have been motivated to combine the front end processing circuitry 150, which includes analog to digital converter (Lisogurski, 13:7-12), into **Lisogurski's** detection system and would have been further motivated to put light drive circuitry 150 into **Lisogurski's** LED-based light source (Section IX.A.2), such that the detection system (i.e., including front end processing circuitry 150 and analog to digital converter) is synchronized to the light source (i.e., including the light drive circuitry). Such integration would ensure that the detection system, comprising the front-end processing circuitry 150 and associated analog-to-digital converter, is precisely and reliably synchronized with the operation of the light source, including the timing signals provided by the integrated light drive circuitry. Consequently, this combined integration would enable effective synchronization, directly improving signal fidelity, reducing noise, minimizing latency, and enhancing overall

measurement accuracy and reliability.

151. I understand that Defendants identified this limitation—**"wherein the detection system is configured to be synchronized to the light source**"—as potentially indefinite in the Texas Case. Ex. 1023, 243-244.

152. Regardless of its outer bounds (e.g., extent of synchronization), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the limitation. For example, embodiments of the '790 patent describe a lock-in technique for "detecting at the same frequency as the pulsed light source and also possibly phase locked to the same signal," and a person of ordinary skill in the art would have understood that the limitation [7.f] at least includes such embodiments. *See, e.g.*, '790 patent, 44:19-23.

153. Consistent with that embodiment, **Lisogurski** discloses that "front end processing circuitry 150 may…operate synchronously with light drive circuitry 120. For example, front end processing circuitry 150 may synchronize the operation of an analog-to-digital converter and a demultiplexer with the light drive signal based on the timing control signals." Lisogurski, 11:41-46.

h. Element [7.g]

154. Element [7.g] recites: "**wherein the detection system comprises a plurality of detectors that are spatially separated from each other, and wherein**

at least one analog to digital converter is coupled to at least one of the plurality of detectors." This element is met by **Lisogurski**.

155. Regarding a substantially identical limitation in the prior '484 IPR reciting "**wherein the detection system comprises a plurality of** spatially separated detectors**, and wherein at least one analog to digital converter is coupled to at least one of the** spatially separated **detectors**," I understand the Board determined that the petitioner demonstrated that "Lisogurski [] disclos[es] … a plurality of multiple spaced detectors," and that "Lisogurski [] disclos[es] that signals generated by the detectors are passed to front end processing circuitry that includes an A/D converter." '484-FWD, 25-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶128-131 (citing Lisogurski, 11:9-10, 11:14-16, 11:20-22, 13:6-60, 17:40-42, 17:43-45, Figs. 1 & 3).

156. The detectors and the front-end processing circuitry, each depicted in the annotated Figure 1 below, are collectively the claimed "detection system." '484-Anthony, ¶130.

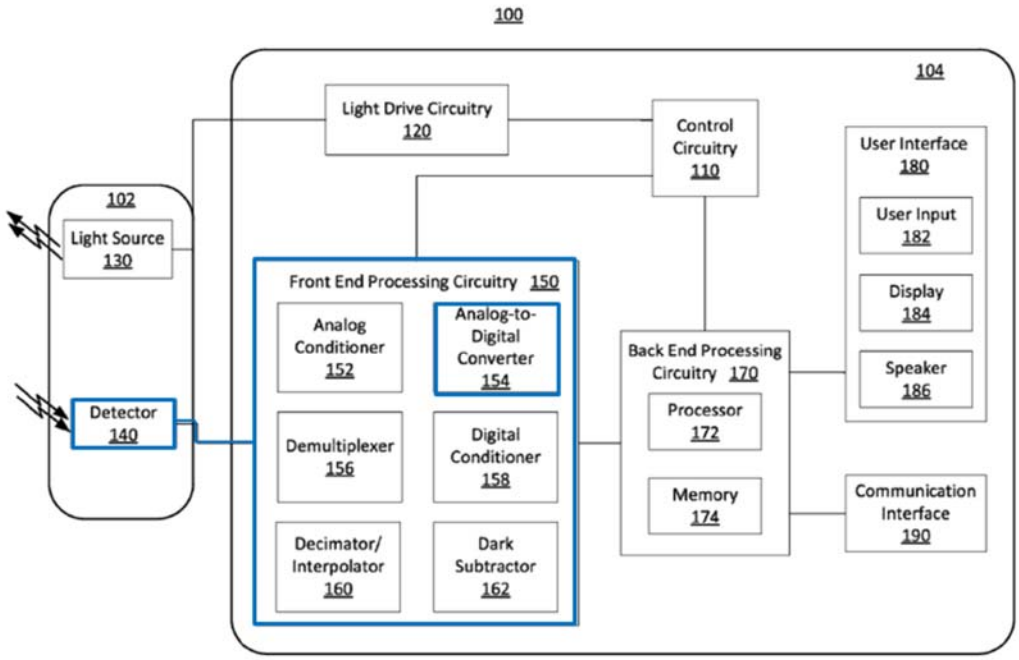


FIG. 1

Lisogurski, Figure 1; '484-Anthony, ¶131.

157. '790 patent element [7.g] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**wherein the detection system comprises a plurality of** spatially separated detectors**, and wherein at least one analog to digital converter is coupled to at least one of the** spatially separated **detectors**." Aside from differing turns of phrases ("detectors that are spatially separated from each other" versus "spatially separated detectors"), these terms are identical. Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.g]. '484-Anthony, ¶¶128-131.

158. I understand that Defendants identified a portion of this limitation—**"a plurality of detectors that are spatially separated from each other"**—as

potentially indefinite in the Texas Case. Ex. 1023, 243-244.

159. Regardless of its outer bounds (extent of spatial separation, e.g., right next to each other or with some intervening space), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. For example, embodiments of the ’790 depicted in Figure 18B show detectors 1854 and 1855 physically spaced apart from each other with at least some intervening space in a physiological monitoring device, and a person of ordinary skill in the art would have understood that the limitation [7.g] at least includes such embodiments:

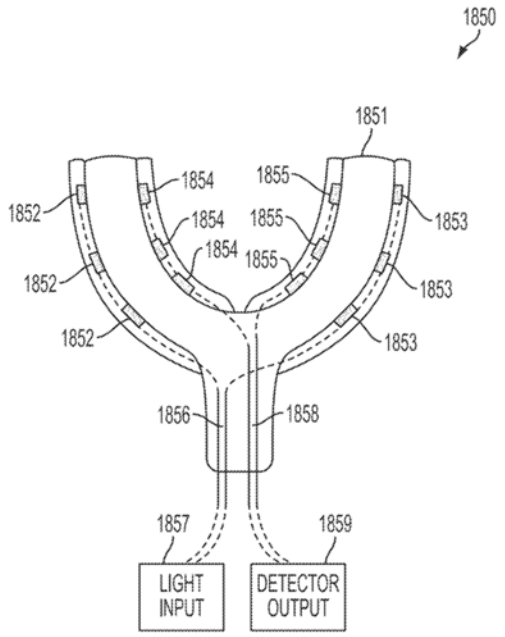


FIG. 18B

See, e.g., ’790 patent, 27:50-28:22.

160. Consistent with that embodiment, **Lisogurski** discloses that “[a]ny suitable configuration of light source 316 and detector 318 may be used,” and that “sensor unit 312 may include multiple light sources and detectors, which may be spaced apart.” Lisogurski, 17:42-45.

i. Element [7.h]

161. Element [7.h] recites: “**wherein the output signal is indicative of the one or more of the physiological parameters.**” This element is met by **Lisogurski**.

162. Regarding a substantially identical limitation in the prior ’484 IPR “**wherein the output signal is indicative of one or more of the physiological parameters**,” I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] that data, i.e., an output signal, transmitted to a server, monitor, or remote device may be stored or published, that MPPM 326 is configured to calculate physiological parameters[.]” ’484-FWD, 26-27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶148-154 (citing Lisogurski, 6:53-7:3, 8:45-9:11, 18:49-53, 20:8-13, 26:55-60).

163. ’790 patent element [7.h] is substantially identical to the corresponding limitation in the ’484 patent on which I previously opined, and which recites: “**wherein the output signal is indicative of one or more of the physiological**

parameters." Aside from differing turns of phrases ("indicative of the one or more of the … parameters" versus "indicative of one or more of the … parameters"), these terms are identical. Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.h]. '484-Anthony, ¶¶148-154.

164. As further support for this limitation, **Lisogurski** discloses measuring various physiological parameters such as pulsatile flow, oxygen saturation of hemoglobin, pulse rate, and blood pressure. Specifically, **Lisogurski** discloses that pulse oximeters may be placed on "any location on the body that has a strong pulsatile arterial flow" and may include multiple sensors placed at "multiple locations," including "the neck to monitor carotid artery pulsatile flow, the wrist to monitor radial artery pulsatile flow, the inside of a patient's thigh to monitor femoral artery pulsatile flow, the ankle to monitor tibial artery pulsatile flow, and around or in front of the ear." Lisogurski, 4:6-62. **Lisogurski** discloses said pulse oximeters, like its system, "measure and display various blood flow characteristics," such as "oxygen saturation of hemoglobin in arterial blood," "pulse rate," (including "when each individual pulse occurs"), and "blood pressure." Lisogurski, 3:66-4:5, 4:40-41; *see also* Lisogurski, 12:9-16 (discussing measuring oxygen saturation and other "physiological parameters").

165. As further support for this limitation, **Lisogurski** discloses that its monitor receives output signals ("physiological signals" or "data relating to light

emission and acoustic detections received from one ore more sensor units") from the detection system, as modified to include front end processing circuitry (Section IX.A.2), to determine physiological parameters. Specifically, **Lisogurski** discloses that a processor, e.g., "processor 172" "determine[s] one or more physiological parameters based on the received physiological signals" and a monitor, e.g., "[m]onitor 314," "calculate[s] physiological parameters based at least in part on data relating to light emission and acoustic detection[s] received from one ore more sensor units[,] such as sensor unit 312," those parameters include "pulse rate, blood pressure, blood oxygen saturation (e.g., arterial, venous, or both), hemoglobin concentration (e.g., oxygenated, deoxygenated, and/or total), any other suitable physiological parameters, or any combination thereof." Lisogurski, 17:59-67. **Lisogurski** further discloses that processor 172 "receive[s] and process[es] physiological signals received from front end processing circuitry 150," and "determine[s] one or more physiological parameters based on the received physiological signals." Lisogurski, 14:60-64. **Lisogurski's** processed data (*i.e.*, output signal) thus at least includes or is indicative of physiological parameters.

j. Element [7.i]

166. Element [7.i] recites: "**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of semiconductor diodes from an initial light intensity; and.**" This element is

met by **Lisogurski**.

