

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

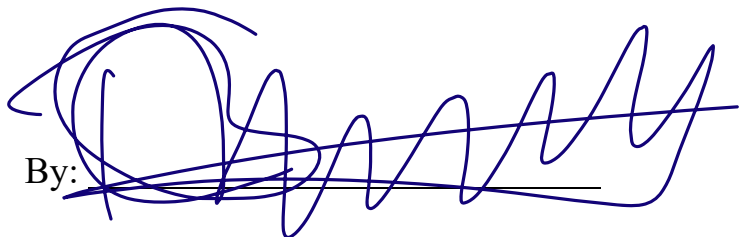
In re Patent of: Tyler S. Bushnell, et al.
U.S. Patent No.: 10,866,619 Attorney Docket No.: 50095-0156IP1
Issue Date: December 15, 2020
Appl. Serial No.: 15/627,336
Filing Date: June 19, 2017
Title: ELECTRONIC DEVICE HAVING SEALED BUTTON
BIOMETRIC SENSING SYSTEM

DECLARATION OF DR. BRIAN W. ANTHONY

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare 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 the Title 18 of the United States Code.

Dated: 4/24/2024

By: 

Brian W. Anthony, Ph.D.

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I. QUALIFICATIONS AND BACKGROUND INFORMATION

1. My name is Dr. Brian W. Anthony. I am an Associate Principal Research Scientist at the Institute of Medical Engineering & Science at Massachusetts Institute of Technology (MIT). I am also a Principal Research Scientist at MIT's Mechanical Engineering department, Director of the Master of Engineering in Advanced Manufacturing and Design Program at MIT, Director of Health Technology at the MIT Center for Clinical and Translational Research, a Co-Director of the Medical Electronic Device Realization Center of the Institute of Medical Engineering & Science, and Associate Director of MIT.nano. My current curriculum vitae is attached and some highlights follow.

2. I earned my B.S. in Engineering (1994) from Carnegie Mellon University. I earned my M.S. (1998) and Ph.D. (2006) in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.

3. 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. For

example, our optical ring included multiple light emitting diodes, multiple photodetectors, techniques for modulation and synchronization, and noise reduction algorithms. 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. 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.

4. 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.

5. 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, microfluidics, and handheld instruments. 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.

6. I am currently the Co-Director of the Device Realization Lab at the Medical Electronic Device Realization Center at the Institute of Medical Engineering & Science at MIT. The Device Realization Lab designs instruments and techniques to sense and control physical systems. Medical devices and manufacturing inspection systems are a particular focus. We develop and combine electromechanical systems, complex algorithms, and computation systems to create instruments and measurement solutions for problems that are otherwise intractable. We design handheld medical imaging systems for imaging and

identification, which combine specialized physical and software interfaces for user interaction and control.

7. The research of the Device Realization Lab focuses on product development interests cross the boundaries of computer vision, acoustic and ultrasonic imaging, large-scale computation and simulation, optimization, metrology, autonomous systems, and robotics. We use computation, and computer science, as methodology for attacking complex instrumentation problems. My work combines mathematical modeling, simulation, optimization, and experimental observations, to develop instruments and measurement solutions. I have taught courses in manufacturing and design, instrumentation, and introduction to electrical engineering and computer science concepts in signal processing, target identification, and tacking in the context of automation systems, communications systems, and medical systems.

8. My record of professional service includes recognitions from several professional organizations in my field of expertise.

9. I am a named inventor on 10 issued U.S. patents. Most but not all of these patents involve physiological monitoring and other measurement technologies.

10. I have published approximately 100 papers and have received a number of best paper and distinguished paper awards. A number of papers that I

have published relate to physiological monitoring and other measurement and human-in-the-loop instrumentation technologies.

11. I have been retained on behalf of Apple Inc. to offer technical opinions relating to U.S. Patent No. 10,866,619 (“the ’619 Patent”) and prior art references relating to its subject matter. I have reviewed the ’619 Patent, and relevant excerpts of the prosecution history of the ’619 Patent. Based on my experience and education, and the acceptance of my publications and professional recognition by societies in my field, I believe that I am qualified to offer opinions as to the knowledge and level of skill of one of ordinary skill in the art at the time of the invention of the ’619 patent (which I further describe below).

12. In addition to any materials cited in the present declaration, I have also reviewed the following references:

Reference No.	Description
Pet.	Petition for IPR, IPR2023-00948
Ex-1003	Declaration of Dr. Ronald D. Berger
Ex-1004	U.S. Patent No. 10,620,828 (“Kim”)
Ex-1005	U.S. Patent Pub. No. 2016/0100499 (“Jung”)
Ex-1006	U.S. Patent No. 9,651,513 (“Dunlap”)

Ex-1007	U.S. Patent Pub. No. 2015/0071509 (“Myers”) ¹
Ex-1008	U.S. Patent No. 8,694,793 (“Evans”)
Ex-1009	U.S. Patent No. 6,131,464 (“Pare”)
Ex-1010	U.S. Patent No. 9,740,381 (“Chaudhri”)
Ex-1011	U.S. Patent Pub. No. 2015/0245514 (“Choung”)
Ex-1012	U.S. Patent No. 8,750,919 (“Hwang”)
Ex-1013	U.S. Patent No. 7,535,799 (“Polany”)
Ex-1014	U.S. Patent Pub. No. 2017/0099742 (“Choi”)
Ex-1015	U.S. Patent No. 10,133,910 (“Chang”)
Ex-1016	U.S. Patent No. 8,367,958 (“Mittleman”)
Ex-1017	U.S. Patent No. 7,486,517 (“Aapro”)
Ex-1018	U.S. Patent No. 9,973,669 (“Vittu”)
Ex-1019	U.S. Patent No. 9,973,840 (“Wagman”)
Ex-1020	U.S. Patent Pub. No. 2013/0108082 (“Dave”)
Ex-1021	Curriculum vitae of Dr. Ronald Berger

¹ The Petition incorrectly identifies Ex-1007 as “Meyers.” *See, e.g.,* Pet., vi.

Exhibit 1007 lists “Myers” as the first-named inventor and this Declaration therefore references Ex-1007 by “Myers.”

Ex-1022	KR 10-2016-0162565 and certified translation thereof (“Kim-KR”)
Ex-1023	KR 10-2018-0062654 and certified translation thereof
Ex-1025	for Patent Infringement, <i>Apple Inc., v. AliveCor, Inc.</i> , Case No. 4:22-cv-07608-HSG (N.D. Cal. 2022)
APPLE-2004	Transcript of April 13, 2024 deposition of Dr. Ronald D. Berger
APPLE-2005	Ahmer Syed, “Packaging Challenges for the Next Generation of Mobile Devices,” IMAPS 2017 KEYNOTE SLIDES, 50th International Symposium on Microelectronics - Raleigh, NC USA, Oct. 9-12, 2017 (“Syed”)
APPLE-2006	U.S. Pat. App. Pub. No. 2017/0032169 (“Pi”)
APPLE-2007	U.S. Pat. No. 8,031,186 (“Oestergaard”)

I have also reviewed various supporting references and other documentation as further noted in my opinions below.

13. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the ’619 Patent at the time of the earliest possible priority date of the ’619 Patent, and I have done so during my review of these materials. The ’619 Patent was filed June 19, 2017

(“the Critical Date”). Counsel has informed me that the Critical Date represents the earliest possible priority date to which the challenged claims of ’619 Patent are entitled, and I have therefore used that Critical Date in my analysis below.

14. I have no financial interest in the parties or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

15. In writing this declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of mechanical engineering, computer science, biomedical engineering, and electrical engineering; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed various publications and materials, in addition to other materials I cite in my declaration.

16. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the ’619 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the Critical Date, or before. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the ’619 Patent and the prior art discussed below.

II. SUMMARY OF CONCLUSIONS FORMED

17. This declaration explains the conclusions that I have formed based on my analysis. To summarize those conclusions, based upon my knowledge and experience and my review of the prior art publications listed above, I believe that:

- Kim does not anticipate or render obvious claims 1, 5, 9, and 10
- Kim does not render obvious claims 1-10
- Jung in view of Myers does not render obvious claims 1, and 3-10
- Chang does not anticipate or render obvious claims 1-2, 6, and 9

III. THE '619 PATENT

A. Specification

18. The '619 Patent is generally focused on novel device assembly structures with specific and concrete manufacturing improvements to prevent liquid or other contaminants from damaging the internal electronics. Ex-1001, 1:14-22, 1:26-40. For example, a biometric button assembly may include an input member, e.g., a button, which is configured to receive inputs, for example, a fingerprint and finger press from a user of the electronic device. *Id.* at Abstr. Figure 1 of the '619 Patent is reproduced below (as annotated by the Panel in its Institution Decision).

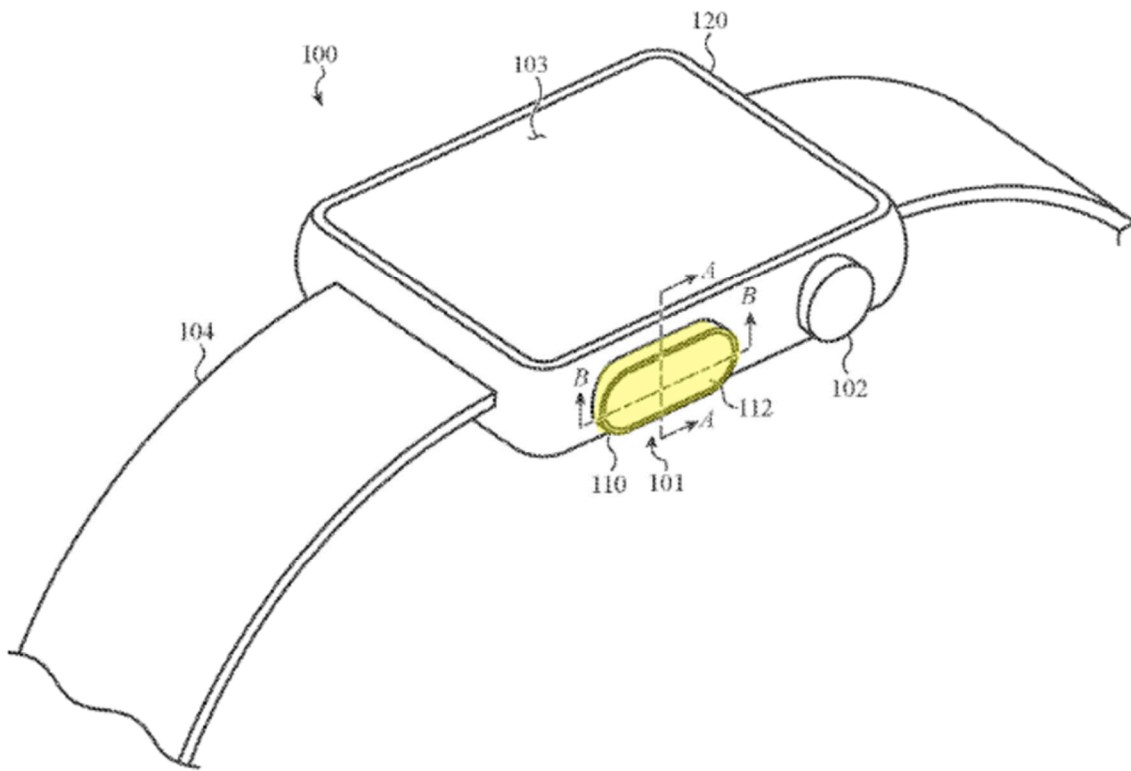


FIG. 1

Inst. Dec., 4 (citing Ex-1001, FIG. 1) (annotation in original)

19. As shown above, an electronic device 100, e.g., a watch, includes a biometric button assembly 110 (highlighted in yellow). Figure 2B shows a cross-sectional view of a biometric button assembly 210, which includes button housing 203, sensor 230 and flexible conduit 240 (highlighted in pink).

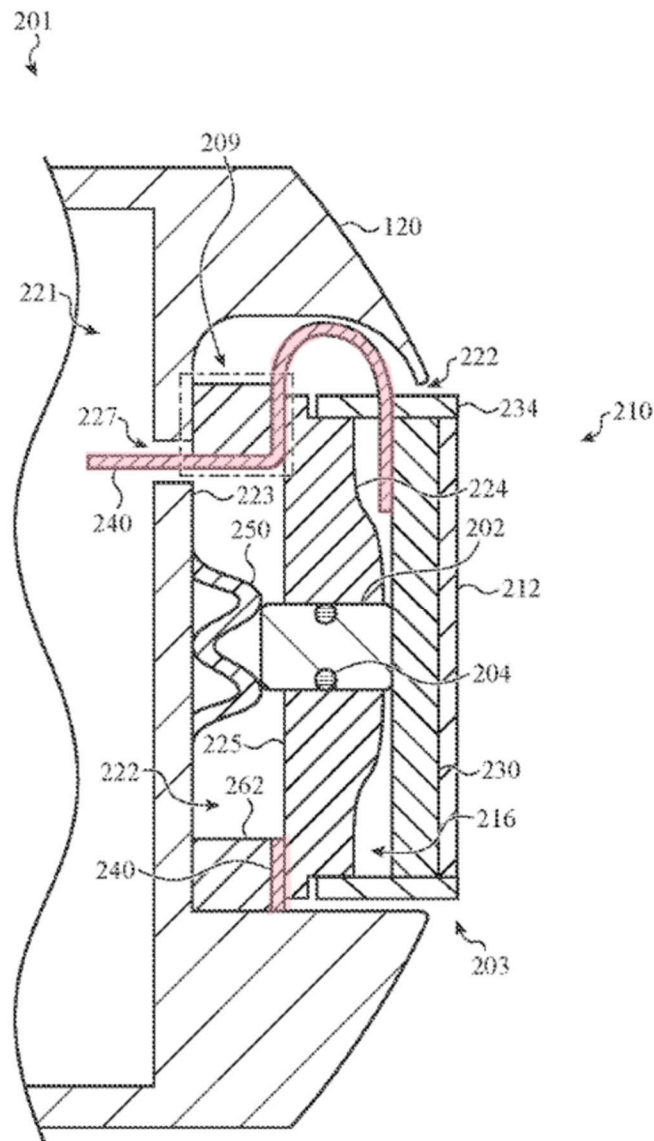


FIG. 2B

Inst. Dec., 5 (citing Ex-1001, FIG. 2B) (annotation in original)

20. Biometric sensor 230 may be a “fingerprint sensor of an array of capacitive sensing elements.” Ex-1001, 9:1-10. Upon a user touching input surface 212, the biometric sensor 230 “senses a change in capacitance or a value of capacitance of the array of capacitive sensing input surface 212” and further

“produces an output signal that includes the sensor measurements” that
“corresponds to a fingerprint of the user.” *Id.* The output signal may be
“processed by a processor positioned in an enclosed volume 221 of the electronic
device” to “determine the user fingerprint.” *Id.*

B. Claims

Claim 1	
[1.pre]	An electronic device comprising:
[1.a]	an enclosure having an enclosed volume and an opening formed in a sidewall;
[1.b]	a processor positioned in the enclosed volume;
[1.c]	a button assembly within the opening, the button assembly comprising: an input member having an input surface; and a biometric sensor positioned below the input member and configured to produce an output signal in response to a touch on the input surface, the output signal corresponding to a biometric characteristic;
[1.c.i]	a button assembly within the opening, the button assembly comprising: an input member having an input surface;
[1.c.ii]	[a button assembly within the opening, the button assembly comprising:]...a biometric sensor positioned below the input member

	and configured to produce an output signal in response to a touch on the input surface, the output signal corresponding to a biometric characteristic;
[1.d]	a seal positioned between a sealing surface of the button assembly and the enclosure;
[1.e]	a flexible conduit coupled to the biometric sensor and configured to transmit the output signal to the processor; wherein:
[1.f]	a portion of the flexible conduit is sandwiched between the seal and the sealing surface or between the seal and the enclosure.
Claim 2	
[2.pre]	The electronic device of claim 1, wherein the button assembly further comprises:
[2.a]	a tactile dome switch configured to compress in response to a press on the input surface;
[2.b]	a plunger positioned below the biometric sensor and above the tactile dome switch, the plunger displacing and compressing the tactile dome switch in response to the press on the input surface;
[2.c]	a retainer defining an aperture housing the plunger;
[2.d]	the retainer defines the sealing surface of the button assembly

Claim 3	
[3.pre]	The electronic device of claim 1, wherein:
[3.a]	the seal includes a gasket and a pressure sensitive adhesive (PSA) layer; and
[3.b]	the portion of the flexible conduit is positioned between the gasket and the sealing surface of the button assembly.
Claim 4	
The electronic device of claim 1, wherein the seal is overmolded around the portion of the flexible conduit.	
Claim 5	
The electronic device of claim 1, wherein the flexible conduit passes through an aperture in the seal.	
Claim 6	
The electronic device of claim 1, further comprising a passage extending from the opening to the enclosed volume, wherein the flexible conduit passes through the passage.	
Claim 7	
[7.pre]	The electronic device of claim 6, wherein:
[7.a]	an enclosure shelf is defined at the bottom of the opening;

[7.b]	the passage is formed in the enclosure shelf;
[7.c]	the seal encircles the passage.
Claim 8	
The electronic device of claim 6, wherein the portion of the flexible conduit encircles the passage.	
Claim 9	
The electronic device of claim 1, wherein the biometric sensor is a fingerprint sensor and the biometric characteristic is a fingerprint.	
Claim 10	
The electronic device of claim 1, wherein: the biometric sensor comprises an array of capacitive sensing elements that are configured to detect either or both of ridges and grooves of a user's finger.	

21. Based on the above, I understand that claim 1 is the only independent claim only independent claim amongst the Challenged Claims and is directed to an *electronic device*² that includes at least the following limitations:

² Claim language referenced in this Declaration is bolded and italicized throughout.

[1.a]³: an enclosure having an enclosed volume and ***an opening formed in a sidewall***;

...

[1.c]: a ***button assembly within the opening***, the button assembly comprising:

[1.c.i] an ***input member*** having an input surface;

and

[1.c.ii] a ***biometric sensor*** positioned below the input member and configured to produce an output signal in response to a touch on the input surface, the output signal corresponding to a biometric characteristic

[1.d] a ***seal*** positioned between a ***sealing surface*** of the button assembly and the enclosure; and

[1.e] a ***flexible conduit*** coupled to the biometric sensor and configured to transmit the output signal to the processor; wherein:

[1.f] a portion of the flexible conduit is ***sandwiched*** between the ***seal*** and the ***sealing surface*** or between the ***seal*** and the ***enclosure***.

See Ex-1001 at 26:64-27:7 (emphasis added)

³ This Declaration adopts the numbering convention applied in the Petition for claim limitations. *See, e.g.,* Pet., 11.

22. The claim language recited in limitations [1.a], [1.c], and [1.c.ii] impose two separate requirements on the *button assembly*. The first requirement is that the *button assembly* comprises *a biometric sensor*. The second requirement is that the *button assembly* is *within [an] opening [formed in a sidewall]*. Additionally, based on a structural arrangement recited in limitation [1.f] for the *seal* and *sealing surface* (recited in limitation [1.d]) and the *flexible conduit* (recited in limitation [1.e]), the *button assembly* also requires that *a portion of the flexible conduit* is *sandwiched* between (a) the *seal* and the *sealing surface*, or (b) the *seal* and the *enclosure*. See Ex-1001, 26:64-27:7.

IV. LEVEL OF ORDINARY SKILL IN THE ART

23. A person of ordinary skill in the art as of the Critical Date of the '619 Patent (hereinafter a "POSITA") would have had at least a bachelor's degree in electrical engineering, mechanical engineering, biomedical engineering, computer engineering, physics, or a related field, and would have had at least two years of relevant work experience with human and machine interfaces, and capture and processing of data or information, including but not limited to physiological information, or equivalents thereof. Less work experience may be compensated by a higher level of education and vice versa.

24. Based on my knowledge, skill, and experiences, I have a good understanding of the capabilities of one of ordinary skill. Indeed, I have taught,

participated in organizations, and worked closely with many such persons over the course of my career. For example, from my industry experience, I am familiar with what an engineer would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience possesses.

Furthermore, I possess those capabilities myself.

V. CLAIM INTERPRETATION

25. I understand the Patent Trial and Appeal Board (“Board”) construes claim terms as having their ordinary and customary meaning to a POSITA at the time of invention (i.e., the same standard used in district court). I have applied this standard in rendering my opinions on claim construction. In addition, I have been asked to assume that the claims are not indefinite.

26. AliveCor has proposed constructions for a term in the Petition. Pet., 5-6. In my opinion, AliveCor’s construction of this term relevant to this proceeding below is not correct. For this reason, I discuss the proper scope for this term below.

A. *Biometric Characteristic*

27. I understand that AliveCor interprets this term to mean “a human characteristic that is so distinctive and measureable [*sic*] that a particular human

individual may be identified.” Pet., 5-6. The portion of the ’619 Patent specification cited by AliveCor describes the following:

A “biometric characteristic” or a “biometric identifier,” as used herein, **may refer to** a human characteristic that is so distinctive and measureable [*sic*] that a particular human individual may be identified. Fingerprints and DNA are example biometric characteristics.

Ex-1001, 5:9-14

28. The ’619 Patent specification includes examples of the “biometric sensor” (which senses the “biometric characteristic”) that includes a “sensor that can identify or determine a human physical characteristic” and “provid[es] an output that corresponds to a biometric characteristic,” such as “fingerprint, palm veins, DNA, heart rate, and blood pressure.” Ex-1001, 4:51-67. In my opinion, “heart rate” and “blood pressure” are embodiments of biometric characteristics that are not included in AliveCor’s proposed construction because they are not sufficiently distinctive to enable identification of a particular human individual.

29. Based on my review, there is no statements in the ’619 Patent specification, or during prosecution, that would have led a POSITA to understand that the *biometric characteristic* should be understood to excluded embodiments disclosed in the ’619 Patent specification.