167. Regarding a substantially identical limitation in the prior ’484 IPR reciting “**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of semiconductor** sources **from an initial light intensity**,” I understand the Board determined that the petitioner demonstrated that “Lisogurski [] disclos[es] that by increasing light intensity the system may increase the brightness of light sources in response to noise to improve signal to noise ratio.”; (2) “Lisogurski describes brightness (light intensity) as a parameter of the light drive signal, i.e., the signal that drives the LED.”; and (3) “Lisogurski states the system may use ‘drive cycle modulation,’ i.e., a relatively higher frequency modulation technique having a period on the order of 1.6 msec, to generate one or more wavelengths of intensity signals.” ’484-FWD, 27. This is consistent with my opinions regarding this ’484 limitation provided in my Prior ’484 Declaration, which I incorporate by reference as if fully set forth herein. ’484-Anthony, ¶¶155-171 (citing Lisogurski, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 6:26-31, 8:22-26, 9:46-52, 9:57-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 16:2-9, 17:21-29, 17:55-59, 18:16-31, 25:49-55, 31:11-24, 31:39-55, 35:5-9, 37:6-22).

168. Regarding a substantially identical limitation in the prior ’533 IPR reciting “the light source **configured to increase signal-to-noise ratio by increasing** a **light intensity** from **at least one of the plurality of semiconductor**

sources," I understand the Board determined that the "[p]etitioner demonstrate[d] how Lisogurski's LED-based light source 130/316 meets this limitation," and that "Lisogurski teaches 'the intensity of light source 130 and the timing of when light source 130 is turned on and off' is controlled by a light drive signal that 'increase[s] the brightness of the light sources in response to . . . noise to improve the signal-to-noise ratio.'" '533-FWD, 26. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶95-109 (citing Lisogurski, 1:19-21, 1:44-46, 1:67-2:3, 5:55-6:6, 6:26-31, 8:22-26, 9:46-52, 9:57-60, 10:48-49, 11:38-41, 11:50-54, 14:49-55, 16:2-9, 16:55-59, 17:21-29, 18:23-25, 25:52-55, 35:5-9, 37:6-22).

169. **Lisogurski's** Figure 1 (annotated below) depicts relevant circuitry—namely, the light source 130, light drive circuitry 120, and control circuitry 110, as modified to (Section IX.A.2) be placed within sensor 102—that work together to alter the light drive parameters of the semiconductor sources to increase the signal-to-noise ratio. '484-Anthony, ¶¶156 (citing Lisogurski, 9:46-52, 5:55-6:6), 166 (citing Lisogurski, 9:46-60).

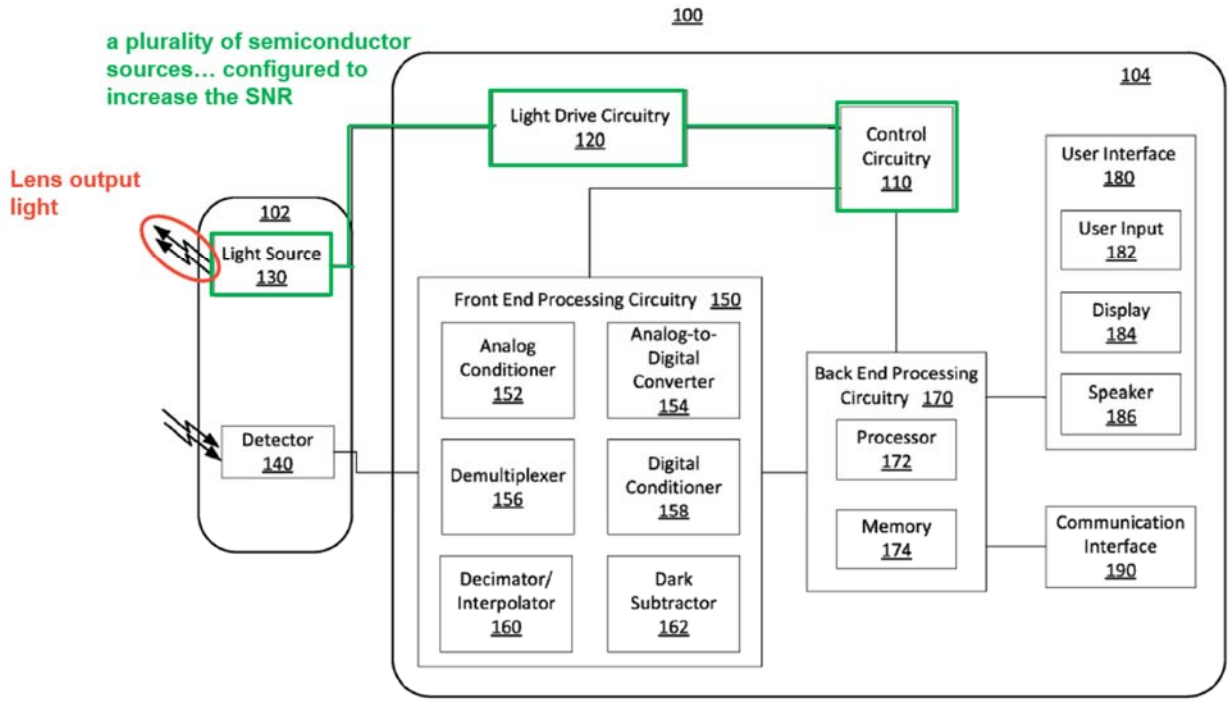


FIG. 1

Lisogurski, Fig. 1; '484-Anthony, ¶159.

170. '790 patent element [7.i] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: "**the wearable device configured to increase the signal-to-noise ratio by increasing light intensity of at least one of the plurality of semiconductor** sources **from an initial light intensity**." Aside from the differing turns of phrasing (e.g., the '790 patent adds "at least one of the …" as opposed to the '484 patent that uses "at least one of the <u>plurality of</u> …"), the only substantive difference between these two limitations is the '790 patent's use of "semiconductor diodes" as opposed to the '484's use of "semiconductor sources." A person of ordinary skill in the art would

have understood that light emitting diodes are semiconductor diodes. *E.g.*, Ex. 1039, 2:6-9 ("The LED is a semiconductor diode that emits incoherent narrow-spectrum light…."), Ex. 1040, 5:11-14 ("The ***semiconductor diode*** is the fundamental building block of solar cells, ***light-emitting diodes***, resonant tunneling diodes, semiconductor lasers, and other devices.") (emphasis my own). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '790 patent element [7.i]. '484-Anthony, ¶¶155-171.

171. '790 patent element [7.i] is substantially identical to the corresponding limitation in the '533 patent on which I previously opined, which recites: "the light source **configured to increase signal-to-noise ratio by increasing** a **light intensity** from **at least one of the plurality of semiconductor** sources." Aside from differing turns of phrases, the main differences between the two limitations are as listed, and each is immaterial to my analysis: (i) the '533 patent's use of "the <u>light source</u> configured to increase signal-to-noise ratio" as opposed to the '790 patent's use of "the <u>wearable device</u> configured to increase signal-to-noise ratio"; (ii) the '790 patent's addition of "<u>from an initial light intensity</u>"; and (iii) the '790 patent's use of "semiconductor <u>diodes</u>" as opposed to the '533 patent's use of "semiconductor <u>sources</u>." **First**, a person having ordinary skill in the art would have understood that **Lisogurski's** wearable device (see my discussion of limitation [7.b] reciting "the

wearable device adapted to be placed on a wrist of a user") includes a light source (see my discussion of limitation [7.c] reciting that the wearable device "includ[es] a light source") and because the timing and activation of this light source is controlled by drive signals generated by light drive circuitry 120 (*see* Lisogurski, 10:42-46, 11:28-31, 11:38-41), a person of ordinary skill would have recognized that the light source can be configured to increase the signal-to-noise ratio by adjusting those parameters. **Second**, a person having ordinary skill in the art would have understood that increasing a signal-to-noise ratio involves increasing it relative to an initial or baseline value. Said differently, there is an original or starting signal-to-noise ratio from which the increase occurs. **Third**, as I explained above, a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor diodes. *E.g.*, Ex. 1039, 2:6-9 ("The LED is a semiconductor diode that emits incoherent narrow-spectrum light…."), Ex. 1040 5:11-14 ("The ***semiconductor diode*** is the fundamental building block of solar cells, ***light-emitting diodes***, resonant tunneling diodes, semiconductor lasers, and other devices.") (emphasis my own). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '533 patent term apply equally to '790 patent element [7.i]. '533-Anthony, ¶¶95-109.

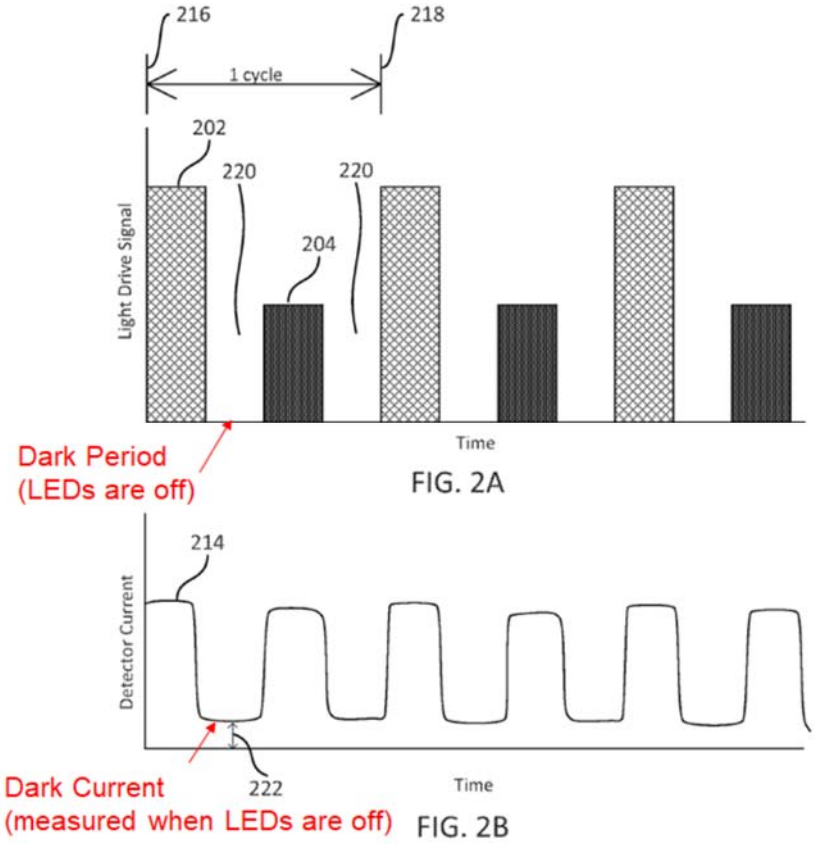
k. Element [7.j]

172. Element [7.j] recites: "**the detection system further configured to:**

generate a first signal responsive to light received while the semiconductor diodes are off." This element is met by **Lisogurski**.

173. Regarding a substantially identical limitation in the prior '484 IPR reciting "**the detection system further configured to: generate a first signal responsive to light received while** the light emitting diodes **are off**," I understand the Board determined that the petitioner had demonstrated that "Lisogurski[] disclos[es] the front end processing uses the current measured when the LEDs are off to generate a dark signal representative of ambient light." '484-FWD, 43-44. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶193-198 (citing Lisogurski, 6:7-19, 11:14-16, 12:59-13:6, 13:35-41, 13:60-14:10, 16:33-54, Figs. 2A & 2B).