30. As described in claim 1, a *biometric sensor* is *configured to produce an output signal [corresponding to a biometric characteristic] in response to a touch on the input surface*. A POSITA would have been able to interpret the claim language to understand that it includes embodiments of the *biometric sensor* where “an input (e.g., a touch, a press, or the like) occurs” and a “measure of the input” includes “a measurement of absolute capacitance or capacitance change” to determine, for example, a biometric characteristic of “heart rate.” Ex-1001, 4:51-67; *see also id.*, 8:60-9:10, 10:37-48.

VI. OVERVIEW OF THE ASSERTED PRIORART

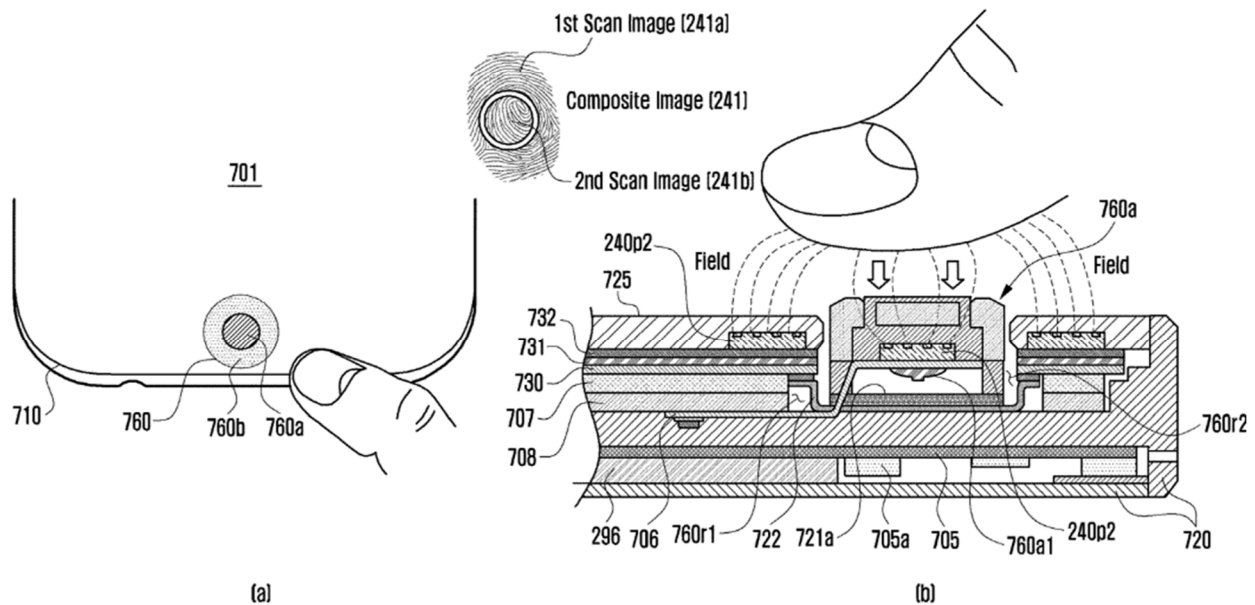
A. Kim (Grounds 1, 2)

31. Kim teaches an electronic device, such as a mobile phone or tablet, including housing 720, a physical button 760a located in an opening of housing 720, and a processor located within housing 720 connected to button 760a. *See* Ex. 1004, Abstr. (“[A] processor located inside the housing and electrically coupled to the display and the mechanical button.”), 4:19–21.

32. Kim’s disclosure is generally focused on providing examples of a “combined button” within an electronic device. Ex-1004, 1:14-16. The “combined button” is a “combined mechanical and virtual button.” *Id.* In various embodiments, the “combined button” is “implemented as a combination of a physical button and a virtual button in response to an increase in screen size...” *Id.*,

2:30-34. One example of such an embodiment of the “combined button” is shown in Figure 10:

FIG. 10

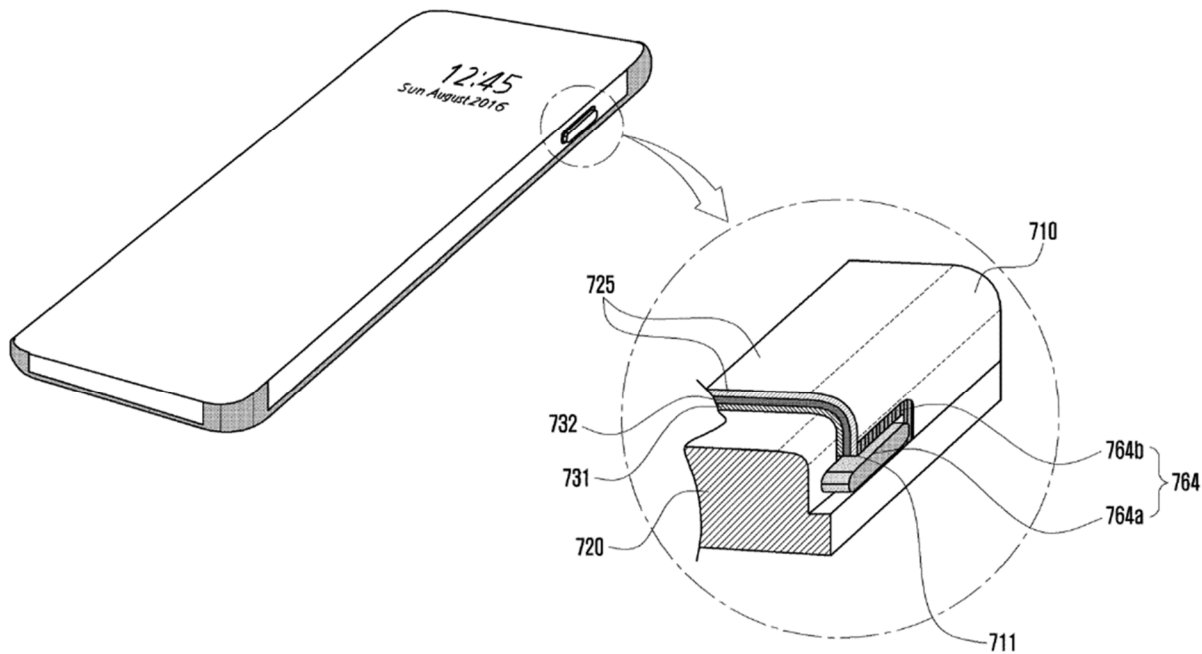


Ex-1004, FIG. 10(a), 10(b)

33. In the Figure 10(a) embodiment, “a circular home button 760 includ[es] a physical button 760a and a virtual button 760b,” which is “implemented as an example of the combined button in the display 710.” Ex-1004, 21:23-26.

34. Another embodiment of the “combined button” is shown in Figure 18:

FIG. 18



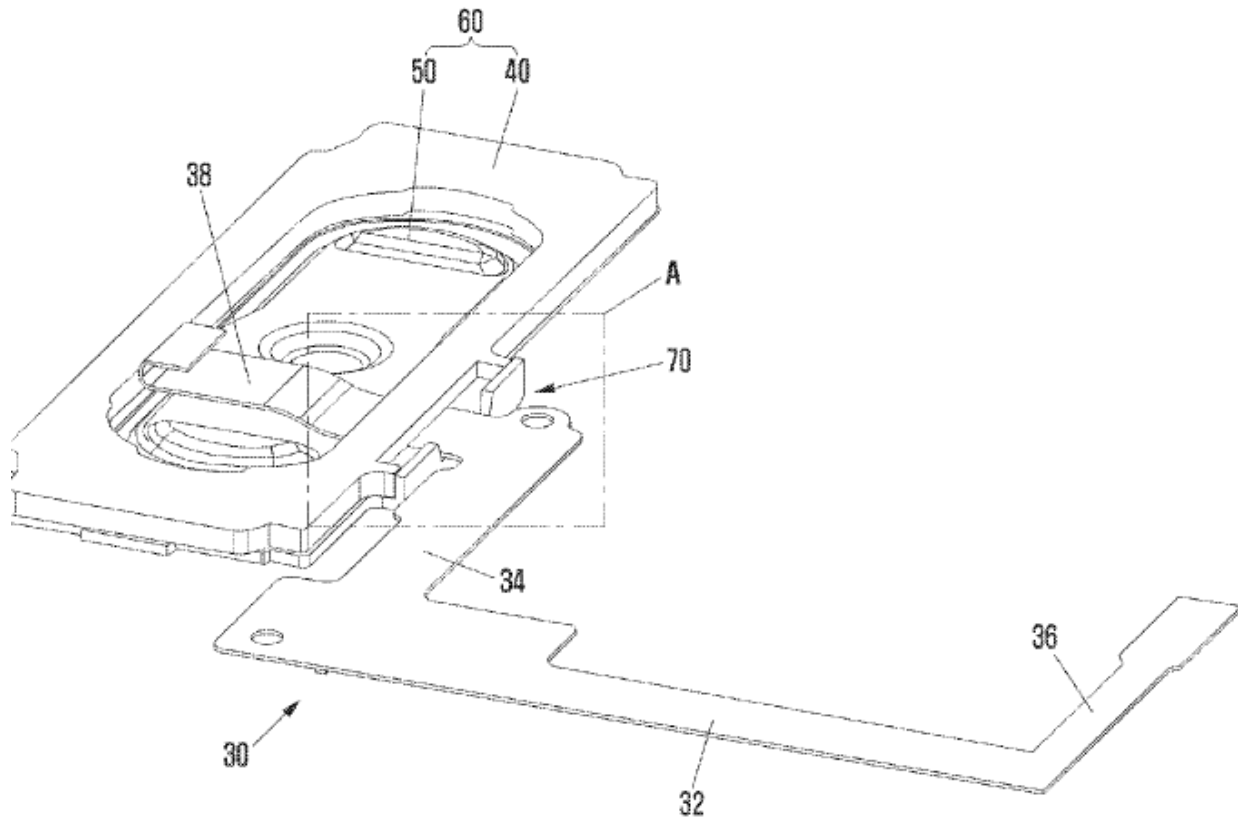
Ex-1004, FIG. 18

In the Figure 18 embodiment, “the combined button is located on the lateral surface (or the back surface) of the electronic device 701.” Ex-1004, 17:23-30.

B. Jung (Ground 3)

35. Jung describes “an electronic device and a method of waterproofing a key” using a “key-waterproof structure.” Ex-1005, Abstract. This structure includes “an insert-injected product that includes an insert-injected sealing area, and a bonding area where a silicon-not-attached portion is formed.” *Id.* Figure 10 shows the insert-injected product to which a flexible printed circuit board is assembled.

FIG. 10



Ex-1005, FIG. 10

C. Myers (Ground 3)

36. Myers describes “structures and methods...for packaging a biometric sensor, such as a capacitive biometric sensor.” Ex-1007, Abstract. Figure 1 shows “an assembly of parts disposed to form the fingerprint recognition sensor 102 circuit and position the sensor 102 circuit below a push button.” Ex-1007, [0042].

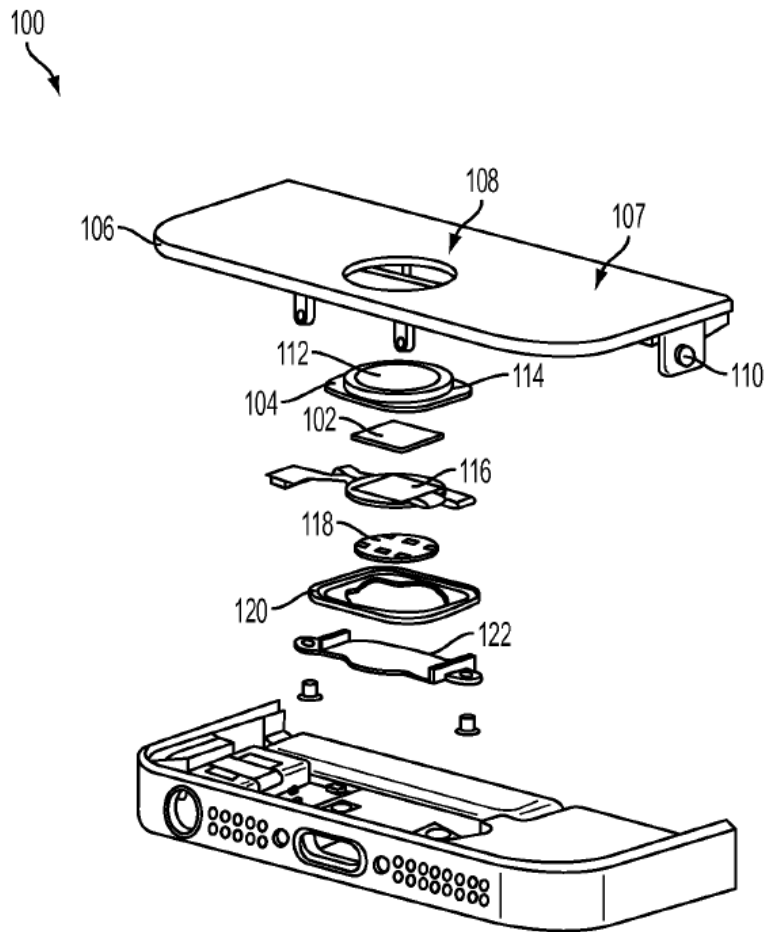


FIG. 1

Ex-1007, FIG. 1

D. Chang (Ground 4)

37. Chang describes an “electronic device including an input device in which an instable waterproof point is removed and a key click feeling is improved with a simple structure.” Ex-1015, 1:54-57. This is accomplished using a “key module,” which may include “a fingerprint recognizing member.” Ex-1015, 2:25-39. Figure 3 shows a “key module 20” with several sub-components, including

button structure 400 (further including cover layer 410, annular structure 430, fingerprint recognizing member 450), flexible conductive member 500, and sealing member 600. Ex-1015, 7:31-8:41.

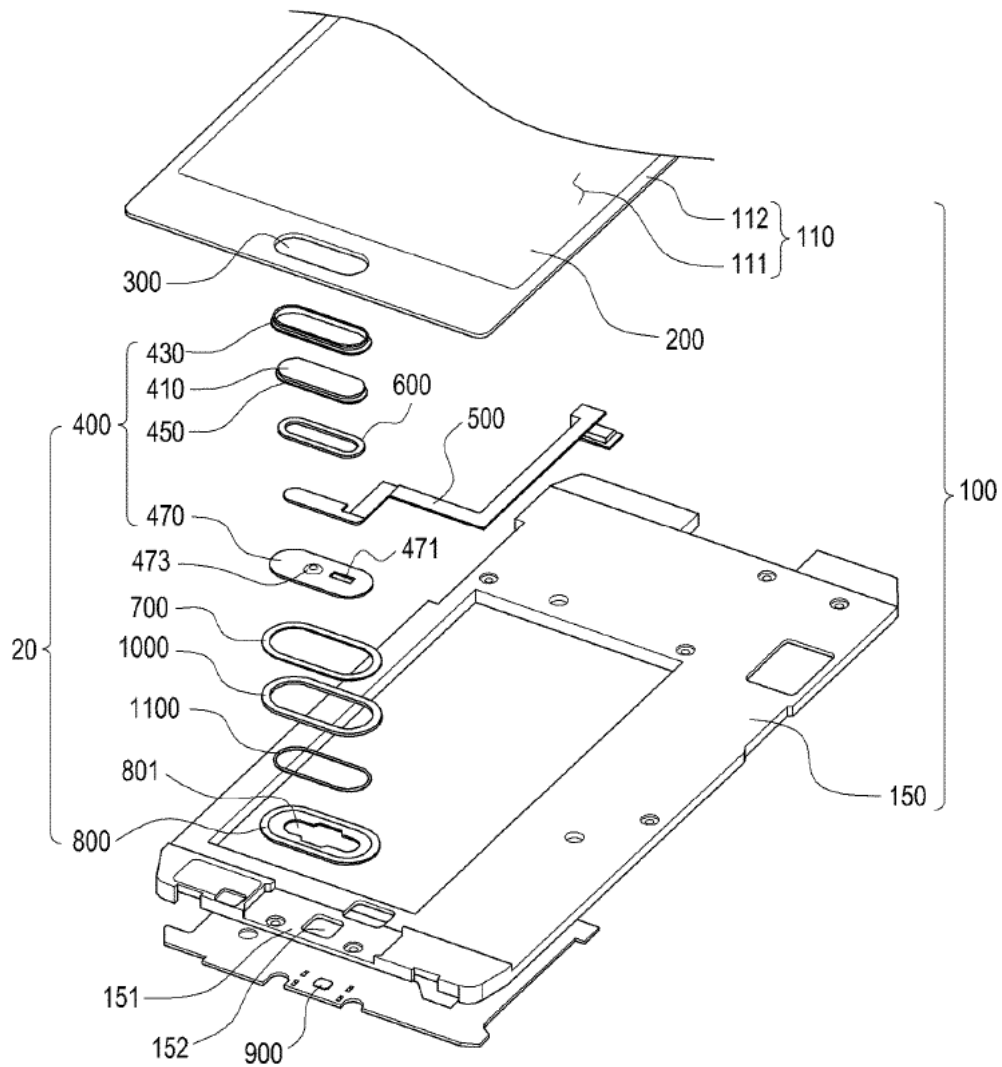


FIG.3

Ex-1015, FIG. 3

VII. ANALYSIS

A. The Asserted Prior Art Does Not Disclose Or Render Obvious The Requirements Of The *Button Assembly* Described In Claim 1 (All Grounds)

38. As explained in Section V.A, the *button assembly* described in claim 1 has three requirements. The first requirement is to comprise a *biometric sensor*. The second requirement is to be *within [an] opening [formed in a sidewall]*. The third requirement is to include a structural arrangement where *[a] portion of the flexible conduit* is *sandwiched* between (a) a *seal* and a *sealing surface*, or (b) the *seal* and the *enclosure*. Each of the prior art references asserted by in the Petition does not satisfy one or more of these requirements.

1. *AliveCor's Anticipation Challenges*

(a) AliveCor's Mappings To Kim Require Combining Distinct Embodiments (Ground 1)

39. The Petition cites Kim's Figure 18 embodiment in addressing limitation [1.a]. *See* Pet., 12, 14. The Petition also cites Kim's Figure 10 embodiment in addressing limitation [1.c]. *Id.*, 16. The Petition then cites both embodiments in addressing limitation [1.c.i]. Based on this, AliveCor's analysis based on Kim requires teachings of both embodiments to address the requirements of the *button assembly*. *Id.*, 17-18 (annotating Figures 10(b) and 18). The Petition assumes the button shown in Figure 10(b) is the same "combined button" shown in Figure 18. Pet., 17 ("Figure 18 shows 'a *combined button*'" and that "Figure 10(b)

shows a ‘cross-sectional view of [the] **combined button**’”). But Kim is clear that Figure 10(b) shows “a cross-sectional view of **a** combined button of an electronic device **according to still another embodiment**”—not the embodiment of Figure 18. Ex-1004, 21:20-22. Dr. Berger also confirmed that Figure 18 shows “a different embodiment” than Figure 10. APPLE-2004, 70:8-9 (“I think Figure 8 shows the button in a different embodiment.”); *see also id.*, 96:9-13.

40. The “combined button” in each of Kim’s Figure 10 and Figure 18 embodiments individually do not address all requirements of the **button assembly**. As summarized in Section V.A, these requirements include (1) comprising a **biometric sensor**, (2) being **within [an] opening [formed in a sidewall]**, and (3) including a structural arrangement where **[a] portion of the flexible conduit** is **sandwiched** between (a) a **seal** and a **sealing surface**, or (b) the **seal** and the **enclosure**.

41. Based on AliveCor’s mapping to **sidewall**, the “combined button” of the Figure 10 embodiment does not satisfy requirement (2) because it is not positioned in **within [an] opening that is formed in a sidewall**. The “combined button” of the Figure 18 embodiment does not satisfy requirement (3) because there is no component representing **a portion of [a] flexible conduit** that is **sandwiched between** components representing (a) **the seal** and **the sealing surface** or (b) **the seal** and **the enclosure**.

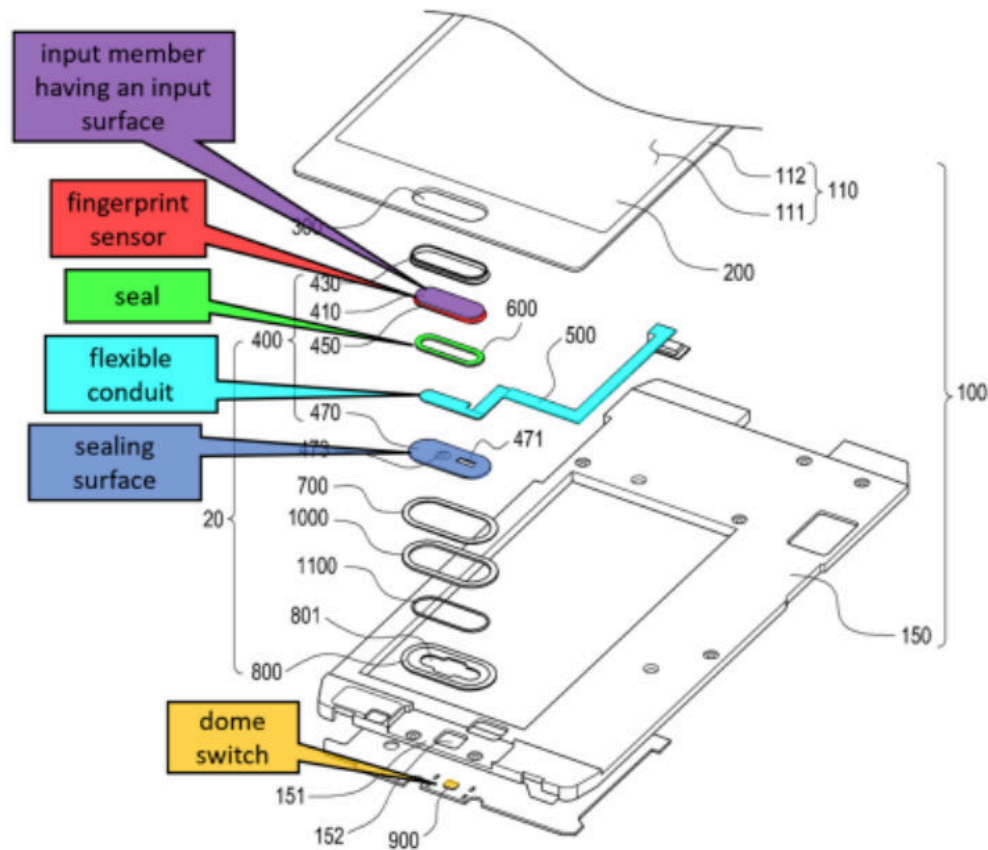
42. AliveCor's characterization of the "combined button" being contemplated in Kim as "a button assembly within an opening formed in a sidewall" is also incorrect. Pet., 14 (citing Ex-1004, 13:46-53, 17:10-12). Kim describes the "combined button" as a button "implemented as a combination of a physical button and a virtual button." Ex-1004, 2:30-34; *see* APPLE-2004, 73:6-20. This description does not equate the "combined button" term to a button assembly with specific components (e.g., fingerprint sensor), or with a specific positioning configuration within an electronic device (e.g., in an opening formed on a lateral surface). Kim's Figure 6 embodiment, for example, includes an example of the "combined button" without a fingerprint sensor. Ex-1004, 16:48-54 (identifying "button 660" as the "combined button").

43. A POSITA would have understood that Kim's usage of the "combined button" term within descriptions of its Figure 10 and Figure 18 embodiments does not itself suggest that Kim contemplates combining the teachings of each embodiment. Kim's description of the "combined button" in relation to Figures 10 and 18 would not have led a POSITA to combine their teachings to arrive at the *button assembly*.

(b) Each of AliveCor's Two Types of Mappings to Chang Are Flawed

44. AliveCor's anticipation challenge in Ground 4 either (a) relies on an embodiment in Chang (without modification) to satisfy the all requirements of the *button assembly* or (b) combines two allegedly "alternative" embodiments of Chang ("the Chang Combination").

45. As to the first challenge (anticipation based on Chang without modification), AliveCor relies on the assembly of Chang's key module shown in Figure 3. See Pet., 81-101.



Pet., 81 (annotations in original)

46. Chang's key module, when assembled, would not have provided an arrangement such that a circular portion of flexible conductive member 500 (mapped to the *flexible conduit*) is *sandwiched* between the sealing member 600 (mapped to the *seal*) and the lower plate 470 (mapped to the *sealing surface*) as required by limitation [1.f]. *See* Pet., 91-101. This is because conductive member 500 (mapped to *flexible conduit*) is not positioned below the sealing member 600 (mapped to *seal*) once Chang's key module is assembled. The arrangement also does not provide any portion of conductive member 500 that is *sandwiched* between the sealing member 600 and the lower plate 470 (mapped to the *sealing surface*).

47. The assembly of the components of Chang's key module (shown in Figure 3) is confirmed by Chang's Figure 10 (below). As shown, in a cross section of the Chang's key module, a portion of conductive member 500 (highlighted in teal) is arranged co-planar with (i.e., not positioned below) the sealing member 600 (highlighted in green) and lower plate 470 (highlighted in blue).

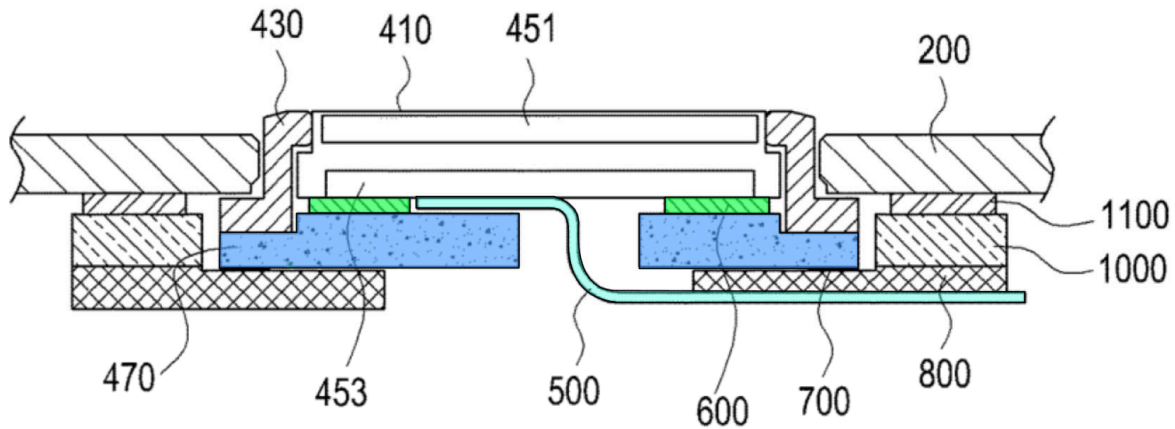
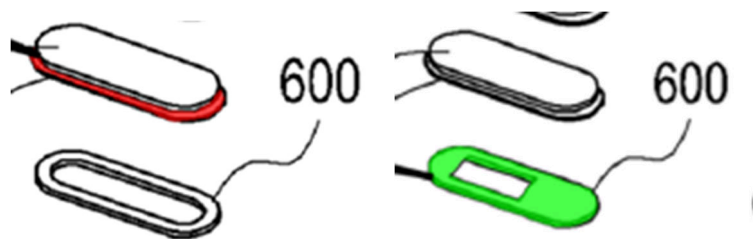


FIG. 10

Ex-1015, FIG. 10 (annotated)

48. As to the second challenge (anticipation based on the Chang Combination), the Petition does not sufficiently address how a POSITA would have arranged elements of Chang to achieve the *button assembly*. The Petition alters the original annular structure of sealing member 600 (below, left) within the key module depicted in Chang's Figure 3 (left, below) with a solid structure includes a rectangular window (right, below):



Pet., 92 (left; annotations in original); Pet., 94 (right; annotations in original)

49. AliveCor states Chang describes an “[a]lternative” embodiment,” but does not explain why a POSITA would performed the specific type of alteration shown above. *See* Pet., 96. According to AliveCor, Chang indicates, “a POSITA would have understood that Chang also teaches a sealing member 600 that is ***not*** designed in an annular or ring shape.” *Id.* (citing Ex-1015, 14:24-29).

50. The cited portion of Chang (reproduced below) does not provide any teaching or suggestion that sealing member 600 may be configured in the specific manner proposed by AliveCor:

According to an example embodiment, the first sealing member 600 may be disposed between the fingerprint recognizing member 450 and the lower plate 470 and/or between the fingerprint recognizing member 450 and the annular structure 430. **Alternatively**, the first sealing member 600 may be designed in an annular shape (e.g., a loop or ring shape), which corresponds to the entire shape of the key module 20 and includes an opening so as to allow the flexible conductive member 500 to extend therethrough.

Ex-1015, 14:20-28; *see id.*, FIG. 3

51. AliveCor implies that the word “[a]lternatively” suggests the possibility of alternative ***shapes*** being contemplated by Chang for sealing member 600. However, the word “[a]lternatively” in the cited portion refers to alternative

arrangements of components (e.g., sealing member 600, recognizing member 450, lower plate 470) within Chang's key module.

52. As explained above, in Ground 4, AliveCor's anticipation challenge is deficient regardless of whether AliveCor relies on Chang's disclosure without modification or on the Chang Combination. The first challenge (based on Chang without modification) is deficient because AliveCor's mapping fails to satisfy the *sandwiched* arrangement recited in limitation [1.f]. The second challenge (based on the Chang Combination) requires combining multiple embodiments within Chang with explanation. The Petition also does not provide any indication as to why or why a POSITA would have arrived at the Chang Combination based on the teachings within Chang.

2. *AliveCor's Obviousness Challenges*

(a) Grounds 1/2—The Kim Combination

53. In Grounds 1 and 2, AliveCor combines Kim's Figure 10 and Figure 18 embodiments ("the Kim Combination"). *See* Pet., 10. The Kim Combination involves positioning the fingerprint sensor assembly of the Figure 10 embodiment on a lateral surface of a device of the Figure 18 embodiment. AliveCor incorrectly assumes that Kim's Figure 10 button is the same button as the Figure 18 button.

54. Kim also does not demonstrate obviousness of the *button assembly* for several reasons. First, Kim's disclosure does not support the combination.

Second, a POSITA would not have been motivated to implement the combination.

Third, a POSITA would not have had a reasonable expectation of success in implementing the combination. Fourth, the combination does not satisfy the requirement of *a biometric sensor positioned below the input member* recited in limitation [1.c.ii]. The Kim Combination is also the product of hindsight, e.g., to satisfy the requirements of *sandwiched* arrangement recited in limitation [1.f] for the *button assembly*.

(i) Kim's Disclosure Does Not Support The Kim Combination

55. AliveCor does not address why a POSITA would have pursued combining the teachings of Figures 10 and 18 to arrive at the Kim Combination. *See* Pet., 11-28. This discussion is also absent in the declaration submitted by AliveCor's expert witness, Dr. Ronald D. Berger.⁴ *See* Ex-1003, ¶¶98-146.

⁴ For example, Dr. Berger states that "*Kim* further contemplates that the "combined button" is a button assembly within an opening formed in a sidewall," but does not explain why a POSITA would have positioned components of the fingerprint assembly within Kim's Figure 10 embodiment into the opening formed in a sidewall. Ex-1003, ¶120. In deposition, Dr. Berger admitted that paragraph 119 of

56. A POSITA would have recognized that Kim clearly and unambiguously indicates that disclosures of Figures 10 and 18 are directed to distinct embodiments. *See, e.g.*, Ex-1004, 17:17-22 (“FIG. 18 shows a perspective view of an electronic device and a partially enlarged view of an indicated area of the electronic device including a combined button of an electronic device **according to one embodiment**”); 21:20-22 (“FIGS. 10(a) and 10(b) show a front view and a cross-sectional view of a combined button of an electronic device **according to still another embodiment**.” Ex-1004, 21:20-22. Each embodiment contemplates a different positioning of the “combined button” within a mobile device. In the Figure 18 embodiment, “the combined button is located on the **lateral surface** (or the back surface) of the electronic device 701” (*id.*, 17:23-30), while in the Figure 10(b) embodiment provides “an example of the combined button **in the display 710**” (*id.*, 21:23-26). AliveCor and Dr. Berger do not address the implications of this difference.

57. Specifically, a POSITA would have understood that button 760 shown in Figure 10(b) cannot simply be taken and used as the button 764 in Figure 18. The buttons have different shapes and sizes, and the surface area of the device at

his declaration modified disclosure from Kim to satisfy the requirements of the ***button assembly*** described in claim 1. APPLE-2004, 92:17-93:12.

the front (Figure 10(b)) and lateral (Figure 18) surfaces of the device is significantly different.

58. The arrangement of enclosure 720 at each button is significantly different with the enclosure 720 in Figure 18 extending to a location adjacent the lower side of the button 764, whereas the enclosure 720 in Figure 10(b) is oriented below and spaced apart from the button 760. In Figure 10(b), the cover glass 725, the display panel 731, and the touch screen panel 732 surround the button 760, whereas these components abut an upper side of the button 764 in Figure 18. In Figure 18, the first and second protective layers 707 and 708 and the force touch panel 730 are missing or at least oriented in a completely different way, which is impactful because the sealing rubber 722 in Figure 10(b) is “adhered to the force touch panel 730.” Ex-1004, 22:17-42. The recesses 760r1 and 760r2 separated by the sealing rubber 722 are missing in Figure 18 and could not be formed in the same way as in Figure 10(b) given the different orientations of the components at the different locations.

59. As such, modifications would be needed in terms of the size and shape of the components of the button assembly, how you seal the button, and how you route electrical connections to the button. AliveCor does not account for these considerations. The Petition also does not explain how a POSITA would have modified the Figure 10(b) button to make it work in the Figure 18 embodiments

and still meet all requirements of the *button assembly*. In my opinion, Kim's disclosure does not suggest using the button 760 of Figure 10 in the Figure 18 embodiment.

(ii) A POSITA Would Not Been Motivated To
Implement The Kim Combination

60. In general, AliveCor's proposed prior art combinations for addressing the *button assembly* element requires a fingerprint sensor assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device.⁵ By the relevant time frame (around 2015-2017, "Relevant Time Frame"), a POSITA would have been aware of several technical complexities associated with this

⁵ This Declaration uses the phrase "front surface" to reference surfaces of an electronic device, e.g., a surface that contains a front display and has a width that coincides to a device width of the electronic device. Reference to "lateral surface," in contrast, refers to surfaces on the side of an electronic device that are perpendicular to a front surface, for example, a surface that has a width representing a device thickness of the electronic device. This is consistent with how such surfaces are referenced in Kim. Ex-1004, 14:1-11, 14:44-53, 14:63-15:13.

modification. These complexities would have discouraged a POSITA to combine the teachings of the asserted prior art in the manner proposed by AliveCor.

61. Around the Relevant Time Frame, a POSITA would have recognized a desire within the portable device industry to reduce device thicknesses of portable electronic devices. APPLE-2005, 2. This desire would have discouraged a POSITA from seeking implementations that increase device thickness, e.g., implementations that require positioning sophisticated fingerprint sensor assemblies (which often have greater space requirements) on the lateral surface of an electronic device. These implementations would have predictably increased device thickness to, for example, accommodate the requisite structures/components of fingerprint sensor assemblies while also maintaining the positioning in the lateral surface of the device.

62. Additionally, around the Relevant Time Frame, a POSITA would have recognized that implementations of fingerprint sensor assemblies that are positioned in a lateral surface of an electronic device have several disadvantages relating to fingerprint recognition and/or detection (relative to fingerprint sensor assemblies positioned elsewhere on an electronic device, such as those positioned in a front surface of the electronic device). For example, a POSITA would have expected touch input surfaces of fingerprint sensor assemblies positioned in a lateral surface of an electronic device to have an asymmetrical (e.g., rectangular)

shape to accommodate positioning in a manner that reduces device thickness but also ensures sufficient surface area for finger contact).

63. In contrast, a POSITA would have expected the touch input surfaces of fingerprint sensor assemblies positioned in a front surface of an electronic device to have a contact surface that is sized such that the smallest dimension is larger than the largest dimension of the finger pad. Such fingerprint sensor assemblies may be implemented to have a contact surface that is shaped to be symmetrical (e.g., circular, square-like) shape given the size of a display similarly positioned on the front surface.

64. A POSITA would have then recognized that contact sensors surfaces used for fingerprint detection and/or recognized that are sized such that the smallest dimension is larger than the largest dimension of the finger pad (e.g., symmetrically-shaped contact surfaces) provide various advantages over asymmetrically-shaped contact surfaces. This includes enabling detecting a fingerprint regardless of orientation of a finger relative to the touch input surface. Another example is that symmetrically-shaped contact surfaces increase the likelihood of capturing distinctive features used for fingerprint recognition, such as the presence of certain minutiae patterns.

65. Another disadvantage of fingerprint sensor assemblies with asymmetrically-shaped contact surfaces is that they often are unable to capture

sufficient information from a single touch input. A contact surface that is smaller in any axis than the finger pad is insufficient to capture a full image of the finger pad with a single touch. A POSITA would have recognized that several well-known techniques were used to address this problem. One example is Pi (APPLE-2006), which describes a “contact from a finger associated with a swipe motion” associated with a “fingerprint detection module having a rectangular share.” APPLE-2006, Abstract. Additionally, it would have been challenging to integrate techniques required to enable on a narrow topology. For example, Oestergaard (APPLE-2007) teaches that conventional fingerprint sensors “require that an interface surface (e.g., a surface that is engaged by a user) have a **generally planar, or otherwise uniform topology**.” APPLE-2007, 1:14-37.

66. Additionally, fingerprint sensor assemblies with asymmetrically-shaped contact surfaces are often unable to capture enough information from a single touch input to accurately detect and/or recognize a fingerprint input. A POSITA would have recognized that such fingerprint sensor assemblies require mechanical (dynamic gesture) input (swiping fingerprint motion) to enable a sufficiently large finger pad area for sufficient fingerprint detection and/or recognition accuracy. One example of such a fingerprint sensor assembly configuration is Pi (APPLE-2006), which describes a “rectangular shaped fingerprint detector module” that is configured to “analyz[e] the partial image of

the finger captured during the swipe motion to determine whether a sufficient portion of the finger was captured to qualify as the registered fingerprint profile of an authorized user.” APPLE-2006, [0006]. Based on the discussion above, where a fingerprint sensor may be implemented in different surfaces of an electronic device, a POSITA would have been motivated to seek an implementation that involves less manufacturing complexity, enables accurate fingerprint detection, and increases flexibility. This would have led the POSITA would to be motivated to implement fingerprint sensor on a front surface of an electronic device over a lateral surface of the electronic device.

67. As for Kim, a POSITA also would not have found the Kim Combination obvious. This is because fingerprint detection by the Figure 10 embodiment requires “compos[ing] fingerprint images 241a and 241b respectively obtained by the first and second fingerprint sensors into a single image 241.” Ex-1004, 21:63-22:3. Kim also does not teach or suggest incorporating this specific sensor configuration into the optional fingerprint sensor of the “combined device” of the Figure 18 embodiment.

68. The most relevant disclosure of the “combined button” of Kim’s Figure 18 embodiment incorporating a fingerprint sensor is the following:

Under the physical button 764a of the power button 764,
a sensor (e.g., a fingerprint sensor) may be disposed. The

fingerprint sensor may include an optical fingerprint sensor, a capacitive fingerprint sensor, or an ultrasonic fingerprint sensor.

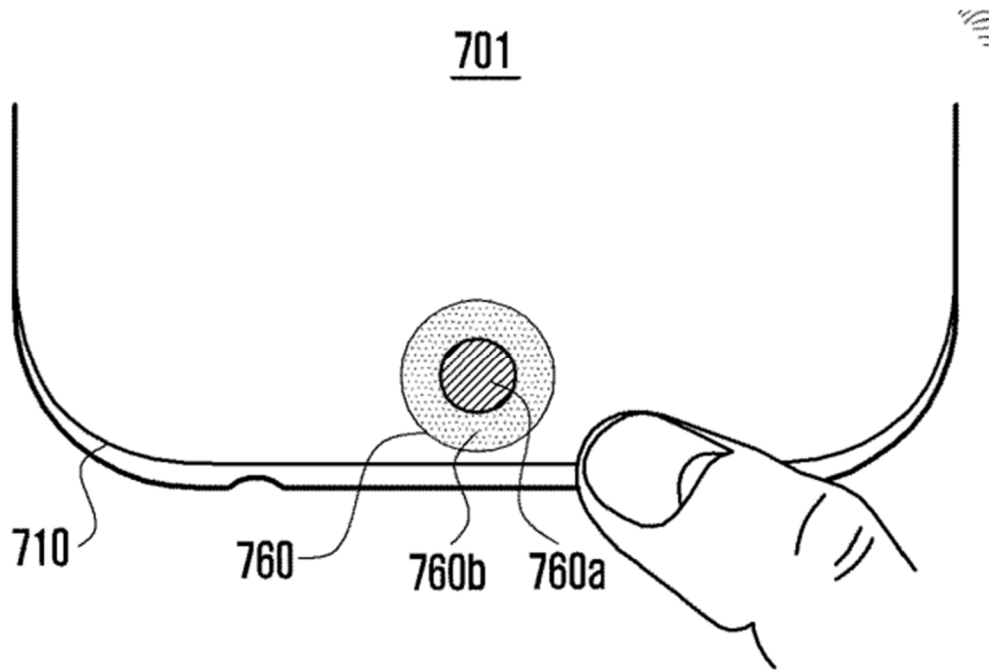
Ex-1004, 19:26-30

While this paragraph describes a fingerprint sensor being integrated in a combined button that is positioned in the lateral surface of an electronic device, there is no indication of the specific assembly structures of Kim's Figure 10 embodiment (e.g., fingerprint sensors 240p1, 240p1) being positioned in the lateral surface. *See generally* Ex-1004, 21:42-22:3. AliveCor does not identify any other disclosure that would have specifically led a POSITA to predict such a configuration. In my opinion, no such disclosure exists within Kim. *See generally* Ex-1004, 19:26-30, 21:42-22:3.

69. Kim does not provide any disclosure or suggestion that incorporating the fingerprint button assembly structures of the Figure 10 embodiment into a lateral surface of an electronic device would have been a predictable configuration. A POSITA would have recognized from Kim's descriptions of its Figure 10 embodiment, which the inclusion of fingerprint sensors 240p1 and 240p2 is critical to the specific type of fingerprint detection technique used by this embodiment. Both sensors are used to collect "fingerprint images 241a and 241b," which are then combined "into a single fingerprint image 241." Ex-1004, 21:63-22:3.

70. Kim also teaches that fingerprint sensor 240p2 is “disposed **between** the cover glass 725 and the touch screen panel 732.” Ex-1004 at 22:18-27. From this disclosure, a POSITA would have recognized that each of fingerprint sensors 240p1 and 240p1 are required within the fingerprint sensor assembly to collect respective fingerprint images 241a and 241b, respectively, in order to generate fingerprint image 241 (which is then used for fingerprint detection and/or recognition). Removing either one of fingerprint sensors 240p1 and 240p1 from the fingerprint sensor assembly would have not only changed how touch input data is acquired, but changed the data processing required for achieving fingerprint detection and/or recognition with sufficient accuracy.

71. The fingerprint sensor assembly of the Figure 10 embodiment also includes a specific arrangement in relation to a device display that is not specifically related to a fingerprint sensor that is positioned on the lateral surface of a device. As shown in Figure 10(a) (below), the fingerprint sensor assembly includes a physical button 760a and a virtual button 760b. *See* Ex-1004, 21:42-22:3; *see also id.*, 17:53-61. Each of buttons 760a and 760b are located on display 710. Additionally, the surface area of virtual button 760b occupied on the display 710 is larger than, and encompasses a surface area of physical button 760a on the display 710.