174. Below I've annotated **Lisogurski's** Figures 2A and 2B to explain **Lisogurski's** dark subtraction technique, where **Lisogurski's** detectors and front end processing circuitry generate signals when the light source is off.



Lisogurski, Figs 2A & 2B; *see also* Lisogurski, 6:12-15, 11:14-16, 12:59-13:6, 13:35-41, 13:67-14:6; '484-Anthony, ¶196.

175. '790 patent element [7.j] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: "**the detection system further configured to: generate a first signal responsive to light received while** the light emitting diodes **are off**." The main difference between the two limitations is the '484 patent's use of "light emitting diodes" as opposed to the '790 patent's use of "semiconductor diodes." As I discussed regarding claim element [7.i] (Section IX.A.3.j.[7.i]), a person of ordinary skill in the art would have

understood that light emitting diodes are semiconductor diodes. *E.g.*, Ex. 1039, 2:6-9 ("The LED is a semiconductor diode that emits incoherent narrow-spectrum light…."); *see also* Ex. 1040, 5:11-14 ("The ***semiconductor diode*** is the fundamental building block of solar cells, ***light-emitting diodes***, resonant tunneling diodes, semiconductor lasers, and other devices."). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '790 patent element [7.j]. '484-Anthony, ¶¶193-198.

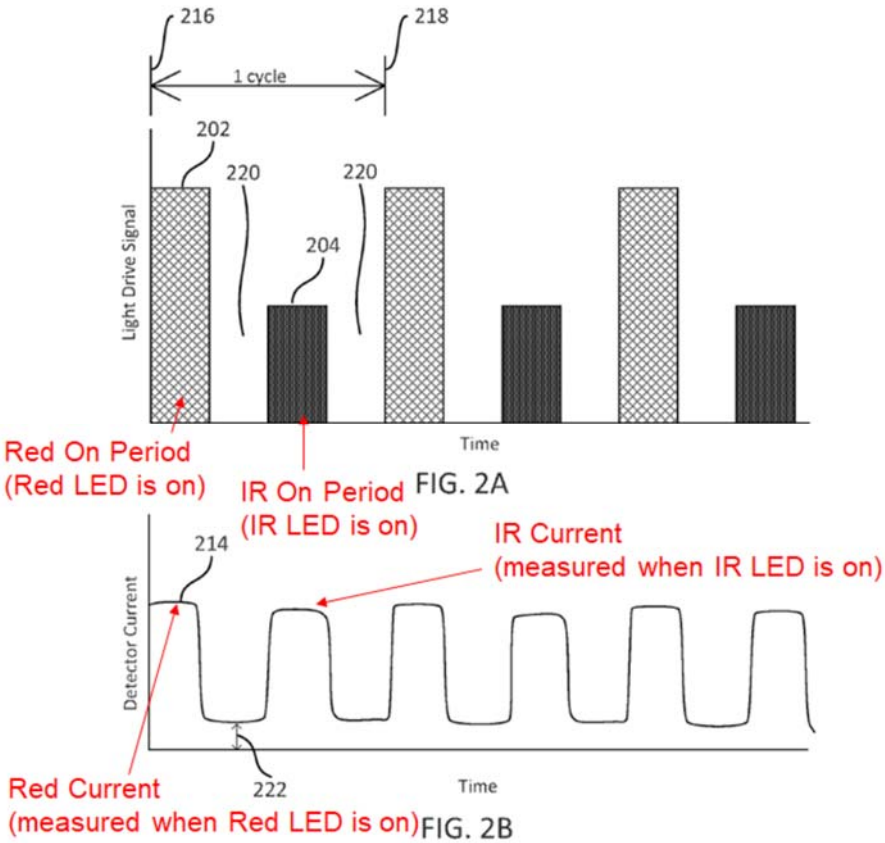
l. Element [7.k]

176. Element [7.k] recites: "**generate a second signal responsive to light received while at least one of the semiconductor diodes is on, and.**" This element is met by **Lisogurski**.

177. Regarding a substantially identical limitation in the prior '484 IPR reciting "**generate a second signal responsive to light received while at least one of the** light emitting diodes **is on**," I understand the Board determined that the petitioner demonstrated that "**Lisogurski** [] disclos[es] the front end processing circuitry measuring the signal when at least one LED is on to capture a portion of the optical beam, e.g., a red signal and an IR signal, reflected from the tissue." '484-FWD, 43-44. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶199-202 (citing Lisogurski, 6:12-19, 11:12-20,

12:52-13:6, 13:35-41, 13:67-14:2, 17:8-10, 17:40-42, Figs. 2A & 2B).

178. Below are **Lisogurski's** Figures 2A and 2B with annotations to illustrate **Lisogurski's** dark subtraction technique, where **Lisogurski's** detectors and front end processing circuitry generate signals when the light source is on:



Lisogurski, Figs 2A & 2B; *see also* Lisogurski, 6:12-15, 11:12-20, 13:35-41, 13:67-14:2, 17:8-10, 17:40-42; '484-Anthony, ¶202.

179. '790 patent element [7.k] is substantially identical to the corresponding limitation in the '484 patent on which I previously opined, which recites: "**generate a second signal responsive to light received while at least one of the** light emitting

diodes **is on**." The main difference between the two limitations are the '484 patent's use of "light emitting diodes" as opposed to the '790 patent's use of "semiconductor diodes." As I discussed above regarding claim element [7.i] (Section IX.A.3.j.[7.i]), a person of ordinary skill in the art would have understood that light emitting diodes are semiconductor diodes. *E.g.*, Ex. 1039, 2:6-9 ("The LED is a semiconductor diode that emits incoherent narrow-spectrum light…."); *see also* Ex. 1040, 5:11-14 ("The ***semiconductor diode*** is the fundamental building block of solar cells, ***light-emitting diodes***, resonant tunneling diodes, semiconductor lasers, and other devices."). Thus, the differences between the two terms do not change my analysis, and my opinions regarding the '484 patent term apply equally to '790 patent element [7.k]. '484-Anthony, ¶¶199-202.

m. Element [7.l]

180. Element [7.l] recites: "**increase the signal-to-noise ratio by comparing the first signal and the second signal; and.**" This element is met by **Lisogurski**.

181. Regarding an identical limitation in the prior '484 IPR, I understand the Board determined that the petitioner demonstrated that "Lisogurski [] disclos[es] a 'dark subtraction' technique that subtracts the dark signal from the red and IR signals to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio," and that "that Lisogurski describes ambient light as noise."

'484-FWD, 44. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶203-206 (citing Lisogurski, 11:43-46, 13:35-41, 13:60-14:10, 14:46-55, 16:51-54, 33:65-34:13).

182. '790 patent element [7.l] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**increase the signal-to-noise ratio by comparing the first signal and the second signal**." I understand that in the prior '484 IPR, the Board and petition stated that the corresponding '484 limitation recited "increase the signal-to-noise ratio by ***differencing*** the first and second signals." '484-FWD, 43; '484-Pet., 57. However, the '484 limitation at issue actually recites "increase the signal-to-noise ratio by ***comparing*** the first signal and the second signal," as recited in [7.l] of '790. *See* '484-FWD, 6 ('484 limitation 1(o)). This difference does not affect my analysis as a person of ordinary skill would have understood that differencing and comparing the first and signals would involve the same process—removing the effects of ambient light. Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.l]. '484-Anthony, ¶¶203-206.

183. I understand that Defendants identified portions of this limitation—**"increase the signal-to-noise ratio by comparing the first signal and the second signal**"—as potentially indefinite in the Texas Case. Ex. 1023, 243-244.

184. Regardless of its outer bounds (e.g., how comparing alone can increase the signal-to-noise ratio), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of this limitation. For example, embodiments of the '790 patent disclose achieving "higher signal-to-noise ratios" by, for example, "chang[ing] detection schemes" wherein "the detection system captures the signal with the light source on and with the light source off…. Then, the signal with and without the light source is differenced," which "may enable the sun light changes to be subtracted out." '790 patent, 58:24-45. A person of ordinary skill in the art would have understood that limitation [7.l] at least includes such embodiments.

185. Consistent with that embodiment, **Lisogurski** discloses "dark subtractor 162 may subtract dark values from the Red and IR components to generate adjusted Red and IR signals. For example, dark subtractor 162 may determine a subtraction amount from the dark signal portion of the detection signal and subtract it from the peak portion of the detection signal in order to reduce the effect of the dark signal on the peak." Lisogurski, 13:60-14:10, 16:51-54 ("The system may subtract the background or dark level from the levels received during red 'on' portion 286 and IR 'on' portion 290."). Lisogurski, 17:8-10. Therefore, **Lisogurski** discloses subtracting (e.g., differencing) two signal to improve signal-to-noise ratio.

n. Element [7.m]

186. Element [7.m] recites: "**wherein the wearable device is at least in part configured to identify an object**." This element is met by **Lisogurski**.

187. Regarding an identical limitation in the prior '484 IPR, I understand the Board found that "[a]s Lisogurski discloses a method of measuring oxygen saturation that uses different wavelengths to distinguish hemoglobin from oxygen carrying hemoglobin, i.e., oxyhemoglobin, Lisogurski teaches identifying an object, i.e., the blood constituent oxyhemoglobin." 484-RFWD, 4-7; Lisogurski, 4:36-62. In other words, **Lisogurski's** calculation and measurement of the amount of oxyhemoglobin exists in blood includes distinguishing and identifying the oxyhemoglobin blood constituent. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶220-222 (citing Lisogurski, 9:46-52, 24:41-57, 36:66-37:2, 37:8-14, 40:42-41:39).

188. '790 patent element [7.m] is identical to the corresponding limitation in the '484 patent on which I previously opined, and which recites: "**wherein the wearable device is at least in part configured to identify an object**." Thus, my opinions regarding the '484 patent term apply equally to '790 patent element [7.m]. '484-Anthony, ¶¶220-222.

189. I understand that Defendants identified this limitation as potentially

indefinite in the Texas Case. Ex. 1023, 243-244.

190. Regardless of its outer bounds (e.g., the extent of the identification that needs to take place), however, and without opining on whether it has adequate written description support, **Lisogurski** meets this term because **Lisogurski** discloses and renders obvious the indisputable scope of the term. For example, embodiments of the ’790 patent disclose that, “[v]arious signal processing methods may be used to identify and quantify the concentration of cholesterol 876 and/or glucose 877, or some of the other blood constituents.” ’790 patent, 21:3-6. A person of ordinary skill in the art would thus have understood that limitation [7.m] at least includes such embodiments contemplating identifying blood constituents.

191. Consistent with that embodiment, **Lisogurski** discloses a process for determining blood saturation stating “[t]he light intensity or the amount of light absorbed may then be used to calculate any of a number of physiological parameters, including an amount of a blood constituent (e.g., oxyhemoglobin) being measured as well as pulse rate and when each individual pulse occurs” such that a blood constituent could be identified and distinguished from others. Lisogurski, 4:36–62.