Ex-1004, FIG. 10(a)

72. Based on the descriptions of Kim discussed above, the Proposed Kim Combination would not have been a predictable combination that naturally results from teachings within Kim. As previously explained, Kim does not specifically include a description that would have suggested to a POSITA that the specific fingerprint sensor assembly structures of the Figure 10 embodiment would have been positioned in a lateral surface of an electronic device. Kim offers several examples of sophisticated fingerprint sensor assemblies, and in each example, the fingerprint sensor assemblies are positioned on a front surface of an electronic device. *See, e.g.*, Ex-1004, FIGs. 7-9, 11, 13, 14. These examples confirm that the

modification required by the Proposed Kim Combination would not have been predictable to a POSITA.

73. As previously noted in paragraphs 60-66, positioning differences of fingerprint sensor assemblies within electronic devices are non-trivial differences, because each implicate different manufacturing processes, sensor designs and constructions, touch input detection mechanisms, among other factors.

(iii) A POSITA Would Not Have Had A Reasonable
Expectation of Success In Implementing The Kim
Combination

74. As previously noted, AliveCor's proposed prior art combinations for addressing the *button assembly* element generally require a fingerprint sensor assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device. *See* ¶60. By the Relevant Time Frame, a POSITA would have been aware of several challenges associated with this modification. These challenges would have prevented a POSITA from reasonably expecting success in implementing the teachings of the asserted prior art, as proposed by AliveCor.

75. A POSITA would have recognized that implementing a button assembly with an integrated fingerprint sensor in a lateral surface of an electronic device would have created unique manufacturing challenges relative to the implementation of a comparable button assembly with a fingerprint sensor in a

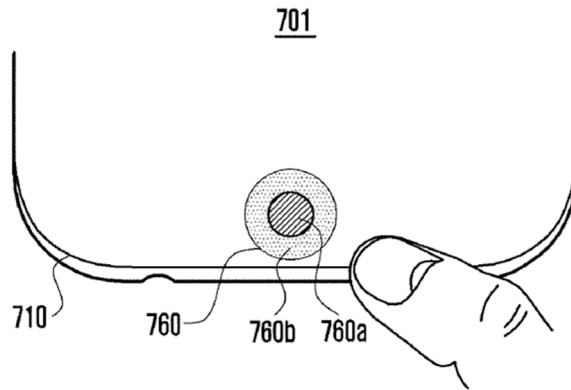
front surface of the electronic device. Around the Relevant Time Frame, sophisticated fingerprint sensors are often relatively large and require significant space, which makes integrating them into the slim sides of a smartphone a challenge.

76. For example, button assemblies positioned in the lateral surface require use of non-planar structures. A POSITA would have known that non-planar gaskets present a range of challenges. Due to their irregular shape, non-planar gaskets are prone to uneven compression when installed between mating surfaces. This can result in inadequate sealing in certain areas, leading to leaks or compromised performance. Installation of non-planar gaskets can also be more complicated compared to their planar counterparts. Achieving uniform compression across the entire gasket surface requires careful handling and precise alignment, which a POSITA would have recognized can increase assembly time. Non-planar gaskets are more susceptible to misalignment during installation, which can create gaps or areas of insufficient compression. These gaps provide pathways for fluids or gases to escape, leading to leakage and potential system failures.

77. A POSITA would have also perceived various challenges involved in implementing the Kim Combination. Implementing the fingerprint sensor assembly of Kim's Figure 10 embodiment in the "lateral surface" of Kim's Figure

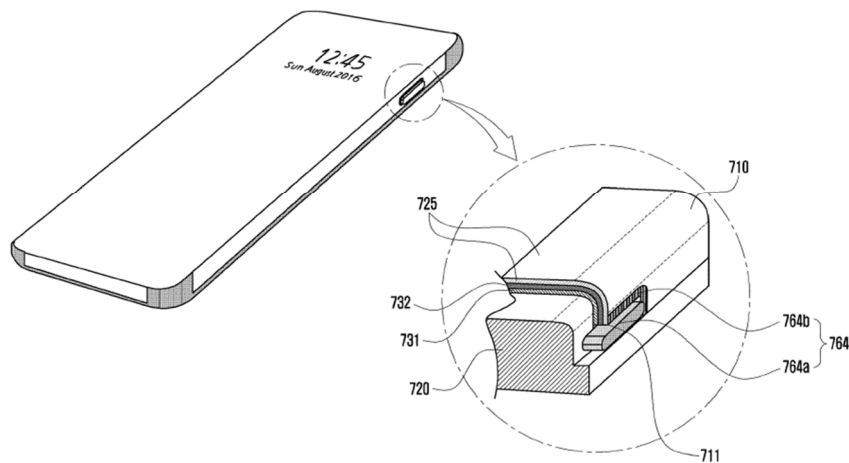
18 embodiment would have complicated the manufacturing process for the resulting mobile device given industry objectives to reduce mobile device thickness around the Relevant Time Frame. APPLE-2005, 2. This desire would have discouraged a POSITA from seeking implementations based on Kim that increase device thickness, e.g., the Kim Combination, which requires positioning the fingerprint sensor assembly components shown in Figure 10 on the lateral surface shown in Figure 18.

78. The positioning of the fingerprint sensor assembly of Kim's Figure 10 embodiment on the lateral surface of a mobile device would have also reduced fingerprint detection and/or recognition accuracy. The positioning would have reduced the surface area available for touch input for fingerprint detection relative to the surface area available for touch input in the Figure 10 embodiment. As shown below, the "front surface" of Figure 10(a) provides the opportunity to implement a fingerprint sensor with a larger surface area for touch input detection relative to the "lateral surface" of Figure 18. *Id.*; see Ex-1004, 17:23-30.



(a)

FIG. 18



Ex-1004, FIG. 10(a) (top), FIG. 18 (bottom)

79. I also agree with Dr. Berger that “capturing a certain amount of surface area may improve [fingerprint detection] accuracy.” APPLE-2004, 103:17-18. A POSITA would have preferred to seek fingerprint sensor implementations that *maximize* surface area for receiving touch input to, for example, increase fingerprint detection and/or recognition accuracy.

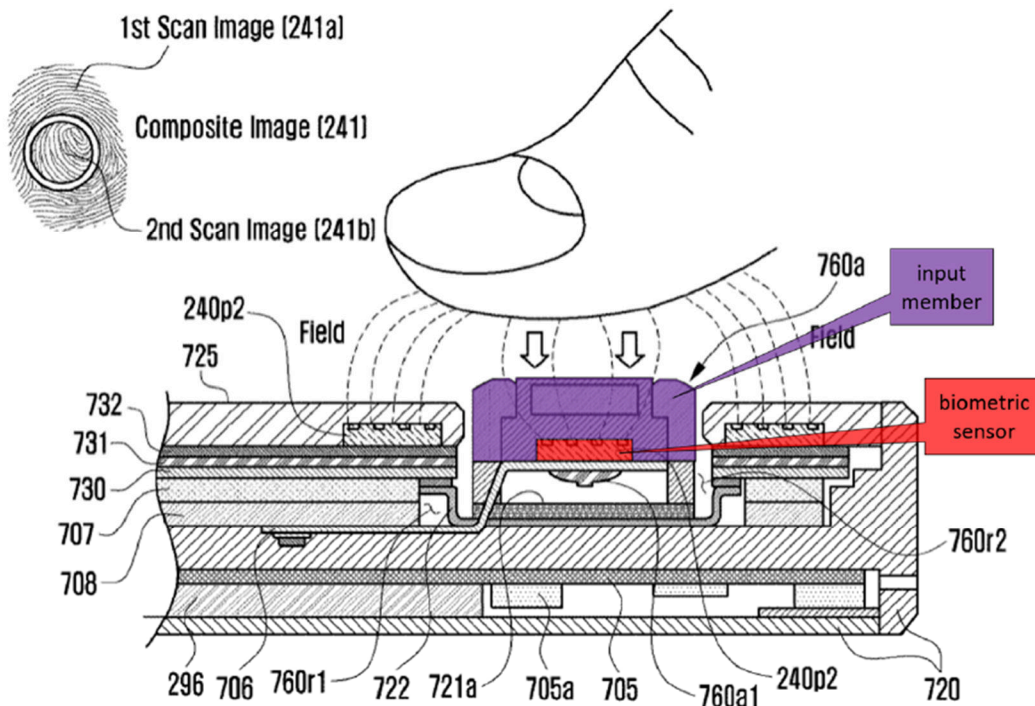
80. A POSITA would have recognized that the more natural positioning of the fingerprint sensor assembly shown in Figures 10(a) and 10(b) would be on the “front surface” of an electronic device and would not be suitable for the lateral surface shown in Kim’s Figure 18. As explained above, placing a fingerprint sensor on small surface (e.g., lateral surface of an electronic device) would necessitate a new sensor design, involve using a different type of user input for fingerprint detection and/or recognition (e.g., from single touch input to swiping touch input), and also require additional complex software and electronics to monitor and account for mechanical scanning of a finger over a smaller available contact surface.

- (iv) The Kim Combination Does Not Satisfy The Requirement Of *A Biometric Sensor Positioned Below The Input Member* Described In Limitation [1.c.ii]

81. In mapping Kim to the biometric sensor described in this limitation, AliveCor identifies only one of two fingerprint sensors (specifically fingerprint sensor 240p2⁶) within the fingerprint sensor assembly of Kim’s Figure 10(b) embodiment.

⁶ Kim’s Figure 10(a) identifies two sets of fingerprint sensor 240p2. As Kim describes that “capacitive fingerprint sensor 240p2” is “embedded in the physical

Ex-1004, Fig. 10(b); Ex-1022, Fig. 10(b)



Pet., 60 (annotations in original)

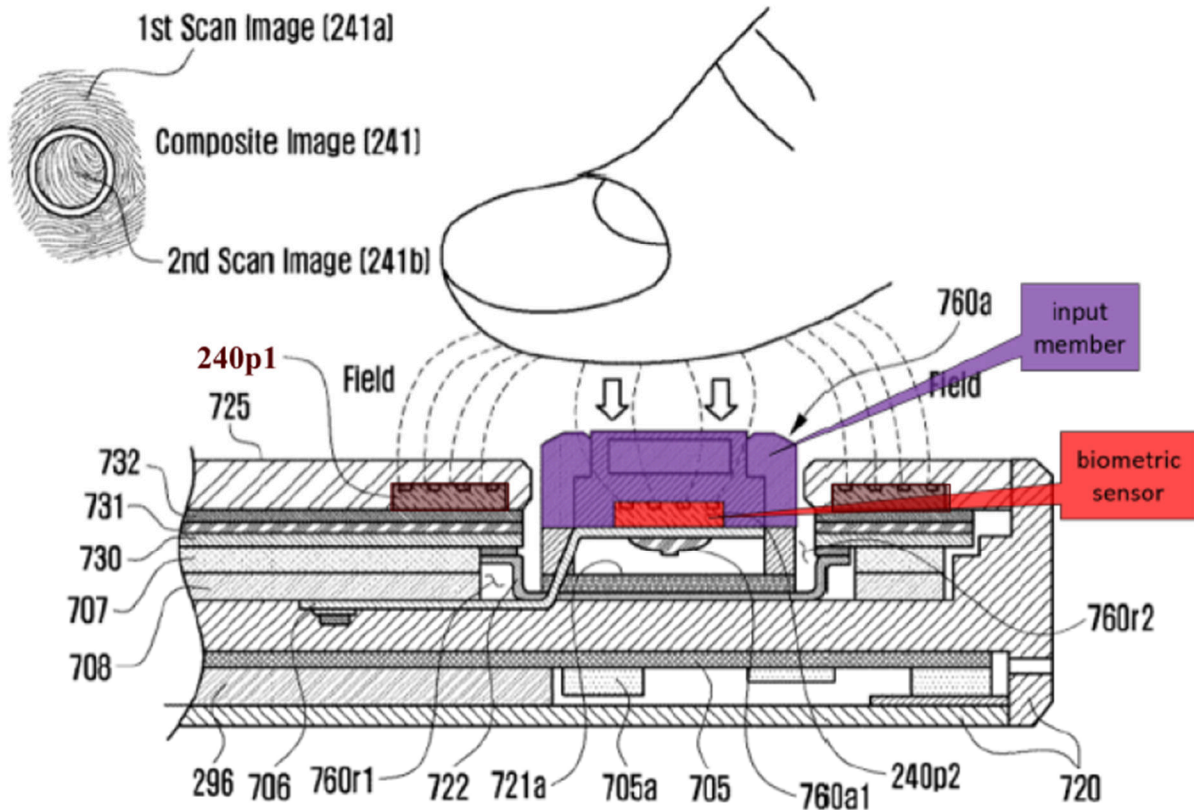
82. If fingerprint sensor 240p1 were included in the mapping to *biometric sensor*, then the Kim Combination would not have satisfied the requirement in limitation [1.c.ii] that the *biometric sensor* be *positioned below the input member*.

As shown below, the fingerprint sensor 240p1 is co-planar with (i.e., not

button 760a,” whereas “optical fingerprint sensor 240p1” is “disposed on the flexible PCB 706.” Ex-1004, 22:14-17. Based on this description, Figure 10(a) is inaccurately labels optical fingerprint sensor 240p1 as “sensor 240p2.”

positioned below) a body representing physical button 760a (which the Petition maps to the *input member*).

Ex-1004, Fig. 10(b); Ex-1022, Fig. 10(b)



Pet., 60 (further annotated to include maroon elements)

83. The omission of fingerprint sensor 240p1 contradicts how a POSITA would have understood functionality of the fingerprint sensor assembly of Kim's Figure 10 embodiment. The fingerprint sensor assembly of Kim's Figure 10 embodiment relies on data collected by each of fingerprint sensors 240p1 and 240p2 to generate a composite fingerprint image. As shown in Figure 10(a) above, electronic device 701 acquires a user fingerprint image "through the first

fingerprint sensor corresponding to the physical button 760a and the second fingerprint sensor corresponding to the virtual button 760b in the home button 760.” Ex-1004, 21:63-22:3. The electronic device 701 “compose[s] fingerprint images 241a and 241b respectively obtained by the first and second fingerprint sensors into a single fingerprint image 241.” *Id.*

(b) Ground 3—The Jung-Myers Combination

84. In Ground 3, AliveCor combines the teachings of Jung and Myers (“Jung-Myers Combination”). *See* Pet., 47. The Jung-Myers Combination involves incorporating Meyer’s button assembly components in a lateral surface of Jung’s device. The Jung-Myers Combination does not demonstrate obviousness of the ***button assembly*** for several reasons. First, a POSITA would not have sought Myers in reviewing Myers. Second, a POSITA would not have been motivated to combine their teachings. Third, the combination does not satisfy the requirement of a ***button assembly within [an] opening [formed in a sidewall]*** recited in limitations [1.a] and [1.c].

(i) A POSITA Would Not Have Sought Myers When Reviewing Jung

85. According to AliveCor, “a POSITA would have turned to *Meyers*” because “Jung does not expressly disclose the structure of its ‘fingerprint sensor’[.]” Pet., 50.

86. When reviewing Jung, a POSITA would not have looked to Myers's disclosure of fingerprint sensor assemblies because Jung does not contemplate any button assembly with an incorporated fingerprint sensor (as recited for the **button assembly** in claim 1). Jung's description of fingerprint sensors is limited to a single paragraph. Ex-1005, [0060]. The discussion of fingerprint sensors within this paragraph is also in the context of a "sensor module 240" and there is no indication that "sensor module 240" corresponds to a physical structure of a button assembly. *See* Ex-1005, [0007], [0090]-[0092], [0097], [0099]-[0103].

87. The button assembly identified in (e.g., "home-key") it not does indicate any benefit that would have been recognized by a POSITA to be provided through incorporation of any fingerprint sensor. *See, e.g.*, Ex-1005, [0007], [0090]-[0092], [0097], [0099]-[0103]. Jung's disclosure of fingerprint sensors is limited to a single paragraph relating to a "sensor module 240." Ex-1005, [0060]. In paragraph [0060], the fingerprint sensor is also identified as one of several examples of various types of sensors. *Id.* The number of sensing elements described in this paragraph would have suggested to a POSITA that Jung does not disclose or suggest specifically incorporating a fingerprint sensor in a home-key (or any other button assembly of an electronic device). A POSITA would have also recognized that it would not have been appropriate for several of the sensors described in paragraph [0060] to be incorporated into Jung's "home-key" (or any

other button assembly of an electronic device). For example, paragraph [0060] identifies a barometer sensor 240C and a temperature/humidity sensor 240J, which would have been understood by a POSITA to not typically be incorporated into the types of button assemblies discussed in the '619 Patent. Jung's disclosure in paragraph [0060] would not have motivated the Jung-Myers Combination because a POSITA would have wanted to look to implementation details to improve Jung's (limited) disclosure of fingerprint sensors.

88. In discussing the Jung-Myers Combination, AliveCor references Myers, which AliveCor and Dr. Berger states "teaches that its **button assembly should be incorporated** in devices using biometric recognition." Pet., 50; Ex-1003, ¶241. This proposal is not consistent with the motivation that a POSITA would have sought the teachings of Myers when reviewing Jung. That is, if a POSITA would have sought to improve Jung by seeking implementation details regarding a fingerprint sensor, AliveCor and Dr. Berger do not to explain the relevancy of a Myers' button assembly since Jung does not teach button assemblies (which the Petition does not expressly contend otherwise). See Pet., 49-51; Ex-1003, ¶¶240-242. AliveCor and Dr. Berger also do not identify any motivation that relating to a gap in Jung that would have led a POSITA to predictably seek teachings outside its disclosure. *Id.*

(ii) A POSITA Would Not Been Motivated To
Combine Jung And Myers

89. As previously noted, AliveCor's proposed prior art combinations for addressing the **button assembly** element generally require a fingerprint sensor assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device. See ¶60. By the Relevant Time Frame, a POSITA would have been aware of several technical complexities associated with this modification. These complexities would have discouraged a POSITA to combine the teachings of the asserted prior art in the manner proposed by AliveCor. See ¶¶60-66 (discussing disadvantages associated with fingerprint sensor assemblies required by AliveCor's proposed combinations).

90. AliveCor contends a POSITA would have combined Jung and Myers to improve Jung's device by seeking implementation details regarding the button assembly structures described in Myers, but its rationale for the Jung-Myers Combination is the opposite. AliveCor states that "**Jung in view of Meyers** discloses and/or renders obvious claims 1, and 3-10 of the '619 Patent." Pet., 47. AliveCor later states "a POSITA would have been motivated to **waterproof Meyers's 'fingerprint sensor' button assembly using Jung's 'key-waterproof structure'**" (Pet., 51; Ex-1003, ¶¶242). AliveCor switches the order of the

primary and secondary references, supporting not the Jung-Myers Combination but instead offering a different motivation for the opposite modification (Myers in view of Jung).

91. AliveCor's depiction of the Jung-Myers Combination shows depicts a modification of Meyer's button assembly (Figure 1 of Myers) to incorporate Jung's key-waterproofing structures (Figure 10 of Jung):

Ex. 1005, Fig. 10; Ex. 1007, Fig. 1

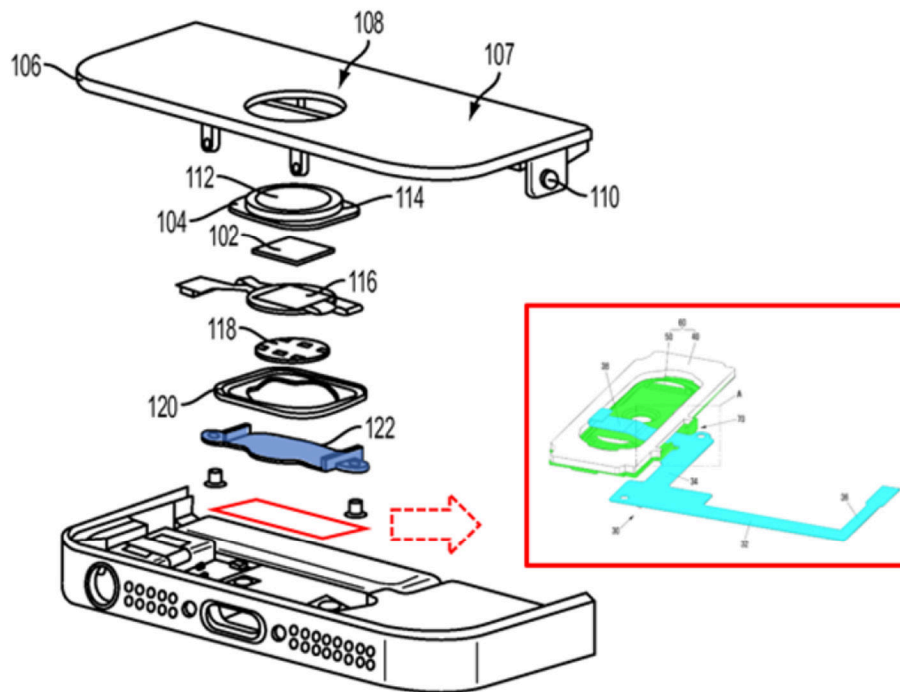


FIG. 1

Pet., 64 (annotations in original)

The only reason to modify Meyer's button assembly in the manner shown above is to achieve satisfaction of the *sandwiched* arrangement described in limitation [1.f]

of claim 1. Myers already proposes a “gasket 1025, such as a silicone gasket” that “may form a seal” and can “prevent dirt, sweat, water and the like from entering the interior of the electronic device.” Ex-1007, [0130]. Based on this disclosure, a POSITA would not perceived any benefit from incorporating Jung’s key-waterproofing structures into its button assembly. Ex-1007, [0130].

(iii) A POSITA Would Not Have Had A Reasonable
Expectation of Success In Implementing the Jung-
Myers Combination

92. As previously noted, AliveCor’s proposed prior art combinations for addressing the *button assembly* element generally require a fingerprint sensor assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device. *See* ¶60. By the Relevant Time Frame, a POSITA would have been aware of several challenges associated with this modification. These challenges would have prevented a POSITA from reasonably expecting success in implementing the teachings of the asserted prior art, as proposed by AliveCor. *See* ¶¶74-76 (discussing challenges associated with fingerprint sensor assemblies required by AliveCor’s proposed combinations).

93. A POSITA would have also perceived various disadvantages involved in implementing the Jung-Myers Combination. Like Kim, Myers teaches that its button assembly is positioned on a front surface of an electronic device (e.g.,

device 100). *See* APPLE-1007, [0041]-[0054]. Implementing Meyer's button assembly in a lateral surface of device 100 would have complicated the manufacturing process for the resulting mobile device, e.g., by requiring use of non-planar structures. As discussed above, a POSITA would have known that non-planar gaskets present a range of challenges (e.g., inadequate sealing, complicated installation, increased assembly time, susceptible to misalignment).

94. The positioning of Meyer's fingerprint sensor assembly on a lateral surface of a device (e.g., Jung's device, or device 100) would have also potentially reduced fingerprint detection and/or recognition accuracy. The types of devices described in Jung and Myers (e.g., smartphones) have a width along the lateral surface that is smaller than a width of the front surface. The positioning of the Jung-Myers combination would have therefore reduced the surface area available for touch input for fingerprint detection (relative to the surface area available for touch input on the front surface). As shown below, the front face of Meyer's device 100 (APPLE-1007, FIG. 1) or Jung's device (*see* Pet., 55 (annotating APPLE-1005, Fig. 4A)) would have provided opportunity to implement a fingerprint sensor assembly with a larger surface area for touch input detection (relative to a fingerprint sensor assembly positioned on a lateral surface).

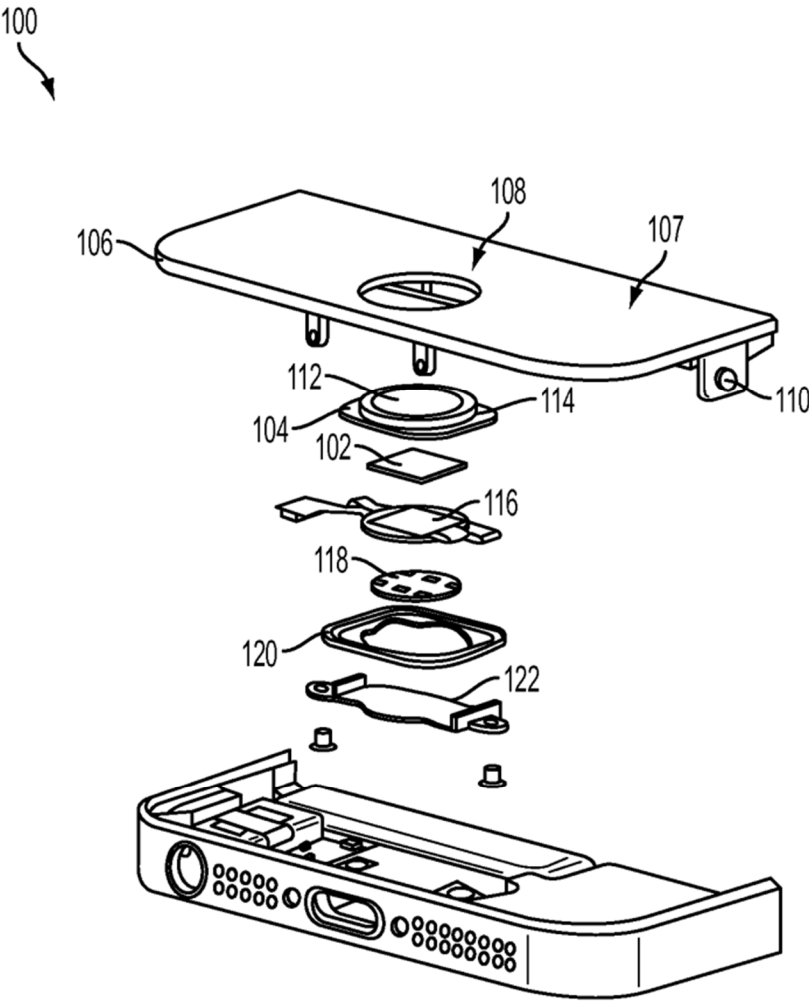
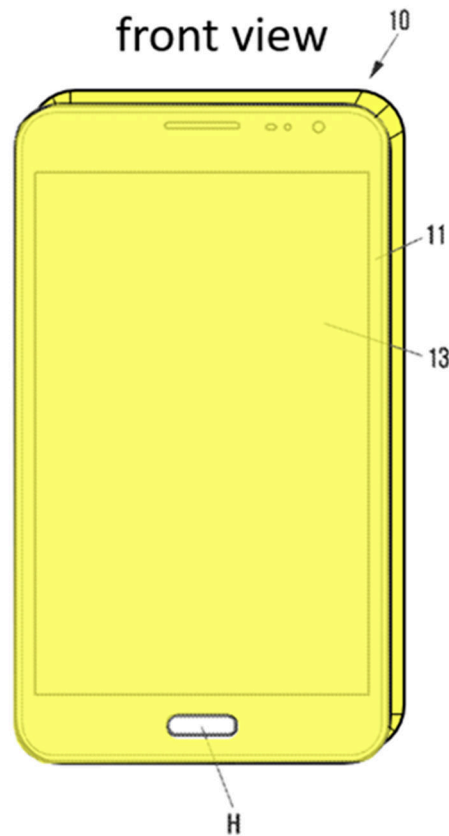


FIG. 1

Ex-1007, FIG. 1



Pet., 55 (original annotation and alteration to APPLE-1005, Fig. 4A)

95. A POSITA would have recognized that the more natural positioning of the fingerprint sensor assembly shown in Meyer's Figure 1 would be on the front surface of an electronic device (as depicted in the figure). As explained above, placing a fingerprint sensor on small surface (e.g., lateral surface of an electronic device) would either necessitate a new sensor design, and additional complex software and electronics to monitor and account for swiping (mechanical scanning) of a finger over a small sensor.

96. Additionally, AliveCor does not explain why, even if a POSITA were to combine the Jung and Myers references (a POSITA would not for the reasons discussed above), the POSITA would have arrived at a configuration where the flexible printed circuit board 30 of Jung is sandwiched between Jung's silicon rubber 50 and Myers' button support plate 122. In Myers, the "fingerprint recognition circuit is disposed above and coupled to a flexible element 116." Ex-1007, [0049]. Myers already discloses a flexible element 116 to provide electrical connection to its button and a POSITA would have found use of Jung's flexible printed circuit board 30 unnecessary.

97. Even if a POSITA would have considered using Jung's flexible printed circuit board 30 to connect to Myers' button, the POSITA would have understood that Jung's flexible printed circuit board 30 would need to be arranged to connect to Myers' button at the same location as the flexible element 116. That location, as shown in Myers' Fig. 1, is clearly above, not below, Myers' button support plate 122. Even if a POSITA would have considered using Jung's flexible printed circuit board 30 to connect to Myers' button, the POSITA would have routed Jung's flexible printed circuit board 30 above Myers' button support plate 122 to the location where Myers' flexible element 116 connects to the button. A POSITA would not have sandwiched it between Jung's silicon rubber 50 and

Myers' button support plate 122, a component to which the flexible printed circuit board 30 would not connect.

98. Additionally, Myers' button support plate 122 holds in place the tactile dome switch 118 and the switch gasket 120. Ex-1007, [0052]. Jung similarly describes "a dome switch (not shown)." Ex-1005, [0100]. In Jung, "the silicon rubber 50 may be pressed by the pressure to thereby apply the pressure to a dome switch (not shown)." *Id.* Through this description, Jung confirms that the dome switch rests under the silicon rubber 50. If a POSITA would have considered adding Myers' button support plate 122 to Jung, the POSITA would have used Myers' button support plate 122 to support Jung's dome switch, resulting in Myers' button support plate 122 being located under the silicon rubber 50. With this configuration, Jung's flexible printed circuit board 30 would not be sandwiched between Myers' button support plate 122 and Jung's silicon rubber 50.

- (iv) The Jung-Myers Combination Does Not Satisfy
The Requirement Of *A Button Assembly Within
[An] Opening [Formed In A Sidewall]* Described
In Limitations [1.a] and [1.c]

99. AliveCor's application of the Jung-Myers Combination does not satisfy the requirements of limitations [1.a] and [1.c]. The Petition also does not to explain how that the button assembly provided by the combination would have been *positioned in an opening [formed in a sidewall]*.

100. AliveCor states that “Jung renders obvious that the enclosure has an opening formed in a sidewall, stating ‘other keys for performing various functions rather than the home-key may be applied to the key-waterproof structure of the present disclosure.’” Pet., 55-56 (citing Ex-1005, [0123]). However, the cited portion of Jung (Ex-1005, [0123]) disclose, teach, or suggest any particular location of a “home-key.”

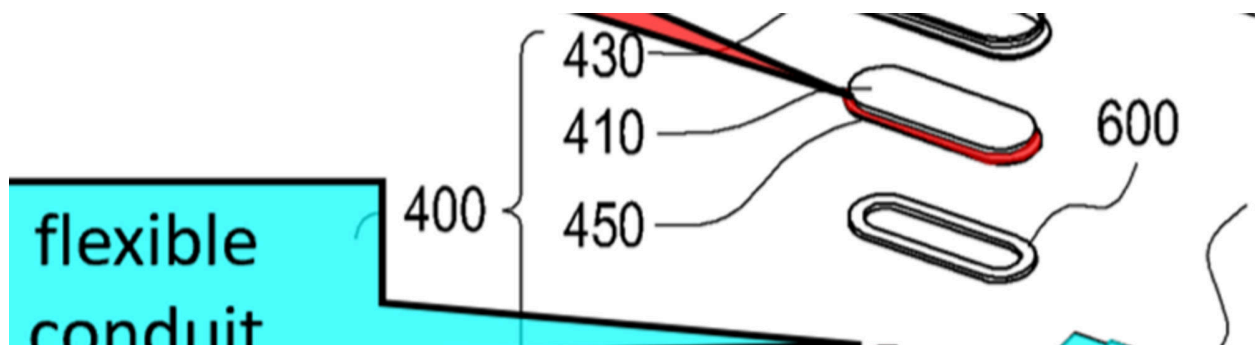
101. AliveCor interprets Jung in addressing the claim language. AliveCor cites to statements from Dr. Berger that “a POSITA would have understood that the key-waterproof structure can be applied to one or more keys and/or buttons, including keys located in the sidewall of the electronic device.” Pet., 56 (citing Ex-1003, ¶¶252-253). Dr. Berger also does not cite to any other reference. In my opinion, the interpretation of Jung that “a person of ordinary skill in the art would understand that the key-waterproof structure can be applied to one or more keys and/or buttons, including keys located in the sidewall of the electronic device” is not correct and supported. A POSITA would have recognized that small dimension and high-radius curves associated with lateral surfaces are challenging to waterproof because complex geometry introduces more sources of dimensional variation.

(c) Ground 4 –The Chang Combination

102. In Ground 4, AliveCor combines “alternative” embodiments that described in Chang (“the Chang Combination”). *See* Pet., 96. The Chang Combination does not demonstrate obviousness of the **button assembly** for several reasons. First, Chang does not support AliveCor’s structural alteration to sealing member 600. Second, a POSITA would not have been motivated to implement the Chang Combination. Third, a POSITA would not have had a reasonable expectation of success in implementing the combination. Fourth, the combination fails to satisfy the **sandwiched** arrangement recited in limitation [1.f].

(i) Chang Does Not Support AliveCor’s Structural Alteration To Sealing Member 600

103. As explained in Section VII.A.1(b), the Chang Combination is based on a structural alteration to sealing member 600. *See* Pet., 96. This alteration relies on a mischaracterization of Chang’s disclosure. As shown below, the structural alteration involves changing the annular shape of sealing member 600 to instead include a rectangular window:



Pet., 92 (excerpted to show original annular structure of sealing member 600 in

Chang's Figure 3)



Pet., 94 (excerpted to show AliveCor's proposed alteration of sealing member 600)

104. AliveCor starts its analysis by paraphrasing of Chang's reference to "[a]lternative embodiments," which, according to AliveCor, indicates "a POSITA would have understood that Chang also teaches a sealing member 600 that is *not* designed in an annular or ring shape." Pet., 96 (citing Ex-1015, 14:24-29). But, when read in its entirety, the cited portion of Chang does not identify any alternative embodiments regarding the shape of sealing member 600:

According to an example embodiment, the first sealing member 600 may be disposed between the fingerprint recognizing member 450 and the lower plate 470 and/or between the fingerprint recognizing member 450 and the annular structure 430. Alternatively, the first sealing member 600 may be designed in an annular shape (e.g., a loop or ring shape), which corresponds to the entire shape of the key module 20 and includes an opening so as to allow the flexible conductive member 500 to extend

therethrough.

Ex-1015, 14:20-28; *see id.*, FIG. 3

105. AliveCor seemingly implies that the word “[a]lternatively” suggests the possibility of alternative *shapes* being contemplated by Chang for sealing member 600. However, Chang uses the word “[a]lternatively” to reference alternative arrangements of components (e.g., sealing member 600, recognizing member 450, lower plate 470) within Chang’s key module.

106. AliveCor also states “a POSITA would have understood that sealing member 600 would be constructed...such that the planar faces are adjacent to both the lower plate 470 and fingerprint recognizing member 450, and the opening is in the shape of the ‘contact points formed on the lower portion [of the fingerprint recognizing member 450] to be electrically contacted with another printed circuit board’ such as flexible conductive member 500.” Pet., 96 (citing Ex-1015, 10:13-21). This statement does not find any support in Chang because the cited portion (Ex-1015, 10:13-21, reproduced below) does not make any reference to the sealing member 600 or its structure:

According to an example embodiment, the circuit region 453 may be disposed below the fingerprint recognizing pad 451. Conductive routes connected at least some of the plurality of conductive lines of the fingerprint recognizing pad 451 may be included. For example, the

circuit region 453 may be a printed circuit board (PCB), and may include a plurality of contact points formed on the lower portion thereof to be electrically contacted with another printed circuit board.

Ex-1015, 10:13-21

107. AliveCor also cites various other portions of Chang, none of which seem specifically relevant to the structure of sealing member 600. *See* Pet., 96-97 (citing Ex-1015, 10:32-42, 10:59-11:3, 11:36-42). These cited portions reference a “sealing member.” It is also not clear how the “design characteristics” discussed by AliveCor are relevant to the altered structure that it proposes for the sealing structure 600 depicted in Chang’s Figure 3. AliveCor’s reference to Chang’s Figure 7A (below) also does not provide support for the proposed alteration because it does not specifically depict sealing structure 600.

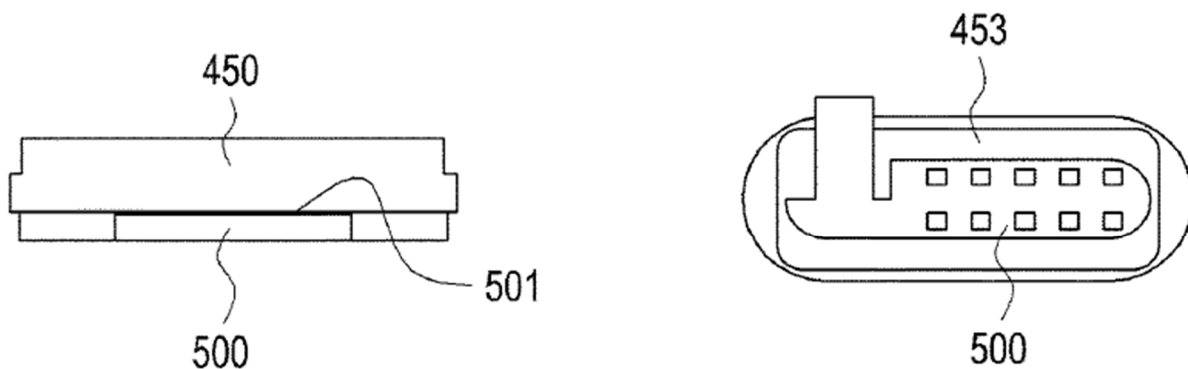


FIG. 7A

Ex-1015, Fig. 7A

Because the portions of Chang that AliveCor relies on to support its proposed alteration of sealing member 600, the Petition's application of Change is based on the *sandwiched* arrangement described in limitation [1.f] for the *button assembly* of claim 1.

(ii) A POSITA Would Not Been Motivated To
Implement The Chang Combination

108. As previously noted, AliveCor's proposed prior art combinations for addressing the *button assembly* element generally require a fingerprint sensor assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device. *See* ¶60. By the Relevant Time Frame, a POSITA would have been aware of several technical complexities associated with this modification. These complexities would have discouraged a POSITA to combine the teachings of the asserted prior art in the manner proposed by AliveCor. *See* ¶¶60-66 (discussing disadvantages associated with fingerprint sensor assemblies required by AliveCor's proposed combinations).

109. Around the Relevant Time Frame, a POSITA would have recognized a desire within the portable device industry to reduce device thicknesses of portable electronic devices. APPLE-2005, 2. This desire would have discouraged a POSITA from seeking implementations that increase device thickness, e.g.,

implementations that require positioning sophisticated fingerprint sensor assemblies (which often have greater space requirements) on the lateral surface of an electronic device. These implementations would have predictably increased device thickness to, for example, accommodate the requisite structures/components of fingerprint sensor assemblies while also maintaining the positioning in the lateral surface of the device.

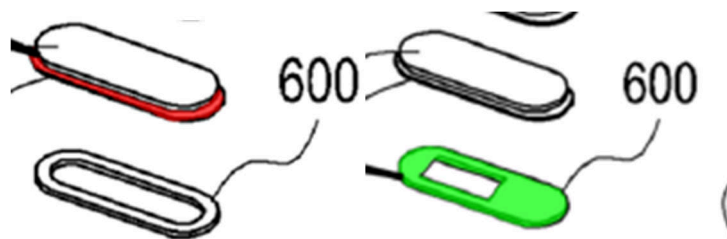
110. Additionally, around the Relevant Time Frame, a POSITA would have recognized that implementations of fingerprint sensor assemblies that are positioned in a lateral surface of an electronic device have several disadvantages relating to fingerprint recognition and/or detection (relative to fingerprint sensor assemblies positioned elsewhere on an electronic device, such as those positioned in a front surface of the electronic device). For example, a POSITA would have expected touch input surfaces of fingerprint sensor assemblies positioned in a lateral surface of an electronic device to have an asymmetrical (e.g., rectangular) shape to accommodate positioning in a manner that reduces device thickness but also ensures sufficient surface area for finger contact).

(iii) A POSITA Would Not Have Had a Reasonable
Expectation of Success In Implementing The
Chang Combination

111. As discussed above, AliveCor's proposed prior art combinations for addressing the *button assembly* element generally require a fingerprint sensor

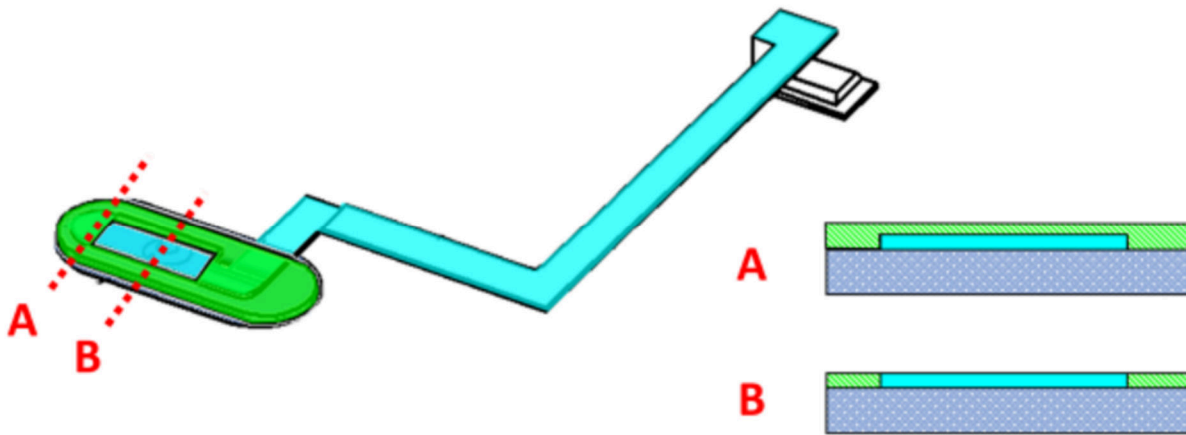
assembly positioned on a front surface of an electronic device to be modified such that the fingerprint sensor assembly is positioned on a lateral surface of the electronic device. *See* ¶60. By the Relevant Time Frame, a POSITA would have been aware of several challenges associated with this modification. These challenges would have prevented a POSITA from reasonably expecting success in implementing the teachings of the asserted prior art in the manner proposed by AliveCor. *See* ¶¶74-76 (discussing challenges associated with fingerprint sensor assemblies required by AliveCor's proposed combinations).

112. A POSITA would have also perceived various challenges involved in implementing the Chang Combination. As discussed above, AliveCor proposes altering the shape and structure of Chang's sealing member 600 from an annular ring (as depicted in Chang's Figure 3) to a solid structure with a rectangular window. The original structure of Chang's sealing member 600 is shown on the left side below, while AliverCor's altered structure of sealing member 600 is shown on the right side below.



Pet., 92 (left; annotations in original); Pet., 94 (right; annotations in original)

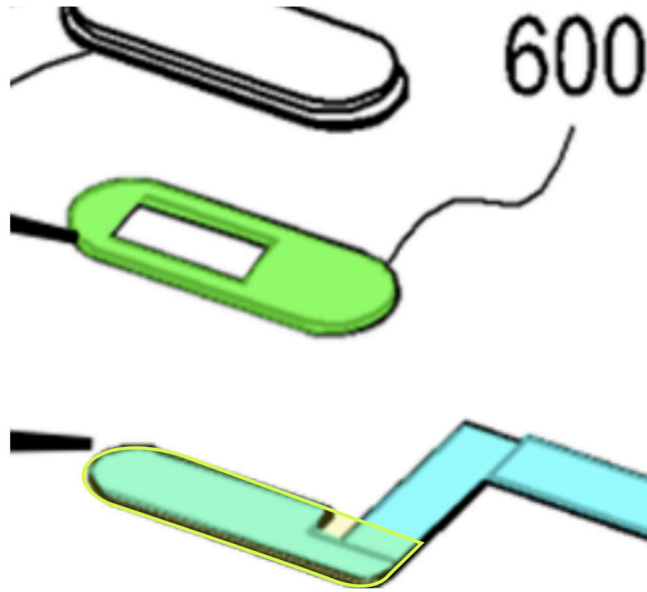
113. Using the altered structure of the sealing member 600, AliveCor then provide the following figure as representing a “condensed configuration” of how the sealing member 600 and flexible conductive member 500 would, according to AliveCor, within the Chang Combination.