B. GROUND 2: Lisogurski in further view of Carlson (Claim 7):

1. Overview of Carlson

192. **Carlson** is directed to an “ear clip 1,” which is an “optical pulsoximetry [device] used for non-invasive measurement of pulsation and oxygen saturation in

arterial human or animal blood" designed to be worn on a user's ear. Carlson, [0002]; *see also* Carlson, [0049]. An example of the "ear clip 1" is depicted in Figure 2, which I've reproduced below. Carlson, [0033], Fig. 2.

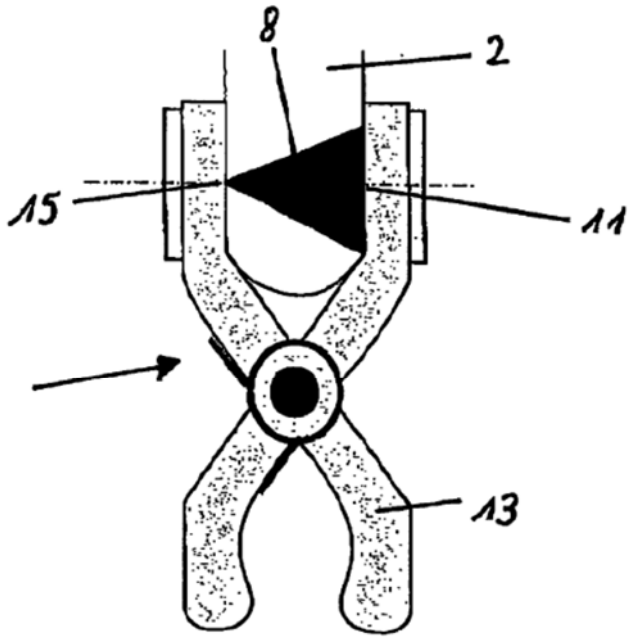


Figure 2

193. **Carlson** discloses that "ear clip 1" (also referred to in **Carlson** as "ear sensor 1"; *see* [0048]-[0049]) includes a "light source 15 which emits a light beam 8," and light beam 8 travels throughs the patient's earlobe 2 to "light receiver 11," which is a light detector that detects the transmitted light. Carlson, [0049]. Light source 15 emits light at two wavelengths, one at 660 nm, and the other "within the range of 800 to 1000 nm, which … in the present case [is] 890 nm." Carlson, [0050]. **Carlson** teaches that the configuration of light source 15 includes having "two light

emitting sources" (i.e., "two LEDs"). Carlson, [0050]. **Carlson** discloses the use various "optical … means," including lenses: "light is emitted from the two LEDs 15 and is shaped by the two beam shaping elements or lenses 21 to be guided as beams 12 through the earlobe 2." Carlson, [0062]. '533-FWD, 18-20.

194. **Carlson** teaches that patient mobility can cause "standard pulsoximeter sensors [to] suffer from signal instability and insufficient robustness versus environmental disturbances" including ambient light, such as sunlight, that influences the measurement of the pulsoximeter sensor. Carlson, [0004], [0068]. **Carlson** teaches that the "basic idea therefore is to use a beam-shaping element, such as e.g. diffractive or refractive lenses, to direct the emitted optical radiation of, e.g., the LED light source into the human or animal tissue and the photon detecting element in order to increase the optical signal power, detected by the pulsoximeter sensor, and thus increasing the Signal/Noise—and signal/Background ratio" by "a factor of 5." Carlson, [0014]. '533-FWD, 18-20.

2. Motivation to Combine

195. Like **Lisogurski**, **Carlson** is analogous art, in the same field as the '790 patent—including physiological monitoring—and is reasonably pertinent to the problems addressed by the '790 patent—e.g., improving optical physiological monitoring. '790, 8:34-9:3; Lisogurski, 1:10-11; Carlson, [0002], [0004], [0006]-[0008], [0010]. Similarly, both **Lisogurski** and **Carlson** identify similar

problems, including mitigating noise from ambient light and enhancing overall signal-to-noise performance, clearly demonstrating their direct relevance to the technological context of the ’790 patent. Lisogurski, 9:46-60, 14:40-55, 26:5-14; Carlson, [0054]. A person of ordinary skill in the art would have understood that both **Lisogurski** and **Carlson** are directly within the relevant technical field, addressing analogous problems and, therefore, are compatible. The explicit discussions in both references about mitigating similar technical challenges would have made their combination straightforward and logical from a person of ordinary skill in the art’s perspective.

196. With respect to **Carlson’s** lenses teachings, in the prior ’484 IPR, I understand that the Board found that “a person of ordinary skill would have had reason to employ lenses as taught by **Carlson** in **Lisogurski’s** sensor to focus light from the LED onto a person’s skin and in doing so, increase optical power and improve signal to noise ratio.” 484-FWD, 23, 26-27. This is consistent with my opinions in my Prior ’484 Declaration and my opinions herein. ’484-Anthony, ¶¶111-114.

197. With respect to **Carlson’s** lenses teachings, in the prior ’533 IPR, I understand that the Board agreed, determining that “a person skilled in the art would have incorporated Carlson’s lenses 21 into Lisogurski’s wireless sensor 102/312 to increase its optical signal power and signal-to-noise ratio without increasing its

actual power." '533-FWD, 37. This is consistent with my opinions in my Prior '533 Declaration and my opinions herein. '533-Anthony, ¶¶131-134.

198. With respect to **Carlson's** lenses teachings, a person of ordinary skill in the art would have applied **Carlson's** lens teaching to **Lisogurski's** sensor to focus the light emitted by the LEDs onto a user's skin to advantageously increase its signal-to-noise ratio without also having to increase the amount of power consumed by the device. '484-Anthony, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-Anthony, ¶133 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20). **Lisogurski** recognizes the importance of "improv[ing] the signal-to-noise ratio" of its system. Lisogurski, 9:50-52; *see also* Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20. Thus, a person of ordinary skill in the art would have looked to a reference like **Carlson** that discloses "us[ing] a beam-shaping element, such as e.g. diffractive or refractive lenses, to direct the emitted optical radiation of, e.g., the LED light source into the human or animal tissue and the photon detecting element in order to increase the optical signal power, detected by the pulsoximeter sensor, and thus increasing the Signal/Noise—and signal/Background ratio," by a factor of 5. Carlson, [0014]; *see also* Carlson [0010]. Accordingly, a person of ordinary skill in the art would have been motivated to include lenses, as disclosed in **Carlson**, to **Lisogurski's** system to further its own

goals of improving the signal-to-noise ratio of the measured optical signal. '484-Anthony, ¶112 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20); '533-Anthony, ¶133 (citing Carlson, [0010], [0014]; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20).

199. A person of ordinary skill in the art would have had a reasonable expectation of success in applying **Carlson's** lenses teaching to **Lisogurski's s**ystem. Both **Lisogurski** and **Carlson** teach optical physiological measurement systems utilizing LEDs as light sources, and using lenses to focus the light of LEDs was well-known in the art. For example, **Lisogurski** discloses an "optical physiological monitoring system" that uses "one or more light source 316 for emitting light at one or more wavelengths into a subject's tissue." Lisogurski, 1:10-11, 17:37-45; *see also* Lisogurski, 10:48-56. **Carlson** discloses "lenses[ ] to direct the emitted optical radiation of, e.g., the LED light source into the human … tissue." Carlson, [0014]; *see also* [0054]. These references demonstrate that lenses were routinely employed in optical systems to enhance the precision with which light is directed into biological tissue. The use of lenses for this purpose was well-understood and widely adopted in the field of optical physiological monitoring. Ex. 1038, 765. Accordingly, incorporating **Carlson's** lens teachings into **Lisogurski's** sensor would have been a predictable and straightforward combination of known elements within the art. *See also* '484-Anthony, ¶113; '533-Anthony,

¶134. Thus, a person of ordinary skill in the art would have known such a combination (yielding the claimed limitations) would predictably work and provide the expected functionality.

3. Invalidity of Claim 7 Over Lisogurski in view of Carlson

200. As I discuss below, Claim 7 is rendered obvious by **Lisogurski** in view of **Carlson**.

a. Element [7.d]

201. Element [7.d] (the "lenses"/"lens" limitation) is disclosed and rendered obvious by **Lisogurski**, for the reasons I discussed above in connection with '790 patent element [7.d] (Section IX.A.3.e).

202. To the extent additional disclosure is required for the "lens" limitations, **Carlson discloses the wearable device** (*e.g.*, "ear clip" "pulse oximetry" device) **comprising one or more lenses** (*e.g.*, "lenses 21") **configured to receive at least a portion of the output optical light and to deliver a lens output light to tissue** (*e.g.*, "light…is shaped by…lenses 21 to be guided as beams 12 through the earlobe 2").

203. Regarding the "lens limitations" in the prior '484 IPR reciting "**the wearable device comprising one or more lenses configured to receive a portion of** at least one of the **output optical** lights **and to** direct **a lens output light to tissue**," I understand that the Board determined that "a person of ordinary skill would

have had reason to employ lenses as taught by Carlson in Lisogurski's sensor to focus light from the LED onto a person's skin and in doing so, increase optical power and improve signal to noise ratio," and that "Carlson discloses … lenses and that … can be diffractive or refractive and direct the emitted optical radiation into human or animal tissue." '484-FWD, 23, 26-27. This is consistent with my opinions regarding this '484 limitation provided in my Prior '484 Declaration, which I incorporate by reference as if fully set forth herein. '484-Anthony, ¶¶110-114 (citing Carlson, [0010], [0013], [0014], [0024], [0054], [0062], Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038, 765).

204. Regarding the "lens limitations" in the prior '533 IPR reciting "**the wearable** measurement **device comprising** a plurality of **lenses configured to receive a portion of the output optical** beam **and to deliver** an analysis output beam to a sample," I understand that the Board determined "[p]etitioner demonstrate[d] that a person skilled in the art would have included lenses in Lisogurski's wireless sensor 102/312 because Carlson teaches the advantages of doing so," and that "Carlson teaches lenses 21 'increase the optical signal power without increasing the actual power used by the system,' thereby 'increasing the Signal/Noise . . . ratio.'" '533-FWD, 36-37. This is consistent with my opinions regarding this '533 limitation provided in my Prior '533 Declaration, which I incorporate by reference as if fully set forth herein. '533-Anthony, ¶¶130-135 (citing

Carlson, [0010], [0013], [0014], [0024], [0054], [0062], Fig. 4; Lisogurski, 6:3-6, 9:49-60, 13:60-14:10, 14:40-55, 37:6-20; Ex. 1038, 765). A person of ordinary skill in the art would have understood that the motivation to incorporate lenses into a wearable sensor device (e.g. to focus emitted optical radiation into human tissue to increase optical power, enhance signal-to-noise ratio, and improve measurement reliability, etc.) is clearly taught by **Carlson**, aligned with well-established industry practice, and supported by **Lisogurski**.

205. For the reasons I discuss above regarding claim element [7.d], the "lens" limitation is substantially identical to the '484 and '533 patent limitations on which I previously opined and my opinions regarding the '484 and '533 patent terms apply equally to the "lens" limitations (Section IX.A.3.e.[7.d]).