Pet., 99

114. As discussed below, a POSITA would have not reasonably expected to succeed in implementing the “condensed configuration” shown above due to several technical hurdles that would have rendered Chang inoperable.

115. For example, the cross sections depicted for the “condensed configuration” shown above, AliveCor’s position seems to be that, in the Chang Combination, the entirety of a circular portion of the conductive member 500 is fit within the rectangular window of the altered sealing member 600. This circular portion of the conductive member 500 is highlighted and outlined in yellow below:



Pet., 98 (excerpt of annotated figure; highlights added)

116. AliveCor is wrong in suggesting (through the portrayal of the “condensed configuration” in the Petition) that the circular portion of the conductive member 500 could have fit within the rectangular window of the altered sealing member 600. The fit of the circular portion of the conductive member 500 in the rectangular window of the altered sealing member 600 within the Chang Combination is vague because AliveCor’s statements do not make clear whether it proposes fitting only a part of the circular portion of the conductive

member 500 within the rectangular window, or if instead, it proposes fitting the entire part of the circular portion.⁷

117. As shown above, the size of the circular portion of conductive member 500 is larger than the size of the rectangular window within the Chang Combination. For a portion of the circular portion of conductive member 500 to fit within the rectangular window, the circular portion of conductive member 500 would need to be further modified to include a raised part that is sized such that it would then be mated with the boundaries of the rectangular window. AliveCor id not provide such a modification of the circular portion of the conductive member 500 within the Petition. *See* Pet., 97-101. As the above-referenced figure confirms, AliveCor proposes *no change* to the surface of the circular portion of the conductive member 500 in the Chang Combination. AliveCor also proposes no change to the shape of the circular portion, as confirmed by the annotated figures included in the Petition.

⁷ AliveCor also does not address the printed circuit board (PCB) portion of the conductive member 500, which extends past the boundaries of the altered sealing member 600. The Petition provides no analysis on how this PCB portion would have been arranged in the Chang Combination.

118. Additionally, for the entire part of the conductive member 500 to be fit within the space/volume defined by the rectangular window of the altered structure of sealing member 600 (shown in the cross-sections “A” and “B” identified in the figure above) without any changes to its top surface, the conductive member 500 would need to be flowable or bulk deformable. This is similar to how a liquid occupies the volume of a container that holds the liquid.

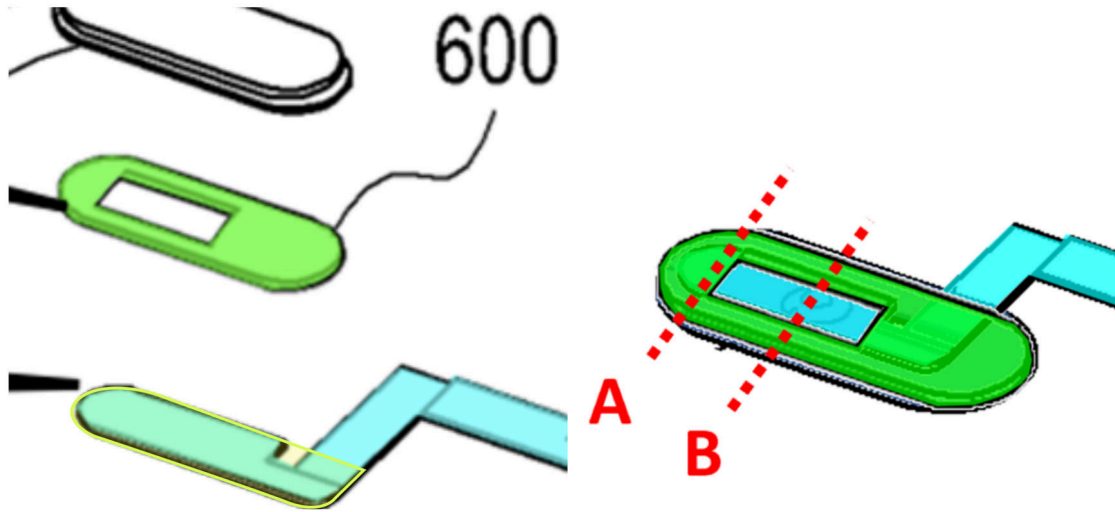
119. Chang does not teach that any portion of the conductive member 500 is flowable or bulk deformable. A POSITA also would not have understood conductive member 500 to be flowable or bulk deformable because Chang describes that flexible conductive member 500 may include “a Flexible Printed Circuit Board (FPCB).” Ex-1015, 12:42-49. A FPCB is typically understood as a component that provides electrical connections in electronic devices, which is designed to bend or flex without breaking. While an FPCB can adapt to various shapes within a device, structures incorporating an FPCB would not be understood to possess the characteristics of a fluid or flowable substance, as its flexibility is limited to mechanical bending (rather than bulk deformation).

120. As explained above, the Petition lacks of detail regarding the precise fitment of the circular portion of the conductive member 500 within the rectangular window of the altered sealing member. Beyond this, AliveCor’s portrayal of the component arrangement of components (including AliveCor’s altered sealing

member 600) within the Chang Combination (via AliveCor's figure of the "condensed configuration" depicted in page 99 of the Petition) is also wrong.

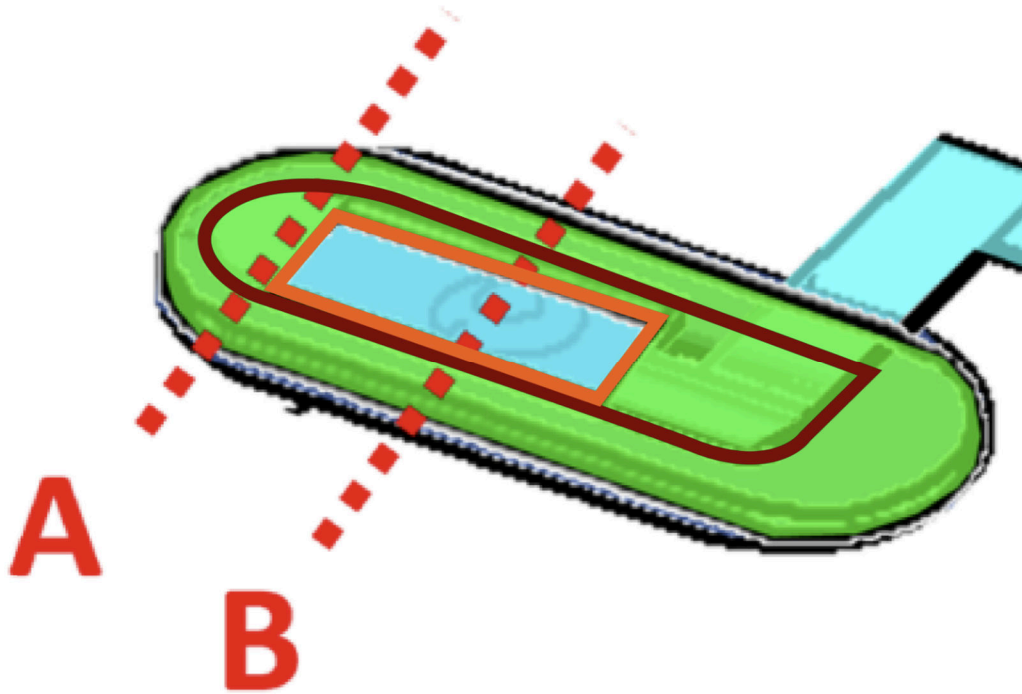
121. As explained above, in the Chang Combination, AliveCor does not propose any alteration to the top surface or shape of a circular portion of the conductive member 500. But if no such alterations are being proposed in the "condensed configuration," then AliveCor still fails to explain how it expects the circular portion of conductive member 500 to fit within the rectangular window of the altered sealing member 600. *See* Pet., 97-101.

122. AliveCor's various portrayals of the Chang Combination seem to contradict themselves. Specifically, while a figure on page 98 of the Petition seems to suggest that the size of the circular portion of conductive member 500 is not being changed, a later-presented figure on page 99 inexplicably changes the size the circular portion of conductive member 500 (when portraying the "condensed configuration") to be smaller than the boundaries of the altered sealing member.



Pet., 98 (left; excerpt of annotated figure; highlights added); Pet., 99 (right; excerpt of annotated figure)

123. As shown in the excerpted figure of the “condensed configuration” above (right), AliveCor appears to have modified the size of the circular portion of the conductive member 500 when positioning the circular portion underneath the altered sealing member 600. And, based on this figure, when the Chang Combination is assembled, the circular portion of the conductive member 500 is required to be positioned below the sealing member 600 because the area defined by its boundaries (outlined below in brown below) is larger than the area provided by the rectangular window (outlined below in orange).

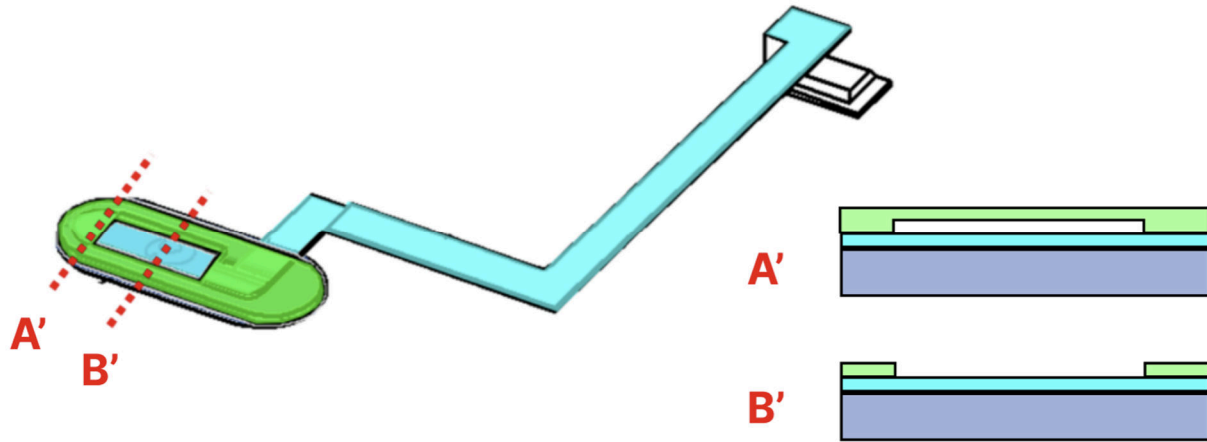


Pet., 99 (excerpt of annotated figure; further annotated to include brown and orange outlines)

124. Based on the above, a POSITA would have recognized that cross sections of the “condensed configuration” shown in page 99 of the Petition are incorrect. Specifically, when assembled, the Chang Combination would not have provided a configuration where “at least a portion of the flexible conduit (teal) is sandwiched between the seal (green) and the sealing surface (blue).” Pet., 99.

125. Instead, based on AliveCor’s portrayal of the “condensed configuration,” on page 99 of the Petition, the components of the Chang

Combination would have actually been assembled as shown in the figure below
("Corrected Chang Combination").⁸



Pet., 99 (modified to depict adjusted cross sections "A'" and B'")

126. As shown above, in section cuts A' and B' of the Corrected Chang Combination, the altered sealing member 600 would have been stacked on top of the conductive member 500 because of size differences between the rectangular

⁸ As explained in Section VII.A.2(c)(i), Chang's disclosure does not support the Chang Combination (advanced by AliveCor in its obviousness ground based on Chang). See Pet., 96. The portrayal of the Corrected Chang Combination responds to AliveCor's portrayal of the "condensed configuration" of the Chang Combination on page 99 of the Petition. Additionally, as explained below, the Chang Combination is not an appropriate configuration of Chang's teachings because it would have rendered the overall disclosure inoperable.

window of the altered structure of the sealing member 600 and the portion of the conductive member adjacent to the sealing member 500.

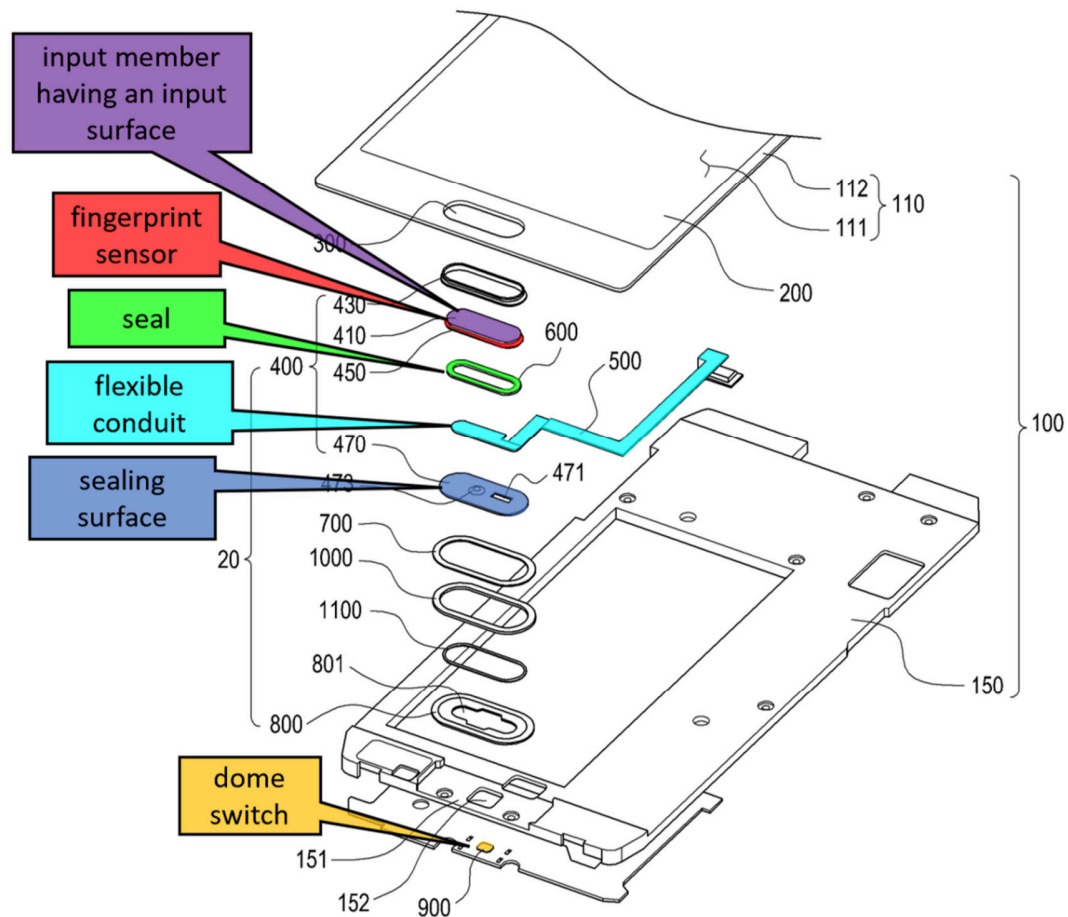
127. Finally, a POSITA also would not have implemented the assembly of the Chang Combination⁹ depicted above because this would have prevented electrical connection to the *conductive* member 500. This is because, as shown in section cuts A' and B' above, the body of the altered structure of the sealing member 600 would have prevented such a connection. *Id.* This configuration would have been understood to be problematic and/or rendered the Chang Combination inoperable based on Chang's disclosure. Ex-1015, 8:31-41, 10:1-21. A POSITA would not have had a reasonable expectation of success in implementing the Chang Combination for the reasons discussed above.

- (iv) The Chang Combination Does Not Satisfy The *Sandwiched* Arrangement Recited in Limitation [1.f]

⁹ The Chang Combination is technically wrong for reasons discussed above. To the extent that a POSITA would have attempted to implement the "condensed configuration" portrayed on Page 99 of the Petition, the POSITA would have actually identified the Corrected Chang Combination based on the analysis in the Petition. *See* Pet., 97-101.

128. The Petition's application of Chang to limitation [1.f] is flawed. The Petition does not establish that Chang's button assembly would have been assembled such that a circular portion of flexible conductive member 500 (mapped to the *flexible conduit*) is *sandwiched* between the sealing member 600 (mapped to the *seal*) and the lower plate 470 (mapped to the *sealing surface*) as required by limitation [1.f]. See Pet., 91-101. This mapping is flawed regardless of whether it includes the original sealing member 600 (depicted in Chang's Figure 3), or AliveCor's altered sealing member 600. As discussed below, the arrangement of components in Chang's button assembly fails to satisfy the *sandwiched* arrangement of limitation [1.f].

Ex. 1015, Fig. 3



Pet., 81 (annotating Chang's Figure 3)

As discussed below, the arrangement of components in Chang's button assembly (i.e., with original sealing member 600) fails to satisfy the *sandwiched* arrangement of limitation [1.f].

129. As for the sealing member 600 depicted in Chang's Figure 3, Chang's key module does not satisfy the requirements of limitation [1.f] because, when assembled, conductive member 500 (mapped to *flexible conduit*) is co-planar (i.e., not positioned below) the sealing member 600 (mapped to *seal*). This arrangement

does not provide any portion of conductive member 500 that is *sandwiched* between the sealing member 600 and the lower plate 470 (mapped to the sealing surface).

130. Chang's Figure 10 (below) confirms the assembly configuration of Chang's key module discussed above. As shown, in a cross section of the Chang's key module, a portion of conductive member 500 (highlighted in teal) is arranged co-planar with (i.e., not positioned below) the sealing member 600 (highlighted in green) and lower plate 470 (highlighted in blue).

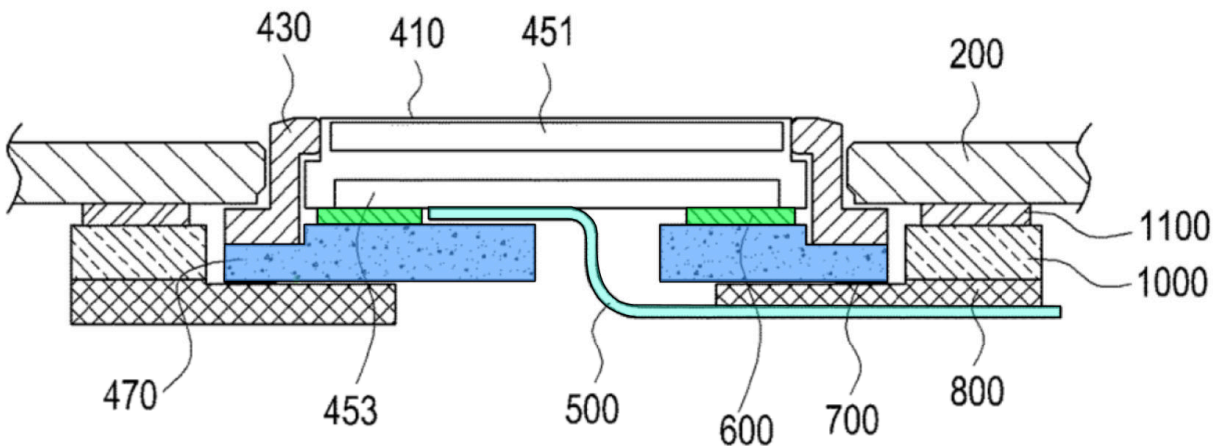


FIG.10

Ex-1015, FIG. 10 (annotated)

B. The Asserted Prior Art Does Not Render Obvious A *Seal* That Is Overmolded As Required By Claim 4 (Grounds 2, 4)

131. The grounds against claim 4 in the Petition do not provide a proper analysis in mapping teachings of the asserted prior art to the claimed requirement that the *seal* (recited in limitation [1.d] of claim 1) is ***overmolded around the portion of the flexible conduit*** (recited in limitation [1.f] of claim 1).

*1. Kim Does Not Render Obvious A **Seal** That Is Overmolded*

132. The Petition does not cite to Kim in mapping to claim 4. *See* Pet., 40-41. AliveCor also relies exclusively on Dr. Berger’s testimony characterizing a POSITA’s knowledge of overmolding as one example of a manufacturing means of effecting the assembly of components. *See* Ex-1003, ¶¶203-209.

133. Specifically, Dr. Berger speculates that “a person of ordinary skill in the art would understand that the seal of Kim **could be** overmolded around the portion of the flexible conduit in order to enhance the quality of the seal” (*id.*, ¶209) because “overmolding, unlike mechanical fasteners such as screws, bolts, snap fit components, etc., provides for a liquid-tight seal, which is essential for waterproofing delicate electronic components” (*id.*, ¶207). But these statements assume a POSITA would have selected overmolding as a manufacturing means of effecting the assembly of components of Kim’s “combined button” assemblies merely because overmolding was understood to “provide[] for a liquid-tight seal, which is essential for waterproofing delicate electronic components.” *Id.*, ¶207.

Dr. Berger does not cite to any supported references regarding the use of overmolding in the assembly of components similar to those disclosed in Kim.

134. Dr. Berger also does not address why a POSITA would have specifically chosen overmolding (amongst several well-known manufacturing means of effecting the assembly of components) in implementing the button assembly structures described in Kim. *See* Pet., 40-41. He also notes “one skilled the art would recognize **many different methods**” that are not overmolding, such as use of “screw[s], bolts, snap fit components, adhesives, press fits, co-molded components” or “ultrasonically welded components, rotational fits, wedge fits, and other manufacturing means of effecting the assembly of components.” Ex-1003, ¶207.

135. While Dr. Berger identifies examples of certain mechanical fasteners, such as “screws, bolts, snap fit components, etc.” as methods that may not provide a “liquid-tight seal,” he omits discussion of methods other than overmolding that may otherwise enable a “liquid-tight seal.” *Id.* Creating water-resistant seals in electronics involves employing various techniques and materials to prevent water ingress and protect sensitive components from damage. In my opinion, a POSITA would not have understood overmolding to be the only manufacturing method that enables a “liquid-tight seal.” As one example, Myers (which is asserted by AliveCor in this proceeding) describes a “silicone gasket” that may form “a seal

between the trim 805 and a housing of the electronic device” such that “[t]he gasket may **prevent** dirt, sweat, **water** and the like from **entering the interior of the electronic device.**” Ex-1007, [0130]. While it teaches a sealed structure that prevents water from entering the interior of the electronic device (i.e., liquid-tight seal), Myers does not teach that within this paragraph construction of the gasket involves overmolding.

136. A POSITA would have also recognized that there are several common techniques used to achieve water resistance in electronic devices that do not involve use of overmolding.

137. One example is gasket sealing, which involves using rubber or silicone gaskets in conjunction with mating surfaces to create a watertight seal. These gaskets are often placed between housing components or around openings like buttons, ports, and connectors.

138. Another example is potting, which involves filling electronic enclosures or components with a liquid resin or gel-like material, such as epoxy or silicone, to protect them from moisture and other environmental hazards. This technique forms a protective barrier around the components, sealing out water and providing mechanical support.

139. Waterproof adhesives and sealants can also be used to bond housing components together, sealing gaps and preventing water infiltration. Other

common examples of creating watertight seals (i.e., liquid-tight seals) include conformal coating, O-Ring seals, ultrasonic welding, among others.

140. AliveCor also points to no prior art disclosure of overmolding in Kim and does not explain how Kim's rubber seal could be constructed as shown through overmolding. A POSITA would not have understood the rubber seal 722 to be overmolded with the flexible PCB 706 in place. At the left and right sides of the rubber seal 722, the edges are raised and form a recess 760r1 that sits between the rubber seal 722 and the flexible PCB 706. If the rubber seal 722 was formed by overmolding as AliveCor defines it, the edges of the rubber seal 722 would not be raised with the recess 760r1 present. Instead, the rubber seal 722 would conform to and take the shape of the structure over which it is overmolded and thus would reside against the flexible PCB 706 for the entire length (i.e., without the recess). Overmolding the rubber seal 722 would not result in the structure shown in Figure 10(b) and a POSITA would not have found it obvious to construct Kim's rubber seal 722 with overmolding, particularly because AliveCor provides no prior art disclosure of overmolding in its ground.

2. *The Jung-Myers Combination Does Not Render Obvious A **Seal** That Is **Overmolded***

141. In mapping to claim 4, AliveCor cites to a single paragraph of Jung (paragraph [0122]) regarding its broad contention that components of the

assemblies provided by the Jung-Myers Combination are formed using overmolding. *See* Pet., 71. AliveCor also relies similar expert testimony characterizing a POSITA's knowledge of overmolding as one example of a manufacturing means of effecting the assembly of components. *See* Ex-1003, ¶¶309-312. This statement is not supported by other references. *See* Pet., 71; Ex-1003, ¶¶309-312.

142. In my opinion, Dr. Berger's testimony also does not establish that the processes in the cited paragraph of Jung accurately represent overmolding. Dr. Berger identifies the following disclosure from Jung in his declaration:

...the electronic device adopting the key-waterproof structure and a method of waterproofing a key, according to various embodiments of the present disclosure, may be made of two processes, such as *a process of forming the silicon-not-attached portion for assembling the flexible printed circuit board in the insert-injected product after* the circuit board bracket and the silicon rubber are *sealed* through the insert injection, and a process of bonding only the silicon-not-attached portion for waterproofing after assembling the flexible printed circuit board through the silicon-not-attached portion.

Ex-1003, ¶307 (citing Ex-1005, [0122]) (italicized emphasis in original, underlined emphasis added)

Dr. Berger then concludes that “[a] person of ordinary skill in the art would understand that the ‘process of forming the silicon-not-attached portion for assembling the flexible printed circuit board in the insert-injected product’ described by Jung is overmolding.” *Id.*, ¶308.

143. In the cited portion of Jung, the process of forming the silicon-not-attached portion (mapped to the *seal* that is *overmolded*) is one that is performed “**after** the circuit board bracket and the silicon rubber are **sealed through the insert injection.**” Ex-1005, [0122]. And, given Dr. Berger’s later statement that “overmolding refers to a technique in which [] [*sic*] one material is molded over a substrate, often by injection” (Ex-1003, ¶309), a POSITA would not have understood Jung’s process of forming the silicon-not-attached portion. Ex-1003, 309. This assembly process is performed *after* sealing through insert injection, which is not the type of overmolding described in claim 4.

144. Dr. Berger ultimately confirmed this in deposition:

...I believe what Jung is saying is that you can have that you can have that printed circuit board, you can have part of the assembly above that, **obviously you are not going to, you are not going to inject into, inject a product that no restraint on it.**

APPLE-2004, 130:22-131:8

Based on this statement, Jung's process of forming the silicon-not-attached portion is not one that involves injection, and is not a process through which a *seal* is *overmolded*, as recited in claim 4.

145. Additionally, the insertion injection discussion in Jung relates to how the flexible circuit board 30, bracket 40, and silicon rubber 50 attach, not how the silicon rubber 50 (seal) is formed and whether it is overmolded on the flexible circuit board 30. As shown in Fig. 5, Jung's flexible circuit board 30, bracket 40, and silicon rubber 50 are all separate structures that are later assembled together. Attaching separately molded/formed components is not overmolding. Also, Jung's flexible circuit board 30 and silicon rubber 50 do not have an injection based connection. As discussed above, Jung's bracket 40 and silicon rubber 50 are sealed with an opening 70 where the flexible circuit board 30 is later inserted. Jung does not describe that its silicon rubber 50 (seal) is formed by overmolding, much less that it is overmolded around the portion of the flexible conduit that sits on top of it.

VIII. LEGAL PRINCIPLES

A. Anticipation

146. I have been informed that a patent claim is invalid as anticipated under 35 U.S.C. § 102 if each and every element of a claim, as properly construed, is found either explicitly or inherently in a single prior art reference. Under the

principles of inherency, if the prior art necessarily functions in accordance with, or includes the claimed limitations, it anticipates.

147. I have been informed that a claim is invalid under 35 U.S.C. § 102(a) if the claimed invention was known or used by others in the U.S., or was patented or published anywhere, before the applicant's invention. I further have been informed that a claim is invalid under 35 U.S.C. § 102(b) if the invention was patented or published anywhere, or was in public use, on sale, or offered for sale in this country, more than one year prior to the earliest effective filing date of the patent application (i.e., the Critical Date). And a claim is invalid, as I have been informed, under 35 U.S.C. § 102(e), if an invention described by that claim was described in a U.S. patent granted on an application for a patent by another that was filed in the U.S. before the date of invention for such a claim.

B. Obviousness

148. I have been informed that a patent claim is invalid as "obvious" under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called "secondary considerations" of non-obviousness, which include: (i) "long felt need" for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results

of the claimed invention, and (iv) “copying” of the claimed invention by others.

For purposes of my analysis above and because I know of no indication to the contrary, I have applied the Critical Date as the date of invention in my above analyses, although in many cases the same analysis would hold true even at an earlier time than the Critical Date.

149. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason to modify the single prior art reference, or combine two or more references, in order to achieve the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved and may be explicit or implicit from the prior art as a whole. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

IX. CONCLUSION

150. I reserve the right to supplement my opinions to address any information obtained, or positions taken, based on any new information introduced throughout this proceeding.

151. I declare under penalty of perjury that the foregoing is true and accurate to the best of my ability.

Curriculum Vitae

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: October 20, 2021

Name:

Brian W. Anthony

Department:

Mechanical Engineering / Institute of Medical Engineering and Science

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

<u>School</u>	<u>Degree</u>	<u>Date</u>
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:
Computational Instrumentation, Medical Device Design and Manufacturing, Innovation and Product Realization, Ultrasound Imaging and Novel uses of Ultrasound

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

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

<u>Employer</u>	<u>Position</u>	<u>Beginning</u>	<u>Ending</u>
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:

<u>Rank</u>	<u>Beginning</u>	<u>Ending</u>
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 Master of Engineering in Manufacturing Program (MEngM)	2006	(present)
Faculty Lead for Education, MIT Skoltech Initiative	2011	2016
Deputy Director, MIT Skoltech Initiative	2014	2016
Associate Director, AIM Academy	2016	2017
Associate Director, MIT.nano	2017	
Faculty Lead for Industry Engagement, MechE	2018	

9. Consulting Record:

<u>Firm</u>	<u>Beginning</u>	<u>Ending</u>
Engagements greater than 3 months.		
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
Apple	2017	

10. Professional Service

<u>Activity</u>	<u>Beginning</u>	<u>Ending</u>
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
MIT's role in reducing the cost of health care	2014	2015

<u>Activity</u>	<u>Beginning</u>	<u>Ending</u>
SPIE Conference Committee	2011	2018
SPIE Conference Committee	2012	2018
Co-Chair Education Workstream, AMP 2.0	2013	2014

11. Awards Received:

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

12. Current Organization Membership:

<u>Organization</u>	<u>Offices Held</u>
ASME	
IEEE	
SPIE	
AIUM (American Institute of Ultrasound in Medicine)	
Sigma Xi	

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. (to be updated)

14. Professional Registration:

N/A.

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

See next.

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

The following is split between a) University Programs or Significant Initiatives, b) Products, and c) Companies.

A. Programs, Centers, or Significant Initiatives

MechE Alliance – Industry Immersion Project Program

The I2P Program provides MechE graduate students with an exclusive opportunity to gain real-world experience working on a 3-to-6 month industry project at a participating company while still enrolled at MIT. Project concepts are first proposed by the company, and then refined and improved by students and their faculty advisors to best suit their academic experience and career interests.

Living Lab in IMES

The Sekisui House at MIT will establish a multi-year and sustained collaboration around specific themes and needs, answer key questions—via targeted projects designed to collect clinically relevant evidence—and generate significant technology innovations. The program will be staffed and operated by clinicians, researchers, and technical instructors, while fostering educational and global exchange between disparate communities, all while highlighting efforts in medical and observational research. The broader MIT community will be engaged with annual workshops and calls for proposals, as well as nominations for faculty and students to join programs surrounding specific themes.

Immersion Lab – MIT.nano

The Immersion Lab is a two-story, state-of-the-art space for research in visualization, augmented and virtual reality (AR/VR), and the depiction and analysis of spatially related data. Housed in MIT.nano, the lab is an open-access research space. The Immersion Lab mission is to propel research and education at MIT by: Providing the community with an array of cutting-edge technologies to facilitate immersive experiences; Broadening interdisciplinary interest in immersive technologies at MIT and promoting collaborations in art, science, and technology; Supporting teaching in enhanced reality and mentoring MIT community members seeking to realize their projects using our facility; Bridging the domains of hardware and software—and encouraging cycles in which advances in one domain spark innovation in the other; Fueling experimentation and research in enhanced reality technologies through seed grants, shared equipment, symposia, and other resources.

MEngM

Former Director of the Master of Engineering in Manufacturing Program, and previously the director of the Singapore MIT Alliance - Manufacturing Systems and Technology Program since 2006. In these roles I have developed an education partnership program with small to multi-national corporations, defined and built the MEngM program and structure for the development and execution of company based projects. I place student groups into companies, teach professional engineering practice in the context of industry based group projects, and broadly define and execute the operations of the MEngM degree program. Between 2007 and 2010, I raised over \$900,000 from our partner companies to support program sponsored student fellowship and program operations.

MEDRC

Co-Founder, Co-Director of the Medical Electronic Device Realization Center (MEDRC). Along with Charlie Sodini, and Joel Voldman, I recruit large Medical Device manufacturing companies, lead research, and engage with the Med Tech community nationally and internationally.

The MEDRC establishes partnerships between the microelectronics industry, the medical devices industry, medical professionals, and MIT faculty, researchers and students to collaboratively achieve improvements in the cost and performance of medical electronic devices. The successful realization of such a vision also demands innovations in the usability and productivity of medical devices, and new technologies and approaches to manufacture devices. The MEDRC is a focal point for large business, for venture-funded startups, and for the medical community.

The unique research methodology of the MEDRC begins with the project definition. Research activities are jointly defined by faculty, physicians and clinicians, and industrial partners. Visiting scientists from microelectronic and medical device companies, physically resident at the Center, provide the industrial viewpoint in the project definitions and participate in the realization of the technology. Prototype systems are developed which are used in clinical tests early in the projects to help guide the research technology being developed in parallel.

To date we have raised significant funding and identified a visiting scientist from GE, Analog Devices, Maxim, Philips, Nihon Kohden, Novartis. Each company commits to \$900,000 over 3 years.

MIT Skoltech Initiative

Deputy Director, and Lead Education, MIT Skoltech Initiative. I served as the education faculty lead in the development of high level curriculum concept for SkolTech Master's degree programs, spanning across domains (space, nuclear, biomedicine, IT, and energy). We develop the education-team collaboration, build consensus on vision, objectives, and plans, and to create education programs for each domain.

AIM Academy

Associate Director of AIM Advance Integrated Photonics Manufacturing Academy. The AIM Photonics manufacturing institute is a public-private partnership that focuses the nation's premiere capabilities and expertise to capture critical global manufacturing leadership in Integrated Photonics technology that is essential to the U.S. economy. In this role I supported community, careers and investment for US world leadership in Integrated Photonics manufacturing. I lead development of a Masters program in Integrated Photonics Manufacturing and development of an Education Factory practice facility.

MIT.nano / SENSE.nano

Associated Director, MIT.nano.

Founding director of first center of excellence at MIT.nano, SENSE.nano. New sensors and sensing systems can provide previously unimaginable insight into the condition of the built and natural world and to positively impact man, machine, and environment. For example, new sensors can provide accessible sensing capabilities important to individual's health and wellness, such as recently-developed nanoparticle-embedded paper strips that can rapidly diagnose Zika, Ebola, and other diseases in a simple color-coded test. Massively distributed networks of sensors enable large-scale, global data collection important to agriculture and water distribution, environment monitoring, disaster recovery, disease outbreak detection and intervention, supply chain operations, and the operations of cities. Nano sciences and technologies offer unprecedented opportunities to realize designs for, and scale manufacturing of, the sensors and sensing technologies required to fundamentally understand and fight diverse challenges. MIT—with comprehensive excellence in engineering, business, earth science, electronics, computation, nanoscience, materials science, neuroscience, chemistry, physics, manufacturing, and biology—is poised

to address the engineering, science, policy, and commercial challenges required to realize these grand, but nano, visions, to translate them to scale, and to positively impact society. MIT.nano is a world-class, nano-capable, shared laboratory facility and provides an open collaborative and cross-disciplinary nexus for advanced research, innovation, and education.

MIT Center for Clinical and Translation Research

Director of Clinical Technology.

The CCTR provides the facilities needed to conduct safe human research - in concert with colleagues in MIT Medical, the VPR Office of Research Compliance, and the Committee on the Use of Humans as Experimental Subjects (COUHES). The Center embodies a three-part mission: addressing critical needs in translational research within medicine, expanding central resources essential to MIT, and enabling external links to outside schools (Tufts University, Harvard University, Harvard Medical School), hospitals, and agencies (e.g. FDA).

Other Significant, formative, Initiatives

SMART Center - March through September 2010

I developed consensus around a theme, built the team of 10 investigators in Singapore and 10 investigators at MIT for a whitepaper and requested full center-proposal for SMART, entitled “*Realization (Design, Manufacturing, and Use) of Injectable Physiological Monitors – Enabling a Patient Centric Information Driven Healthcare Future.*” The research was motivated by addressing the need for unobtrusive, continuous, ambulatory, physiological monitoring of Congestive Heart Failure and Chronic Obstructive Pulmonary Disease patients. The 'state of health' information generated from these sensors can help reduce societal health care costs, improve quality of health care, increase quality lifespan, and lead to new understanding of the human physiology. Our proposal made it to the final round but was not selected. However these efforts lead to the creation of the MEDRC.

Pilot Innovation Manufacturing Institute (IMI) Proposal – May, June 2012

A team (University of Massachusetts Amherst, University of Connecticut, Massachusetts Institute of Technology, the Connecticut Center for Advanced Technology, the Pennsylvania State University, UMass Lowell, United Technologies Corporation, and the National Center for Manufacturing Sciences) proposed to form an independent, non-profit technical center of excellence to accelerate technological progress and innovation in additive manufacturing (AM), in response to the May 8, 2012 Air Force Research Laboratory Broad Agency Announcement (BAA-122-17-PKM) for the NNMI pilot. The NNMI Pilot Institute will demonstrate the value of the kind of collaborative problem-solving and asset-building that could occur on a broader scale with a nation-wide network of Institutes for Manufacturing Innovation. Federal government funding for the 2.5-year pilot program is \$30M with a minimum of \$30M in required cost sharing from industry, state government and universities.

In our center, The Advanced Direct Additive Manufacturing Institute (ADAM-I), we proposed to address key gap-bridging challenges in AM, including: rapid net shape production of structural metal, ceramic and polymer parts, and cost-effective manufacturing of large-area functional materials, components and devices.

Marty Schmidt and I spearheaded the MIT collaboration. We developed the business plan and financial sustainability model for the proposed center. I raised \$3 million in matching fund commitments (10% of the total match commitment).

Flexible Hybrid Electronics Manufacturing Innovation Institute (NextFlex) – October 2015

MIT PI on winning proposal, including a team of : Marc Baldo, Duane Boning, Vladimir Bulovic, Karen K Gleason, David E Hardt, Anastasios John Hart, Sang-Gook Kim.

\$150M national center with a mission to catalyze the development of an ecosystem for manufacturing new forms of electronics that integrate bulk ICs and printed devices with functions such as power, communications, fluidics, and bio-sensing in flexible systems that can bend, fold, stretch, and conform.

B. Products

Fuselage Crack Inspection System for FAA

In support of the Federal Aviation Administration National Aging Aircraft Research Program (NAARP) the state-of-the-art Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) Facility was established at the FAA William J. Hughes Technical Center. A fixture was designed to simulate the actual loads to which an aircraft fuselage structure is subjected while in flight. Data from tests using this fixture was used to experimentally validate analytical theories and methodologies to evaluate and predict the onset of Widespread Fatigue Damage (WFD). Crack growth data from testing was gathered from the Remote Control Crack Monitoring System.

I designed, built, and delivered The Remote Control Crack Monitoring System consisting of a pair of cameras with two different fields of view manipulative by with a large gantry robot. The cameras ‘fly’ over the fuselage surface to identify and track cracks using processed camera images to generate the feedback signal

Laser Wave for Textron

Textron Inc.’s LaserWave[®] products integrated advanced signal processing techniques, robust software algorithms, lasers, optics and ultrasonic technology. The LaserWave Instrument could measure material characteristics such as density, hardness, temperature, thickness, elastic constants and more. LaserWave was developed to measure the temperature of Silicon Wafers undergoing rapid thermal processing and evolved to become a general system for material characterization.

A pulse laser system is used to initiate a circular thermo-elastic Lamb wave. I developed propagation models describing the propagation of the collapsing circular, thermo-elastic, transient Lamb waves. I developed real-time inversion routines using a time-frequency wavelet decomposition to extract and identify group velocity mode shapes. The LaserWave products use models and algorithms that I developed to invert the measured temporal signals in order to estimate elastic constants and material thickness of thin layers.

This product line didn’t fit Textron’s business mode. They transferred the technology to Brown University.

<http://investor.texttron.com/newsroom/news-releases/press-release-details/2003/Texttron-Donates-Laser-Technology-to-Brown-University-Research-Foundation/default.aspx>

Motion Tools for Photron Inc

I designed Photron Motion Tools to operate high-speed PCI cameras. Photron Motion Tools provides users with manual and automatic tracking capabilities. By simply selecting the point of interest within the recorded image sequence, Motion Tools automatically tracks the points-motion within the sequence.

http://www.photron.com/index.php?cmd=product_general&product_id=17

i-Speed for Olympus

Capable of capturing images at speeds from 60 to 150,000 frames per second in 'normal' mode (down to 1 second/frame in 'timelapse' mode) i-SPEED cameras are an effective method of locating problems quickly and easily. The user can evaluate designs, increase productivity and reduce maintenance costs. Video images are digitally captured onto its onboard memory, where they can be written to compact flash card or downloaded via Ethernet connection to a laptop or PC.

I designed custom software to provide the operator with the ability to analyze and enhance images. Velocity and distance measurement can also be calculated. The i-SPEED Software Suite was designed to mirror the ease-of-use and high specification power of the camera range.

<http://www.olympus-ims.com/en/ispeed-software/>

Swing Vision for CBS

I designed and built the Swing Vision camera system, camera control system, camera mounts, the server architecture, and the analysis software. Two high-speed cameras record a golfer t-shot. A 2000 fps camera records the full view of the golfer. A 12500 frame per second camera is used to record the ball-club interaction. As the 2000 fps video is broadcast in slow motion, the 12500 fps video (gigabytes of raw video data) is **automatically** analyzed (in under 20 seconds). The ball is located, used for calibration, and tracked, the club is identified and tracked – all under highly variable condition (variable lighting from shadows, grass, occlusions, etc). The calculated speeds, back spin, and launch angle are sent to the broadcast truck. The results are broadcast in a graphic.

I won an Emmy for this system in 2005.

MiDAS - Xcitex

As Xcitex's first engineer, I developed the core of the flagship products - MiDAS and ProAnalyst. And as CTO and Vice-President of Xcitex, I developed and directed the development of products and solutions for the industrial and scientific video markets.

MiDAS is now the the standard for controlling, synchronizing, and automating digital high-speed and industrial video cameras. With thousands of installations worldwide, MiDAS software is used by researchers, production line engineers, scientists, doctors, and military range operators to convert their video cameras into easy-to-use motion capture systems.