206. As further support for this limitation, **Carlson** discloses that, for its system for "measurement of pulsation and oxygen saturation in arterial human or animal blood," it is particularly important to "increas[e] the technical performance of pulsoximetry in terms of quality and robustness of the measurement signal versus environmental disturbances and energy consumption." Carlson, [0002]. Moreover, and consistent with the noted importance of increasing technical performance, **Carlson** includes Figure 4 to show "schematically two light emitting sources for an oximetric sensor including beam shaping optics." Carlson, [0035]; *see also* Carlson, Fig. 4.

207. For the reasons I discuss in Section IX.B.2, a person of ordinary skill in the art would have been motivated to apply **Carlson's** lens teachings to **Lisogurski** to increase optical signal power and signal-to-noise ratio without increasing the system's power consumption.

X. SECONDARY CONSIDERATIONS

208. I have found no evidence in either the '790 patent's prosecution history or elsewhere that supports any secondary considerations arguments, or evidence of nexus to the Challenged Claim. *See generally* '790FH. Indeed, as I have discussed in connection to the prior art referenced herein, any purported solutions to problems or unexpected results in the '790 patent were already well-known in the art.

209. To the extent the Patent Owner asserts the existence of any additional secondary considerations in its responses, or presents any additional evidence or arguments, I reserve my right to address any such evidence.

XI. CONCLUSION

210. In summary, I have concluded that the Challenged Claim is rendered obvious over the prior art references as I discussed above. Specifically, in my opinion, for at least the reasons above, the Challenged Claim of the '790 patent is obvious.

211. To the extent it is argued that any further disclosure is required for an element in the Challenged Claim that I have identified as being disclosed, a person

of ordinary skill in the art would certainly have found that element obvious to include based on the sample explicit disclosure or inherent disclosures and analysis I have identified above.

212. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to take into account new information as it becomes available to me.

213. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

APPENDIX A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: November 20, 2024 Name: Brian W. Anthony

Department: Mechanical Engineering / Institute of Medical Engineering and Science

1. Date of Birth: July 1972
2. Citizenship: USA
3. Education:

School	Degree	Date
Carnegie Mellon University	BS	1994
MIT	SM	1998
MIT	PhD	2006

4. Title of Thesis for Most Advanced Degree:
   Video Based System Monitoring

5. Principal Fields of Interest:
   Biomedical Imaging, Ambient and Wearable Instruments and Sensors, Computational Instrumentation, Optics, Applied ML and AI, Device Design and Manufacturing, Innovation and Product Realization, Imaging.

6. Name and Rank of Other Department Faculty in the Same Field:
   Harry Asada, Professor
   Ian Hunter, Professor
   Kamal Youcef-Toumi, Professor

7. Non-MIT Experience (including military service):

Employer	Position	Beginning	Ending
LANL	Scientist	1992	1994
Independent Consultant	Consultant	1994	1998
Xcitex	CoFounder / CTO	1998	2005
Cooper Perkins	CTO	2005	2007
dRNOME	CoFounder	2011	2016

8. History of MIT Appointments:

Rank	Beginning	Ending
Lecturer, Sloan	2006	2009
Lecturer, MechE	2006	(present)
Research Scientist	2006	2013
Principal Research Scientist	2013	(present)
Director Singapore MIT Alliance – Manufacturing Systems and Technology Program (SMA-MST)	2006	2010
Director Advanced Manufacturing and Design Program	2006	(present)

Faculty Lead for Education, MIT Skoltech Initiative	2011	2016
Deputy Director, MIT Skoltech Initiative	2014	2016
Associate Director, AIM Academy	2016	2017
Faculty Lead for Industry Engagement, MechE	2018	2022
Associate Director, MIT.nano	2017	(present)
Director, Clinical Technology, Center for Clinical and Translational Research	2017	(present)
Director, Immersion Lab	2017	(present)

9. Consulting Record:

Engagements greater than 3 months.

Firm	Beginning	Ending
Los Alamos National Labs		2000
Textron		2000
Federal Trade Commission		2000
FAA		2004
Kodak		2004
Redlake		2005
Olympus		2006
TIS	2009	2012
Photron	2009	2011
Cooper Perkins	2010	2012
IDEO	2012	---
Alcon	2012	---
Ximedica	2013	2014
Herman Miller	2014	2014
Novartis	2015	2015
Lenze	2015	2016
Baxter	2019	2019
Apple	2017	2025
Samsung	2024	2025

10. Professional Service

Activity	Beginning	Ending
MEngM Admissions Committee	2006	present
CDO Admissions Committee	2007	2008
Career Fair – SMA in Singapore, Org Chair	2007	2007
Career Fair – SMA/MIT in Singapore, Org Chair	2008	2008
Mfg. microFluidics Symp, Chair	2009	2010
SMART Proposal Lead on Med Devices	3/2010	9/2010
LMP Summit Co-Chair	2011	2011
MEDRC Workshop, Chair	2012	2012
Pilot IMI Proposal, MIT Lead	5/2012	6/2012
Additive mfg working group, Lead	6/2012	8/2012
Co-Chair Education Workstream, AMP 2.0	2013	2014
MIT's role in reducing the cost of health care	2014	2015

AIM Photonics Workforce Committee	2017	2017
Nextflex Collaboration Lead PI	2016	2017
Campus and Community Heath Management	2020	2021
MIT-Skoltech Steering Committee	2017	2022
SPIE Conference Committee	2011	2022
MIT / Tufts CTSI TAP Committee	2020	
MIT. nano Leadership Council	2017	

11. Awards Received:

Award	Date
National Television Academy, Emmy for Innovative Technical Achievement. "Golf on CBS, SwingVision."	2005
BPLA Invented Here, Featured Honoree	2014

12. Current Organization Membership:

Organization	Offices Held
ASME	
IEEE	
SPIE	
AIUM (American Institute of Ultrasound in Medicine)	
Sigma Xi	
RSNA	

13. Patents and Patent Applications Pending:
    1. US Patent 5606130 "Method for determining the octane rating of gasoline samples by observing corresponding acoustic resonances therein."
    2. US Patent 6393384 "Apparatus and method for remote ultrasonic determination of thin material properties using signal correlation."
    3. US Patent 6226081 "Optical height of fill detection system and associated methods."
    4. US Patent 8,333,704, B. Anthony and M. Gilbertson, "Handheld Force-Controlled Ultrasound Probe," Dec 11, 2012
    5. US Patent 8,328,725, B. Anthony and M. Gilbertson, "Ultrasound Probe," Dec 18, 2012
    6. US Patent 8,382,671, B. Anthony and M. Gilbertson, "Handheld Ultrasound Probe," Feb 26, 2013
    7. US Patent 9,121,705, B. Anthony and D. Ljubicic, "Sensor for Simultaneous Measurement of Thickness and Lateral Position of a transparent object," Sept 1, 2015
    8. US Patent 9,456,800, Brian W. Anthony, Matthew W. Gilbertson, "Ultrasound scanning system", Oct 4, 2016
    9. US Patent 10353191, Circular scanning technique for large area inspection, July 16, 2019.
    10. MIT Case 14088, Force Controlled Ultrasound Probe, 16-Dec-09
    11. MIT Case 14387, Deformation Estimation and Correction in Elastography with a Handheld Force Controlled Ultrasound Probe, 16-Jul-10
    12. MIT Case 14422, High-Speed Profilometer for Manufacturing Inspection, 30-Jul-10
    13. MIT Case 14966J, Force Measurement Ultrasound Probe for Sonographer Fatigue Monitoring, 10-Jun-11
    14. MIT Case 15012, A 6-DOF Optical System for Freehand 3D Ultrasound, 05-Jul-11

15. MIT Case 15681J, Local Actuation and Control of Stamp Deformation in Microcontact Printing, 06-Jun-12
16. MIT Case 15782, Usability Improvements to a Handheld Force-Controlled Ultrasound Probe, 03-Aug-12
17. MIT Case 15884, Computer-Guided Restoration of Ultrasound Scan Poses by Optical Tracking, 01-Oct-12
18. MIT Case 16160, Quick-Release Mechanism for a Force-Measuring Ultrasound Probe, 22-Feb-13
19. MIT Case 16447, Force-correlated Quantitative Ultrasound Image Analysis, 02-Jul-13
20. MIT Case 17106J, Acoustic Characterization of Superficial Body Fluids, 07-May-14
21. MIT Case 17211J, Wireless Capsule Endoscopic Ultrasound, 24-Jun-14
22. MIT Case 17259K, A Concentric Circle Scanning Technique for Large Area Inspection, 09-Jul-14
23. MIT Case 17260K, Grid-Based Matching for Full-Field Large-Area Deformation Measurement, 09-Jul-14
24. MIT Case 17344, Recovery and Computer-Guided Restoration of Ultrasound Scan Poses Based on Human Skin Features, 21-Aug-14
25. MIT Case 17864J, Ultrasound-Based Individual Scatterer Detection Method Using Scatterer Motion Induced by Acoustic Radiation Force, 21-Apr-15
26. MIT Case 17865, Ultrasound-Based Absolute Scatterer Concentration Measurement Technique: Image Volume Estimation from Scatter Spread Function Extracted From the Image, 21-Apr-15
27. MIT Case 17990, Hydrogel Ultrasound Angle Wedge, 04-Jun-15
28. MIT Case 18074, Joint Camera-Ultrasound Data Acquisition for Limb Scanning, 13-Jul-15
29. MIT Case 18544, An Iterative RTM with a Priori Data to Estimate Bone Thickness Using a Cylindrically Scanning Ultrasound Tomography Scanner, 22-Feb-16
30. MIT Case 18545K, Block-Wise Inversion for the Soundspeed of Human Soft Tissue and Bone Using Ray Based Travel Time Tomographic Techniques, 22-Feb-16
31. MIT Case 18636, Concentric Ring-Based Point Pattern Matching of Skin Features, 05-Apr-16
32. MIT Case, Physical and Chemical Characterization of Aerosols with Photonic Waveguides, United States Patent Application 20190234850
33. MIT Case 19192QJ, Non-Invasive Assessment of Venous Pressure via Actuation of Reciprocal Surface Forces for Vessel Collapse Using Single-Crystal Ultrasound in Vertebrates
34. MIT Case 19409, Medical Ultrasound Device with Integrated Force Measurement and Methods for Data Synchronization
35. MIT Case 19460, Shear Wave Elastography Imaging with External Mechanical Vibration
36. MIT Case 19516, Source and Receiver Tracking for Non-Contact Ultrasound
37. MIT Case 19618, Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures
38. MIT Case 19626TE, Apparatus and Methods for Ultrasound Limb Scanning Under Load
39. MIT Case 19710, A Technique for Imaging Cortical Bone and Soft Tissue Using the Level-Set Method to Regularize Travel-Time and Full Waveform Tomography Techniques
40. MIT Case 19791, On chip Photonic Aerosol Spectrometer
41. MIT Case 19921, Equity Disbursement for Bionic Skins LLC (4914743)
42. MIT Case 20289, Miniaturization of External Mechanical Vibration for Ultrasound Shear Wave Elastography Imaging

43. MIT Case 20506L, Systems and Methods for Enabling Non-Contact Laser Ultrasound
44. MIT Case 21078, Microscale Photoacoustic Spectroscopy and Microscopy
45. MIT Case 21123, Tunable Filler Assembly in Mult-imaterial Polymer Extrusions Using Direct Injection and Acoustic Radiation Forces
46. MIT Case 21145, 3D Organ and Tissue Property Mapping using Superficial Vasculature-Based RGBD-SLAM and Deep Vasculature Alignment
47. MIT Case 22420, Integrated Optofluidic Sensor for Thromboembolic and Coagulation Risk Monitoring in COVID-19 Patients at Point-of-Care
48. MIT Case 22432, High Sensitivity and Specificity, Rapid, Low Cost, On-Chip Covid-19 Virus (and Other Virus) Detection using Integrated Photonic Sensors
49. MIT Case 22652, Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning
50. MIT Case 23256, Privacy-Preserving Health Diagnosis of Manufacturing Machines
51. Circular scanning technique for large area imaging (US Patent 10,735,674)
52. Method for detecting circulating cells in superficial body fluids (US Patent 10,639,012)
53. Physical and Chemical Characterization of Aerosols with Photonic Waveguides (US Patent 11,181,454

14. Professional Registration:

N/A.

15. Major New Products, Processes Designs, or Systems:

See next.

Publications of Brian W. Anthony

1. Books:
   Smart Manufacturing On-line course, deployed 2019 and 2020

2. Papers in Referred Journals:
   2.1. B. Anthony, A. Abbate, D. Klimek, P. Kotidis., "Analysis of Ultrasonic Waves in Arbitrarily Oriented or Rotating Anisotropic Thin Materials", Quantitative Nondestructive Evaluation. Vol 18. pgs 215 - 222. (1999).
   2.2 A. Abbate, B. Anthony, D. Klimek, P. Kotidis., "Analysis of Dispersive Ultrasonic Signals by the Ridges of the Analysitc Wavelet Transform", Quantitative Nondestructive Evaluation. Vol 18. pgs 703 - 710. (1999).
   2.3 Dan Klimek, Brian Anthony, Agostino Abbate, Petros Kotidis, "Laser Ultrasonic Instrumentation for Accurate Temperature Measurement of Silicon Wafers in Rapid Thermal Processing Systems", Rapid Thermal and Integrated Processing VII, Materials Research Society, Volume 525, pg 135. (1999)
   2.4 Hardt, D.E., Anthony, B.W., Tor S.B., "A teaching factory for polymer microfabrication - µFac," International Journal of Nanomanufacturing, 2010, Vol. 6, No.1/2/3/4, pp. 137 - 151.
   2.5 Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, "Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features", Book Section, Medical Image Computing and Computer-Assisted Intervention - MICCAI 2014, Springer, 2014, Vol. 8674. Lecture Notes in Computer Science, Pages 365-372.
   2.6 Xian Du, Brian W. Anthony, Nigel C. Kojimoto, “Grid-based matching for full-field large-area deformation measurement”, Optics and Lasers in Engineering, Volume 66, March 2015, Pages 307-319.
   2.7 Xian Du, Nigel C. Kojimoto, Brian W. Anthony, “Concentric circular trajectory sampling for super-resolution and image mosaicing”, Journal of the Optical Society of America A, Volume 32, No. 2, February 2015, Pages 293-304.
   2.8 M. Gilbertson, B. Anthony. "A Force and Position Control System for Freehand Ultrasound”, IEEE Transactions on Robotics, Volume 31, Issue 4. 2015.
   2.9 Andrey Kuzmin, Aaron Zakrzewski, Brian Anthony, Victor Lempitsky, "Multi-frame Elastography Using Handheld Force-Controlled Ultrasound Probe". Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, Volume 62 , Issue 8, Pages 1486 – 1500, 2015.
   2.10 Xian Du and Brian Anthony, "Concentric circle scanning system for large-area and high-precision imaging," Optics Express, Vol 23, Issue 15, Pages 20014-20029, 2015.
   2.11 Du, X.., Anthony, B., “Controlled angular and radial scanning for super resolution concentric circular imaging,” Opt. Express 24(20), 22581, United States (2016).
   2.12 Jimenez, X., Shukla, S. K., Ortega, I., Illana, F. J., Castro-González, C., Marti-Fuster, B., Butterworth, I., Arroyo, M., Anthony, B., et al., “Quantification of Very Low Concentrations of Leukocyte Suspensions In Vitro by High-Frequency Ultrasound,” Ultrasound Med. Biol. 42(7), 1568–1573, England (2016).
   2.13 Koppaka, S., Shklyar, I., Rutkove, S. B., Darras, B. T., Anthony, B. W., Zaidman, C. M.., Wu, J. S., “Quantitative Ultrasound Assessment of Duchenne Muscular Dystrophy Using Edge Detection Analysis,” J. Ultrasound Med. 35(9), 1889–1897, United States (2016).
   2.14 Lee, J., Boning, D., Anthony, B., "Measuring the Absolute Concentration of Microparticles in Suspension using High Frequency B-mode Ultrasound Imaging", Ultrasound in Medicine and Biology, 2018.
   2.15 Correa-de-Araujo, R., Harris-Love, M., Miljkoviv, I., Fragala, M.S., Anthony, B.W., Manini, T., Newman, A.B., "The Need for Standardized Assessment of Muscle Quality in Skeletal Muscle Function Deficit and Other Aging-Related Muscle Dysfunctions: A Symposium Report", Frontiers in Physiology, Section on Striated Muscle Physiology, 2017

2.16 Anthony, B, et al, "A Pilot Study to Precisely Quantify Forces Applied by Sonographers While Scanning: A Step Toward Reducing Ergonomic Injury", WORK: A Journal of Prevention, Assessment, and Rehabilitation, 2017
2.17 Zakrzewski, Aaron M., Anthony, Brian W., "Non-Invasive Blood Pressure Estimation Using Ultrasound and Simple Finite Element Models", IEEE Transactions on Biomedical Engineering, 2017
2,18 Anthony, B., Fitriana, "Computationally-Efficient Optimal Video-Comparison for Machine Monitoring and Process Control", Journal of Manufacturing Science and Engineering, 2017
2.19 Lee I, Du X, Anthony B. "Hair segmentation using adaptive threshold from edge and branch length measures," Computers in Biology Medicine, (2017).
2.20 Pigula-Tresansky AJ, Wu JS, Kapur K, Darras BT, Rutkove SB, Anthony BW. "Muscle compression improves reliability of ultrasound echo intensity," Muscle Nerve, 2017.
2.21 Xian Du, David Hardt, and Brian W. Anthony, "Real time imaging of invisible micron-scale monolayer patterns on a moving web using condensation figure," IEEE Transactions on Industry Electronics, (submitted, in review), 2017.
2.22 Brian W. Anthony, Xian Du, Ina Kundu, Judith Beaudoin, "Skin registration and point pattern matching of skin microrelief structure," (submitted, in revision), 2017.
2.23 Ozturk A, Grajo JR, Dhyani M, Anthony BW, Samir AE. Principles of ultrasound elastography. Abdominal Radiology. 2018.
2.24 Benjamin A, Zubajlo RE, Dhyani M, Samir AE, Thomenius KE, Grajo JR, Anthony, Brian W., "A Novel Approach to the Quantification of the Longitudinal Speed of Sound and its Potential for Tissue Characterization (Part I)", Journal of Ultrasound in Medicine and Biology, 2018
2.25 B. Anthony et al, "Experimental Validation of Longitudinal Speed of Sound Estimates in the Diagnosis of Hepatic Steatosis (Part II)", Journal of Ultrasound in medicine and biology, 2018
2.26 A. Ozturk et al., "Quantitative Hepatic Fat Quantification in NAFLD using Ultrasound-Based Techniques: A Review of Literature and their Diagnostic Performance," Ultrasound in Medicine and Biology, 2018
2.27 Zakrzewski, A. M., Huang, A. Y., Zubajlo, R. E., & Anthony, B. W. Real-Time Blood Pressure Estimation From Force-Measured Ultrasound. IEEE Transactions on Biomedical Engineering, 2018 (Nov 2018 cover article).
2.28 Singh, R., Su, P., Kimerling, L., Agarwal, A., & Anthony, B. W. "Towards On-chip Mid Infrared Photonic Aerosol Spectroscopy." Applied Physics Letters. (Accepted). 2018
2.29 Ranger, Bryan J., Feigin, M., Zhang, X., Moerman, Kevin M., Herr, H., Anthony, Brian W. "3D ultrasound imaging of residual limbs with camera-based motion compensation", Transactions on Neural Systems & Rehabilitation, (accepted) 2018.
2.30 Singh, R., Ma, D., Kimerling, L., Agarwal, A., & Anthony, B. W. "Chemical Characterization of Aerosol Particles Using On-chip Photonic Cavity Enhanced Spectroscopy". ACS Sensors. 2018
2.31 Feigin, M., Ranger, B., Anthony, B., "Probabilistic Framework for Maximal Consensus Image Registration with Application to Medical Ultrasound Imaging" IEEE Transactions on Biomedical Engineering, (submitted) 2019.
2.32 X. Du, D. Hardt, and B. Anthony, "Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures," IEEE Trans. Ind. Electron., pp. 1–1, 2019.
2.33 B. J. Ranger, M. Feigin, X. Zhang, K. M. Moerman, H. Herr, and B. W. Anthony, "3D Ultrasound Imaging of Residual Limbs With Camera-Based Motion Compensation," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 27, no. 2, pp. 207–217, Feb. 2019.
2.34 M. Feigin-Almon, D. Freedman, and B. W. Anthony, "A Deep Learning Framework for Single-Sided Sound Speed Inversion in Medical Ultrasound," IEEE Trans. Biomed. Eng., pp. 1–1, 2019.
2.35 R. Singh, D. Ma, L. Kimerling, A. M. Agarwal, and B. W. Anthony, "Chemical Characterization of Aerosol Particles Using On-Chip Photonic Cavity Enhanced Spectroscopy," ACS Sensors, vol. 4, no. 3, pp. 571–577, Mar. 2019.

2.36 Xiang Zhang, Jonathan Fincke, Charles Wynn, Matthew Johnson, Robert Haupt, and Brian Anthony. Full Noncontact Laser Ultrasound: First Human Data. Nature, Light: Science & Applications. 2019 (Accepted)
2.37 M. Feigin, M. Zwecker, D. Freedman, and B. W. Anthony, "Detecting muscle activation using ultrasound speed of sound inversion with deep learning," Submitted Oct. 2019.
2.38 S. Kim, D. D. Kim, and B. Anthony, "Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning," Submitted Nov. 2019.
2.39 R. Singh, Y. Nie, A. M. Agarwal, and B. W. Anthony, "Inverse Design of Photonic Metasurface Gratings for Beam Collimation in Opto-fluidic Sensing," Submitted Oct. 2019.
2.40 Benjamin A, Chen M, Li Q, Chen L, Dong Y, Carrascal CA, et al. Renal Volume Estimation Using Freehand Ultrasound Scans: An Ex Vivo Demonstration. Ultrasound Med Biol. 2020 Jul;46(7):1769–82.
2.41 Chrzanowski S, Tresansky AP, Nagy J, Rutkove S, Anthony B. Muscle Imaging – MRI. Neuromuscul Disord. 2020 Oct;30:S95.
2.42 Singh R, Agarwal A, W Anthony B. Mapping the design space of photonic topological states via deep learning. Opt Express. 2020 Sep 14;28(19):27893.
2.43 Lee JH, Traverso G, Ibarra-Zarate D, Boning DS, Anthony BW. Ex Vivo and In Vivo Imaging Study of Ultrasound Capsule Endoscopy. J Med Device. 2020 Jun 1;14(2).
2.44 Singh R, Agarwal A, Anthony BW. Design of optical meta-structures with applications to beam engineering using deep learning. Sci Rep. 2020 Dec 16;10(1):19923.
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2.46 Benjamin, Alex; Ely, Gregory; Fincke, Jonathan; Anthony BW. Reflection Ultrasound Tomography Using Localized Freehand Scans. IEEE Int Symp Biomed Imaging. 2020.
2.47 Ozturk A, Zubajlo RE, Dhyani M, Grajo JR, Mercaldo N, Anthony BW, et al. Variation of Shear Wave Elastography With Preload in the Thyroid: Quantitative Validation. J Ultrasound Med. 2021 Apr 20;40(4):779–86.
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2.49 Kim S, Kim DD, Anthony B. Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning. IEEE/ASME Trans Mechatronics [Internet]. 2021;4435(c):1–1.
2.50 Fincke J, Zhang X, Shin B, Ely G, Anthony BW. Quantitative Sound Speed Imaging of Cortical Bone and Soft Tissue: Results from Observational Data Sets. IEEE Trans Med Imaging. 2021;PP(X):1–1.
2.51 Singh R, Nie Y, Gao M, Agarwal AM, Anthony BW. Inverse design of photonic meta-structure for beam collimation in on-chip sensing. Sci Rep. 2021 Dec 5;11(1):5343.
2.52 Benjamin A, Ely G, Anthony BW. 2D speed of sound mapping using a multilook reflection ultrasound tomography framework. Ultrasonics. 2021 Jul;114:106393.
2.53 Hahm KS, Anthony BW. In-home Health Monitoring using Floor-based Gait Tracking. Internet of Things (Netherlands) [Internet]. 2022 Aug;19:100541.
2.54 Goryachev I, Tresansky AP, Ely GT, Chrzanowski SM, Nagy JA, Rutkove SB, et al. Comparison of Quantitative Ultrasound Methods to Classify Dystrophic and Obese Models of Skeletal Muscle. Ultrasound Med Biol. 2022 Sep;48(9):1918–32.
2.56 Jaffe AT, Zubajlo RE, Daniel L, Anthony BW. Automated Force-Coupled Ultrasound Method for Calibration-Free Carotid Artery Blood Pressure Estimation. Ultrasound Med Biol. 2022 Sep;48(9):1806–21.
2.57 Zhang X, Ely G, Shin B, Anthony BW. Multimanipulator Robotic System for Ultrasound Tomography: Design, Calibration, and Image Results. J Med Device. 2022 Dec 1;16(4).

2.58 Ranger BJ, Moerman KM, Anthony BW, Herr HM. Constitutive parameter identification of transtibial residual limb soft tissue using ultrasound indentation and shear wave elastography. J Mech Behav Biomed Mater. 2023 Jan;137:105541.
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3. Proceedings of Refereed Conferences:
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3.18. Inamdar, T., Anthony, B. W., “Characterizing fluidic seals for on-board reagent delivery," Proceedings of SPIE (2013).
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3.32. Pigula, A. J., Wu, J. S., Gilbertson, M. W., Darras, B. T., Rutkove, S. B.., Anthony, B. W., “Force-controlled ultrasound to measure passive mechanical properties of muscle in Duchenne muscular dystrophy,” 2016 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., 2865–2868, IEEE (2016).

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3.53. Singh, Robin; Ma, Danhao; Kimerling, Lionel; Agarwal, Anuradha; Anthony, Brian, "Microscale photoacoustic spectroscopy using integrated photonics for lab-on-chip applications", Spie BIOS, (accepted), 2018.
3.54. J. B. Frontin and B. W. Anthony, "Quantifying Dermatology: Method and Device for User-Independent Ultrasound Measurement of Skin Thickness," in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 5743–5748.
3.55. A. Benjamin et al., "Renal volume reconstruction using free-hand ultrasound scans," J. Acoust. Soc. Am., vol. 145, no. 3, pp. 1922–1922, Mar. 2019.
3.56. A. Y. Huang and B. W. Anthony, "An Instrumented Ultrasound Probe for Shear Wave Elastography With Uneven Force Distribution," in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 6208–6211.
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3.65. Cuiffi JD, Wang H, Heim J, Anthony BW, Kim S, Kim DD. Factory 4.0 Toolkit for Smart Manufacturing Training. In: 2021 ASEE Virtual Annual Conference Content Access. 2021.
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3.67. Hong MS. Teaching Process Data Analytics and Machine Learning at MIT. Chem Eng Educ. 2022;56(4).
3.68. Ranger B, Hira A, Smith B, Zhang X, Anthony B. Work in progress: cost-effective table-top ultrasound systems as platform for biomedical engineering education. In: 2022 ASEE Annual Conference & Exposition. 2022.

Theses Supervised by Brian W. Anthony

Summary:

	Total	Completed	In Progress
Bachelor's	5	5	0
Master's	42	35	7
MEng	29	17	12
Engineer's			
Doctoral			
As Supervisor	26	15	11
As Reader	4	3	1

Last	First	*Title*	Department	Year	
Bachelor's Theses					
Syverud	Brian	*Robotic ultrasound manipulator: calibration of position and orientation measurement system*	MechE	2009	
Johnson	Michael	*Design of a precise X-Y-Theta nanopositioning optical sensor*	MechE	2009	
Chai	Lauren	*Design of mechanical arterial simulator*	MechE	2012	
Ramos	Javier	*Design of Force Measurement Probe*	MechE	2012	
Mireault	Alfred Norman	*Mechanical design of an ultrasonic tomographic imaging system*	MechE	2016	
Master's Theses					
Fitriani		*Multiscale Dynamic Time and Space Warping*	CDO	2008	
Zarrouati	Nadäge	*A precision manipulation system for polymer microdevice production*	MechE	2010	
Gilbertson	Matthew Wright	*Handheld force-controlled ultrasound probe*	MechE	2010	
Sun	Shih-Yu	*Deformation correction in ultrasound imaging in an elastography framework*	EECS	2010	
Zakrzewski	Aaron	*Multi-scale quantitative elastography and its application to blood pressure estimation*	MechE	2013	
Koppaka	Sisir	*Imaging Biomarkers for Duchenne Muscular Dystrophy*	CDO	2015	
Zhang	Xiang (Shawn)	*Design of a single element 3D ultrasound scanner*	MechE	2015	
Primack	Willow	*Analysis and Productivity Improvement of an Automated Material Handling System through Simulation*	LGO	2015	

Churchill	Hugh E.	*Cycle-time Analysis and Improvement Using Lean Methods within a Retail Distribution Center*	LGO	2015	
Sazdanoff	Nicholas	*Evaluation of postponement in the Drug Product supply chain*	LGO	2015	
Kojimoto	Nigel Costello	*Ultrasonic inspection methods for defect detection and process control in roll-to-roll flexible electronics manufacturing*	MechE	2015	
Kundu	Ina Annesha	*Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system*	MechE	2015	
Conover	Susan	*Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system*	SDM	2015	
Hess	Tylor	*Algorithm deployment platform*	MechE	2016	
Lee	Kang Qi Ian	*Computational tools for enabling longitudinal skin image analysis*	CDO	2016	
Huang	Athena Yeh	*May the force be with you : a medical ultrasound system with integrated force measurement*	MechE	2017	
Benjamin	Alex	*The (travel) times they are a changing : a computational framework for the diagnosis of non-alcoholic fatty liver disease (NAFLD)*	CDO	2017	
Yang	Heng	*Ultrasound shear wave elastography imaging with external mechanical vibration*	MechE	2017	
Zubajlo	Rebecca	*Quantitative biomarkers for tissue characterization*	MechE	2017	
Benjamin	Rishon Robert	*Silence of the lamb waves*	CDO	2017	
Haidar	Samer	*Supply chain network strategy for consumer medical device introduction*	LGO	2016	
Al-Meer	Mariam	*Reducing heart failure admissions through improved care systems and processes*	LGO	2017	
Sandford	Michael	*Application of 3D printing in medical devices New Product Development*	LGO	2017	

Graule	Moritz Alexander	*Towards force-correlated ultrasound volume elastography*	MechE	2017	
Sun	Mingxiu	*Education and practice factory : from factory design to first product delivery*	MechE	2018	
Singh	Robin	*Whispering photons : on-chip biophotonic integrated circuits for point-of-care diagnostics*	MechE	2018	
Beaudoin	Judy	*Quantifying dermatology : method and device for user-independent ultrasound measurement of skin thickness*	MechE	2018	
DiAndreth	Chris	*Optimization of Downstream Supply Chain Product Flow based on an Integrated Cost-to-Deliver Perspective*	LGO	2019	
Puppo	Manuel Martinez	*Replenishment in an integrated stock world*	LGO	2019	
Lu	Shirley Suet-Ning	*Design of dynamically controlled desktop fiber accumulator with tension feedback as part of smart manufacturing educational kit*	MechE	2020	
Kim	Sangwoon	*Model-free tracking control of an optical fiber drawing process using deep reinforcement learning*	MechE	2020	
Chen	Hongling (Holly)	*Vascular Imaging System for Longitudinal Registration and Mapping of Superficial Vessels with Quantitative Analysis*	IDM	2020	
Chavez	Yasmin	*System identification and control of a miniature external mechanical vibration device towards clinical ultrasound shear wave elastography*	MechE	2020	
Koeppen	Ryan	*Design of Electromechanical Attachments for Improved Ultrasound Imaging Repeatability*	MechE	2021	
Goryachev	Ivan	*Kiosks for Non-Contact Vital Sign Detection*	MechE	2021	
Adiwijaya	Zenia	*Tenative: ML for Process control*	SDM	2023	expected
Chen	George	*Tenative: ML for Process control*	MechE	2022	expected
Deshpande	Aniruddha	*Tenative: Food manufacturing - ML models*	EECS	2023	expected
Dhar	Shreya	*Tenative: Education Kit*	MechE	2023	expected
Espinoza	Victor Reyes	*Tenative: ML for Process control*	EECS	2022	expected
Justiniano	Eugenio Caraballo	*Tenative: Sound and Light on Cells*	MechE	2023	expected

Magana-Salgado	Uriel	*Tenative: Muscle Health monitoring*	MechE	2023	expected

Master Eng. Theses					
Su	Xiangyong	*Optimization of labor allocation at a syringe production facility : design proposals*	MechE	2008	
Liaw	Sze Sen	*Optimization of labor allocation at a syringe production facility using computer simulation*	MechE	2008	
Ng	Gar Yan	*Optimization of labor allocation at a syringe production facility : work study*	MechE	2008	
Linares	Rodrigo	*Manufacturability of lab on a chip devices: tolerance analysis and requirements establishment*	MechE	2010	
Selvakumar	Sivesh	*Manufacturing of Lab-On-a-Chip devices : variation analysis of liquid delivery using blister packs*	MechE	2010	
Namvari	Kasra	*Manufacturability of lab-on-chip devices : dimensional variation analysis of electrode foils using visual technology*	MechE	2011	
Donoghue	Linda	*Design of a micro-interdigitated electrode for impedance measurement performance in a biochemical assay*	MechE	2011	
Holmes	Jacklyn	*Robustness and repeatability of interdigitated electrodes on a substrate tested in an aqueous environment*	MechE	2011	
Judge	Benjamin	*Thermoplastic bonding of microfluidic substrates*	MechE	2012	
Jain	Nikhil	*A comprehensive study and validation of high-throughput microscale electrode production using thermal transfer printing techniques*	MechE	2012	
Inamdar	Tejas Satish	*Manufacturing of lab-on-a-chip devices : characterizing seals for on-board reagent delivery*	MechE	2013	
Saber	Aabed Saud	*Manufacturability of lab on chip devices : reagent-filled reservoirs bonding process and its effect on reagents flow pattern*	MechE	2013	

Nguyen	Khanh Huy	*Hot embossing as a method for rapid prototyping microfluidic devices*	MechE	2013	
Ragosta	Nicholas Hiroshi	*Design and measurement analysis of hot embossing system for high aspect ratio microfluidics*	MechE	2013	
Kalsekar	Viren Sunil	*Design and process optimization of a hot embossing machine for microfluidics with high aspect ratios*	MechE	2013	
Xue	Elise	*Sensorless ultrasound probe 6DoF pose estimation through the use of CNNs on image data*	EECS	2018	
DiAndreth	Christopher	*Optimization of downstream supply chain product flow based on an integrated cost-to-deliver perspective*	LGO	2019	
Cherna	Samuel	*External virbarion on Butterfly Probes*	EECS	2022	expected
Sawant	Nilay Sanjay	*Tenative: ML for Process Control*	MechE	2022	expected
Othman	Mohamed Ayman Mohamed	*Tenative: ML for Process Control*	MechE	2022	expected
Sardet	Maelle Jade	*Tenative: ML for Process Control*	MechE	2022	expected
Li	Rui	*Tenative: Design and Manufacture of Education Kit*	MechE	2022	expected
Rojrungsasithorn	Tanach	*Tenative: Design and Manufacture of Education Kit*	MechE	2022	expected
Levi	Aviva Jesse	*Tenative: Design and Manufacture of Education Kit*	MechE	2022	expected
Bradley	Russel	*Tenative: Design and Manufacture of Education Kit*	MechE	2022	expected
Smith	Carly Madeleine	*Tenative: Clinical Trial Monitoring Kit Design*	MechE	2022	expected
Aitmbiriq	Imane	*Tenative: Clinical Trial Monitoring Kit Design*	MechE	2022	expected
Noh	Joyce	*Tenative: Clinical Trial Monitoring Kit Design*	MechE	2022	expected
Lin	Ryan Shao-Wei	*Tenative: Clinical Trial Monitoring Kit Design*	MechE	2022	expected

Doctoral Theses, Supervisor					
Ljubicic	Dean	*High Speed Instrumentation for Inspection of transparent parts*	MechE	2013	
Gilbertson	Matthew Wright	*Electromechanical systems to enhance the usability and diagnostic capabilities of ultrasound imaging*	MechE	2014	
Sun	Shih-Yu	*Ultrasound probe localization by tracking skin features*	EECS	2014	

Zakrzewski	Aaron	*Arterial blood pressure estimation using ultrasound*	MechE	2017	
Roberts	Megan	*Design and fabrication of a flexible membrane ultrasound transducer*	MechE	2018	
Lee	John Haeseon	*Measuring the absolute concentration of particles in suspension using high frequency B-mode ultrasound imaging*	EECS	2015	
Fincke	Jonathan Randall	*Non-contact quantitative imaging of limbs, bone and tissue, using ultrasound tomographic techniques*	MechE	2018	
Ranger	Bryan	*Ultrasonic imaging methods for quantitative musculoskeletal tissue assessment and improved prosthetic interface design*	HST	2018	
Kundu	Ina Annesha Kundu	*Imaging skin structures for health, body mapping, and identification (under the Tucson Skin)*	MechE	2018	
Kim	David Donghyun Kim	*Design and development of desktop fiber and fabric manufacturing system for advanced materials*	MechE	2020	
Wang	Jenny Wang	*Formation Process of Acoustophoretic Patterns*	MechE	2022	
Pigula	Anne Pigula	*Statistical analysis of ultrasound signals for tissue characterization : the Homodyned K Distribution*	HST	2020	
Zhang	Xiang Zhang	*Non-contact ultrasound*	MechE	2019	
Benjamin	Alex Benjamin	*3D organ property mapping using freehand ultrasound scans*	MechE	2020	
Singh	Robin Singh	*Integrated bio-photonic devices : sensors, imagers, and beyond*	MechE	2021	
Chen	Melinda Chen	*Liver Vascular Health Imaging*	HST	2022	
Jaffe	Alex	*Venous and Blood Pressure in the extremities*	EECS	2022	
Hahm	Katie	*Ambient Gait Analysis*	MechE	2022	
Chai	Lauren	*Tentative: Radiation Force Manufacturing*	MechE	2022	expected
Zubajlo	Rebecca Zubajlo	*Tentative: Physical Measurement of Cells*	MechE	2022	expected
Lange	April	*Tentative: Volume US - Squishy slam*	MechE	2023	expected
Zhang	Zhuorui	*Tentative: Large Aperture Wearable*	MechE	2024	expected
Gao	Mingye	*Tenative: Integrated Photonics for Biosensensing*	EECS	2024	expected

Lin	QiAn	*Tenative: US Path Planning*	MechE	2024	expected
Kang	David Ha Eun	*Tenative: Homomorphic Encryption and ML*	MechE	2023	expected
Tripathy	Soumya	*Tenative: Integrated Photonics for US*	Media	2024	expected

Doctoral Theses, Reader					
Shi	Chuan	*Efficient buffer design algorithms for production line profit maximization*	MechE	2011	
Petrzelka	Joe	*Contact region fidelity, sensitivity, and control in roll-based soft lithography*	MechE	2012	
Smyth	Katherine	*Piezoelectric micro-machined ultrasonic transducers for medical imaging*	EECS	2016	
Athanassiadis	Athanasios G.	*Optical breakdown acoustics : transduction and sensing underwater*	MechE	2019	

Postdoctoral Associates and Fellows Supervised by Brian W. Anthony

Current Postdocs

Name	*Dates of Appointment*	*PhD Granting Institution*
Jenny Wang	2022 -	MIT
Melinda Chen	2022 -	MIT
David Lee	2024-	

Previous Postdocs

Name	*Current Title*	*Current Employer*
Vannah, Bill	Scientist	Mary Free Bed Rehabilitation Hospital
Victor Lempitsky	Head of AI	Samsung
Javier J. Gonzalez	May 2013 – 2015	University of Madrid
Matthew Gilbertson	Senior Electro-Optical Engineer	Lockheed Martin
Xian, Du	Professor	UMass (2018)
David Ibarra	Professor	Monterery Tec
Micha Feigin	Research Scientist	MIT
Ian Butterworth	Biomedical Research Engineer	MIT
Carlos Castro-Gonzalez	Co-Founder and CEO	Leuko
Berta Martí Fuster	Head of Communications	Oncoheroes Biosciences
Bonghun (Bruce) Shin	Senior Scientist	University Waterloo
Megan Roberts	Director of Product Development	Med Tech Co.
Greg Ely	Senior Algorithm Engineer	Imaging Co.
David Kim	Scientist	Sandia Labs
Shawn Zhang	Scientist	MIT
Praneeth Namburi	Scientist	MIT

APPENDIX B (LIST OF MATERIALS CONSIDERED)

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 12,193,790 ("'790 patent")
1002	File History of U.S. Application No. 18/438,144 ("'790 Patent File History")
1004	Declaration of Brian Anthony in Support of Petition for *Inter Partes* Review of U.S. Patent No. 9,651,533 submitted in IPR2019-00916, Ex. 1003 ("'533-Anthony")
1005	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2019-00916, Paper 1 (P.T.A.B. Apr. 10, 2019) ("'533-Pet.")
1008	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2019-00916, Paper 39 (P.T.A.B. Oct. 14, 2020) ("'533-FWD")
1009	*Omni MedSci, Inc. v. Apple Inc.*, No. 21-01229, ECF 69 (Fed. Cir. June 8, 2022)
1010	Declaration of Brian Anthony in Support of Petition for *Inter Partes* Review of U.S. Patent No. 10,517,484 submitted in IPR2021-00453, Ex. 1003 ("'484-Anthony")
1011	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2021-00453, Paper 1 (P.T.A.B. Jan. 22, 2021) ("'484-Pet.")
1013	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2021-00453, Paper 7 (P.T.A.B. Aug. 6, 2021) ("'484-Inst.")
1015	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2021-00453, Paper 22 (P.T.A.B. Aug. 3, 2022) ("'484-FWD")
1016	*Apple Inc. v. Omni Medsci, Inc.*, No. IPR2021-00453, Paper 26 (P.T.A.B. Feb. 14, 2025) ("'484-RFWD")
1018	*Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00134-RWS, Dkt. No. 211 (E.D. Tex. June 24, 2019)
1019	*Omni MedSci, Inc. v. Apple Inc.*, 2:18-cv-00429-RWS, Dkt. No. 152 (E.D. Tex. Aug. 14, 2019)
1023	Defendants' Supplemental Invalidity and Subject Matter Eligibility Contentions, July 18, 2025. *Omni MedSci, Inc. v. Samsung Electronics Co., Ltd. et al.*, No. 2:24-cv-01070-JRG-RSP (E.D. Tex.)
1025	U.S. Patent No. 9,241,676 ("Lisogurski")
1028	U.S. Patent Pub. No. 2005/0049468A1 ("Carlson")

Exhibit No.	DESCRIPTION
1031	U.S. Patent No. 8,050,730 ("Zhang")
1033	U.S. Patent Pub. No. 2011/0237911 ("Lamego")
1034	U.S. Patent No. 5,942,749 ("Takeuchi")
1035	U.S. Patent No. 5,822,473 ("Magel")
1036	US Patent 5,592,124 ("Mullins")
1037	E.F. Schubert, Light-Emitting Diodes (Cambridge Univ. Press, 2nd ed. reprinted 2014)
1038	"The Biomedical Engineering Handbook," by Joseph D. Bronzino (1995)
1039	U.S. Patent No. 8,079,735 ("Vakil")
1040	U.S. Patent No. 8,304,805 ("Lochtefeld")
1081	US. Patent No. 9,651,533 ("'533 patent")
1082	U.S. Patent No. 10,517,484 ("'484 patent")

*I also considered any additional materials referenced in my declaration.