MiDAS includes intelligent triggering, autonomous recording, synchronized video/data collection, large file organization tools. Features such as distance and velocity measurement calipers, auto-tracking, and video triggering are included.
http://xcitex.com/html/midas_description.php

ProAnalyst - Xcitex

As Xcitex's first engineer, I developed the core of the flagship products - MiDAS and ProAnalyst. And as CTO and Vice-President of Xcitex, I developed and directed the development of products and solutions for the industrial and scientific video markets.

ProAnalyst is a software package for automatically measuring moving objects with video. It is used extensively by NASA, engineers, broadcasters, researchers and athletes. ProAnalyst allows users to measure and track velocity, position, size, acceleration, location and other characteristics. Results can be instantly graphed and reviewed, compared against external data, and exported to a variety of output formats for further analysis or presentation purposes.

http://xcitex.com/html/proanalyst_description.php

C. Companies

Xcitex – CoFounder, formerly CTO, formerly Vice-President, Board of Directors

Xcitex was self-funded and grew through solid product development and consistent execution of our business strategy. As Xcitex's first engineer, I developed the core of the flagship products - MiDAS and Pro Analyst. I also describe these products in a document that I include as supplemental material. As CTO and Vice-President of Xcitex, I built the technical team, architected and directed the development of products and solutions for the industrial and scientific video markets. Our products alone fueled our growth from startup to dominant market leader.

dRNOME – CoFounder, Investor, Board of Director

CueVue is a cloud computing and storage service for the scientific video industry - enabling video content query and generalized motion analysis in video content management systems. We provide tools for managing, manipulating, archiving, and searching your scientific video. It removes the necessity for its customers to make heavy investments in expensive hardware and software solutions, removes the overhead required to manage high-volume video needs, and we back this with a service level guarantee.

Dynamic Time and Space Warping (DTSW), an algorithm that I developed for part of my doctoral work is core technology for CueVue - enabling video content query and generalized motion analysis in video content management systems.

dRNOME Inc. (CueVue.com – Launched in February 2011, sold technology in 2014). Our core technologies can be used to perform automated feature recognition of multiple streaming telemetry sources and to extract metadata and make this information available for ongoing operations, forensics, and security. Our products enable multi-camera real-time feature recognition, extraction & tagging automation.

Enumage – CoFounder, Investor, Board of Director

Specializing in Laser Ultrasound.

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 Analytic 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 - μ Fac," 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., Miljkovic, 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.

3. Proceedings of Refereed Conferences:

- 3.1. Dipen N. Sinha, Brian W. Anthony, David C. Lizon, "Swept Frequency Acoustic Interferometry Techniques for Chemical Weapons Verification and Monitoring", Third International Conference On-Site Analysis, (1995).
- 3.2. David E. Hardt, Brian W. Anthony and Shu Beng Tor, "A Teaching Factory for Polymer Microfabrication – muFac", *Proc. 5th International Symposium on Nano-Manufacturing (ISNM)*, Athens, November 12-15, 2008.
- 3.3. Gilbertson, M., Anthony, B., and Sun, S.Y., "Handheld Force Controlled Ultrasound Probe", *J. Med. Devices* 4, 027540 (2010)
- 3.4. Ljubicic, D. M., Anthony, B., "Development of a high-speed profilometer for manufacturing inspection," *Proceedings of SPIE Vol. 7767, 776705* (2010).
- 3.5. Sun, S., Anthony, B. W., Gilbertson, M. W., "Trajectory-based deformation correction in ultrasound images," *Proceedings of SPIE Vol. 7629, 76290A* (2010).
- 3.6. Anthony, B. W., Hardt, D. E., Hale, M., et al., "A research factory for polymer microdevices: muFac," *Proceedings of SPIE Vol. 7593, 75930A* (2010).
- 3.7. Gilbertson, M. W., Anthony, B. W., "Impedance-controlled ultrasound probe," *Proceedings of SPIE Vol. 7968, 796816* (2011).
- 3.8. Ljubicic, D. M., Anthony, B. W., "3D high-speed profilometer for inspection of micro-manufactured transparent parts," *Proceedings of SPIE Vol. 8082, 808211* (2011).
- 3.9. Anthony, B.W, Hardt, D.E., "Revitalizing US Manufacturing to Capitalize on Innovation – Through Education" 119th ASEE Annual Conference, San Antonio TX, June 10-13, (2012)
- 3.10. Anthony, B. W., Namvari, K., "Dimensional variation of polymer substrate electrode production," *Proceedings of SPIE Vol. 8251, 82510G* (2012).
- 3.11. Selvakumar, S., Linares, R., Oppenheimer, A., Anthony, B., "Variation analysis of flow rate delivered using a blister pump," *Proceedings of SPIE Vol. 8251, 82510I* (2012).
- 3.12. Donoghue, L., Anthony, B. W., "Design for manufacture of a micro-interdigitated electrode for impedance measurement in a biochemical assay," *Proceedings of SPIE Vol. 8251, 82510Y* (2012).
- 3.13. Holmes, J., Anthony, B. W., "Robustness and repeatability test of interdigitated electrodes on a polymer substrate in an aqueous environment," *Proceedings of SPIE Vol. 8251, 825110* (2012).
- 3.14. Sun, S.-Y, Anthony, B. W. "Freehand 3D ultrasound volume imaging using a miniature-mobile 6-DOF camera tracking system". 2012 IEEE International Symposium on Biomedical Imaging (ISBI), 2-5 May, (2012).

- 3.15. Gilbertson, M.W., Anthony, B.A., 2012. "Ergonomic Controls Strategies for a Handheld Force-Controlled Ultrasound Probe," 2012 IEEE/RSJ Intelligent Robots and Systems (IROS) Conference. Vilamoura, Portugal. (2012)
- 3.16. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "6-DoF Probe Tracking via Skin Mapping for Freehand 3D Ultrasound". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).
- 3.17. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "Computer-Guided Ultrasound Probe Realignment by Optical Tracking". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).
- 3.18. Inamdar, T., Anthony, B. W., "Characterizing fluidic seals for on-board reagent delivery," Proceedings of SPIE (2013).
- 3.19. Zakrzewski, A., Anthony, B. W. "Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and Experimental Results". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.20. Gilbertson, M. Anthony, B.W., "An Ergonomic, Instrumented Ultrasound Probe for 6-Axis Force/Torque Measurement". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.21. Dhyani, M, Gilbertson, M., Samir, A., Anthony, B.W., "Precise Quantification of Sonographic Forces: A First Step Toward Reducing Ergonomic Injury", 2014 AIUM Annual Convention, (2014).
- 3.22. Koppaka, S., Gilbertson, M., Wu, J., Rutkove, S., Anthony, B. W. "Assessing Duchenne Muscular Dystrophy With Force-controlled Ultrasound". 2014 IEEE International Symposium on Biomedical Imaging (ISBI), (2014).
- 3.23. Koppaka, S., Gilbertson, M., Rutkove, S., Anthony, B. W. "Evaluating the Clinical Relevance of Force-correlated Ultrasound". 2014 IEEE International Symposium on Biomedical Imaging (ISBI), (2014).
- 3.24. J. H. Lee, C. M. Schoellhammer, G. Traverso, D. Blankschtein, R. Langer, K. E. Thomenius, D. S. Boning, B. Anthony, "Towards Wireless Capsule Endoscopic Ultrasound (WCEU)," IEEE International Ultrasonics Symposium (IUS), Chicago, IL, 2014, pp. 734-7.
- 3.25. Zhang, Xiang; Fincke, Jonathan; Kuzmin, Andrey; Lempitsky, Victor; Anthony, Brian, "A single element 3D ultrasound tomography system," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.5541-5544, 25-29 Aug. 2015.
- 3.26. Ranger, Bryan J.; Feigin, Micha; Pestrov, Nikita; Zhang, Xiang; Lempitsky, Victor; Herr, Hugh M.; Anthony, Brian W., "Motion compensation in a tomographic ultrasound imaging system: Toward volumetric scans of a limb for prosthetic socket design," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.7204-7207, 25-29 Aug. 2015.
- 3.27. Lee, John H.; Jimenez, Javier; Xiang Zhang; Boning, Duane S.; Anthony, Brian W., "Ultrasound image-based absolute concentration measurement technique for materials with low scatterer concentration", IEEE International Ultrasonics Symposium (IUS), 2015.
- 3.28. Lee, John H.; Jimenez, Javier; Butterworth, Ian R.; Castro-Gonzalez, Carlos; Shukla, Shiva K.; Marti-Fuster, Berta; Elvira, Luis; Boning, Duane S.; Anthony, Brian W., "Measurement of very low concentration of microparticles in fluid by single particle detection using acoustic radiation force induced particle motion", IEEE International, Ultrasonics Symposium (IUS), 2015.
- 3.29. Anthony, B. W., "Enhanced ultrasound for advanced diagnostics, ultrasound tomography for volume limb imaging and prosthetic fitting," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97900Q (2016).
- 3.30. Fincke, J. R., Feigin, M., Prieto, G. A., Zhang, X., Anthony, B., "Towards ultrasound travel time tomography for quantifying human limb geometry and material properties," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97901S (2016).
- 3.31. Kuzmin, A., Zhang, X., Fincke, J., Feigin, M., Anthony, B. W., Lempitsky, V., "Fast low-cost single element ultrasound reflectivity tomography using angular distribution analysis," 2016 IEEE 13th Int. Symp. Biomed. Imaging, 1021–1024, IEEE (2016).

- 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).
- 3.33. Ranger, B. J., Feigin, M., Zhang, X., Mireault, A., Raskar, R., Herr, H. M., Anthony, B. W., "3D optical imagery for motion compensation in a limb ultrasound system," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97900R (2016).
- 3.34. Zhang, X., Fincke, J. R., Anthony, B. W., "Single element ultrasonic imaging of limb geometry: an in-vivo study with comparison to MRI," Proc. SPIE 9790, 97901R–97901R–7 (2016).
- 3.35. Nguyen, M.M, Graule, M.A., Huang, A.Y, Shamdasani, V., Anthony, B.W., Xie, H., "Ultrasound shearwave elastography with force sensing – integration design and preliminary ex-vivo results.," Proc. Int. Tissue Elast. Conf. 2016 (2016).
- 3.36. Feigin M., Ranger, B., Anthony, B., "Statistical Consensus Matching Framework for Image Registration," IEEE Int. Conf. Pattern Recognition, (2016).
- 3.37. Zakrzewski, A. M., Dhyani, M., Samir, A. E., Anthony, B. W., "Non-Invasive, Non-Occlusive Blood Pressure Estimation Using Ultrasound: Clinical Results (I)," 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (2016).
- 3.38. Anthony, et al, "Arterial Blood Pressure Estimation Using Ultrasound: Results on Healthy Volunteers and a Medicated Hypertensive Volunteer", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., accepted (2017).
- 3.39. Anthony, et al, "Non-Invasive Diagnosis of Non-Alcoholic Fatty Liver Disease (NAFLD) using Ultrasound Image Echogenicity", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., accepted (2017).
- 3.40. Anthony, et al, "Camera-tracking vs. image-based motion compensation in a tomographic limb ultrasound system", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., (2017).
- 3.41. Fincke JR. Imaging cortical bone using the level-set method to regularize travel-time and full waveform tomography techniques. J Acoust Soc Am. Acoustical Society of America; (2017)
- 3.42. Yang H, Nguyen MM, Huang S-W, Shamdasani V, Xie H, Anthony BW. "Simulation, design, and implementation of external mechanical vibration for ultrasound shear wave elastography.", IEEE International Ultrasonics Symposium (IUS) IEEE; 2017.
- 3.43. A. Benjamin et al., "Non-invasive diagnosis of non-alcoholic fatty liver disease (NAFLD) using ultrasound image echogenicity," 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Seogwipo, 2017,
- 3.44. H. Yang, A.Benjamin, B. Anthony, "Simulation of multi-source external mechanical vibration for shear wave elastography," The Journal of the Acoustical Society of America, 142, 2017
- 3.45. Singh, R., Ma, D., Agarwal, A., & Anthony, B. W. (2018). On-chip photonic particle senso. Presented at the SPIE BiOS, San Francisco, CA.
- 3.46. Kundu, I., & Anthony, B. W. . "Imaging the superficial vascular structure for mapping and identification." |SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.47. Kundu, I., Du, X., & Anthony, B. W. (2018). "Imaging platforms for registering and analyzing the skin microrelief structure." Presented at the SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.48. Zakrzewski, A. M., & Anthony, B. W. (2018). Pre-and-Post Exercise Blood Pressure Estimation from Force-Measured Ultrasound: First Results. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
- 3.49. Donk, F., Yang, H., & Anthony, B. W. (2018). Miniaturization of External Mechanical Vibration for Shear Wave Elastography Imaging. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
- 3.50. Chen, M., Li, Q., Karimian, N., Yeh, H., Duan, Y., Fontan, F., ... Samir, A. E. (2018). Contrast-Enhanced Ultrasound to Quantify Perfusion in a Machine-Perfused Pig Liver. Presented at the 2018

40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.

- 3.51. Wang, Y. J., & Anthony, B. W. (2018). Characterization of wave fields using transient motion of microspheres under acoustic radiation force. Presented at the 21st International Symposium on Nonlinear Acoustics, Santa Fe, NM.
- 3.52. Yang, H., Carrascal, C., Xie, H., Shamdasani, V., Anthony, B.W., “Design and Experimental Validation of Miniature External Mechanical Vibrators towards Clinical Ultrasound Shear Wave Elastography”, IUS, 2018.
- 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.

4. Other Major Publications:

- 4.1. Anthony, B.W.; Zarrouati, N.; Ljubicic, D. “Photogrammetric Based Inspection of Polymer Devices”, Singapore MIT Alliance (SMA) Symposium January 2008.
- 4.2. Fitriani, Brian W. Anthony, "Multiscale Dynamic Time and Space Warping" SMA Symposium, January 21-22, 2009.
- 4.3 Anthony, B.W., "Video Analytics – Future is Fast and Distributed", Government Security News (GSN) Guide to Video Surveillance, September 2011. Invited guest column.

4b. Articles in Preparation:

- 4.4 Du, X., Anthony, B., "Rotational Manufacturing Inspection System: Design for Vibration Reduction", target:
- 4.5 Du, X., Anthony, B., "Local-Active-Rotational-Based Super Resolution", target: IEEE Transactions on Pattern Analysis and Machine Intelligence
- 4.6 Ljubicic, D., Anthony, B., "Sensor for Thickness and Lateral Position of a Transparent Web in a Roll-to-Roll Process", target: IEEE Sensors
- 4.7 Feigin M., Ranger B., Anthony B., “Statistical Maximal Consensus Framework for Image Registration with Application to Medical Ultrasound Imaging”, pending submission to IEEE Transactions on Medical Imaging

5. Internal Memoranda and Progress Reports: List chronologically; number each item.

N/A

6. Invited Lectures (as of 2015):

June 2002, “High-speed software synchronizes images and data”, Technology Interview. Vision Systems Design.

June 2003, 2003 “Highspeed Video and Data”, Brian W. Anthony, MIT High-Speed Photography and Videography for Motion Analysis: Systems and Techniques.

June 2003, 2004, 2005, 2006, “Overview of Machine Vision”, Brian W. Anthony, MIT High-Speed Photography and Videography for Motion Analysis: Systems and Techniques.

June 2006, “Video Event Analysis and Video Event Detection - Video Based System Monitoring”. Brian W. Anthony. CSAIL Machine Vision Colloquium.

July 24, 2008, "Computational Imaging Systems," Samsung Electro Mechanical Research, Korea.

May 5, 2009, "Video Instrumentation," LMP Seminar, MIT

January 5-7, 2011, "Automation of a Work Cell for Polymer Microdevice Production: Precise Alignment and Visual Quality Inspection ", The Second Conference on Advances in Microfluidics and Nanofluidics and Asian-Pacific International Symposium on Lab on Chip (AMN-APLOC 2011). Singapore.

February 11, 2011, "The MEDRC," MassMEDIC Board of Directors Meeting. Greenberg Traurig, International Place, Boston.

March 23-25 2011, "New Perspectives – similar problems", S2I2 Workshop on Collection Digitization, Field Museum, Chicago

June 20-22, 2011, "Design, Manufacturing, Information Technology, and Healthcare – enabling an information-driven healthcare future – industry, academia collaborations", Medical Device Manufacturing Summit, Red Rock Casino Resort & Spa, Las Vegas, NV.

July 6, 2011, “Design, Manufacturing, Information Technology, and Healthcare - enabling an information-driven healthcare future – industry, academia collaborations” Korean Institute of Science and Technology.

Nov 13-15, 2011, Invited Keynote Talk, "Medical Device Manufacturing - Helping to revitalize US manufacturing to capitalize on innovation," Medical Device Manufacturing Summit, Amelia Island, Florida

November 18, 2011, Invited Keynote Talk, "Computational Videography in Manufacturing," MIT Center for Biomedical Innovation’s Biomanufacturing Summit: Implementing Innovation in Biomanufacturing: The Hurdles and Opportunities, Bartos Theater, Building E15 MIT.

January 27, 2012, "The MEngM and MEDRC Models and Experiences," MassMEDIC's Workshop on Catalyzing Innovation through Industry/Academic Collaborations.

March 9, 2012, “Computational Enhanced Manufacturing Inspection Systems” Department of Manufacturing Engineering, Ann Arbor, Michigan

March 13, 2012, "Computational Instrumentation - designing systems at the intersection of mechanical engineering, electrical engineering, and computer science," LMP Seminar, MIT

March 15-16, 2012, "Industry, innovation, and entrepreneurship, in graduate education and research," SKTech Education Workshop, Moscow, Russia.

March 27-28 2012, Invited Keynote Talk, "The Inner Beauty of Computational Enhanced Systems,"
Technology Review EmTech India Conference, Bengaluru, India.

June 9, 2012, Invited Moderator, "American Transformations: the Next Industrial Revolution", MIT Graduate
Alumni - Tech Reunions, MIT, Cambridge, MA.

May 22 2013, Invited Speaker, MIT Vienna Conference

June 16, 2013 , Invited Keynote Talk, "Lessons Learned from the MEDRC," EmTech China Conference,
Shanghai, China.

November 13 2013, Invited Speaker, "Microfluidic Devices Manufacturing - Sensing and Instrumentation
Challenges and Opportunities", Lab-on-a-chip Asia, Singapore

October 2013, Invited Speaker, "Have Russia's Innovation Prospects Stalled or Are You Just Not Looking Hard
Enough?", US Russian Business Council (USRBC) Annual Meeting,

January 2015, Keynote, "Limb Imaging" Wayne State University and Karmanos

October 2015, "Medical Device Innovation", Novartis Innovation Summit

(to be updated)

Summary:

	<u>Total</u>	<u>Completed</u>	<u>In Progress</u>
Bachelor's	4	4	0
Master's	32	27	5
MEngM	16	16	0
Engineer's			
<u>Doctoral</u>			
As Supervisor	20	10	10
As Reader	4	3	1

Bachelor's Theses

Johnson, Michael B., "Design of a precise X-Y-Theta nanopositioning optical sensor", June 2009.

Syverud, Brian, "Robotic ultrasound manipulator: calibration of position and orientation measurement system", June 2009.

Chai, Lauren, "Design and Manufacture of arterial phantoms for ultrasound imaging", expected June 2012

Ramos, Javier, "Design of Force Measurement Probe", June 2012

Master's Theses

Fitriani, "Multiscale Dynamic Time and Space Warping", 2008

Zarrouati, Nadège, "A precision manipulation system for polymer microdevice production", 2010

Gilbertson, Matthew Wright, "Handheld force-controlled ultrasound probe", 2010

Sun, Shih-Yu, "Deformation correction in ultrasound imaging in an elastography framework", 2010

Zakrzewski, Aaron, "Multi-scale elastography with application to real-time blood pressure estimation", 2013

Koppaka, Sisir, "Quantitative Ultrasound for DMD progression tracking", (in CDO) 2015

Zhang, Xiang (Shawn), "3D Ultrasound scanning system for muscle deterioration monitoring, prosthetic fitting, and bone density monitoring", 2015

Primack, Willow. "Capacity Optimization of a Warehouse Flow Sortation System", LGO, 2015

Churchill, Hugh E., II, "Impact of lean implementation on cycle-time and efficiencies within Amazon soft-lines fulfilment", LGO, 2015.

Sazdanoff, Nicholas, "Evaluation of Postponement for Improved Drug Product Supply Chain Stability", LGO, 2015.

Kojimoto, Nigel Costello, "Ultrasonic Inspection Methods for Defect Detection and Process Control in Roll-to-Roll Flexible Electronics Manufacturing", 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", 2015

Conover Susan, "Prime Areas for Improvement in Skin Cancer Detection and How Technology Can Help", SDM, 2015

Hess, Tylor, "System for small-volume high-frequency ultrasound, and quantitative optical molecular imaging assessment of biopsy samples", 2016

Kang Qi Ian Lee, "Skin Feature Analysis", CDO, 2016

Athena Yeh Huang, "New US Probes", 2017

Alex Benjamin, "US Education Hardware", CDO, 2017

Heng Yang, "Pulsed Elastography", 2017

Rebecca Zubajlo, "US Clamp Probe", 2017

Rishon Robert Benjamin, "Roll to roll polymer web inspection", CDO, 2017

Samer Haidar, "Consumer Medical Device Supply Chain Strategy", LGO, 2016

Mariam A Al-Meer, "Reducing Heart Failure Admissions through Improved Care Systems and Processes", LGO, 2017

Michael Sandford, "Improving Speed-to-Market through 3D Printing", LGO, 2017

Moritz Alexander Graule, "Dynamic SLAM", 2017

Mingxiu Sun, "Education and Practice Factory", 2018

Robin Singh. "Integrated Photonics", 2018

Judy Beaudoin, "Quantifying Dermatology: User-Independent Ultrasound Measurement of Skin Thickness, 2018

Andrew Farenheit, "Manufacturing Fleet Flexibility" 2019

Chris DiAndreth, "Product Flow Optimization within the Downstream Supply Chain" 2019.

Manuel Martínez Puppo, “Replenishment in an Integrated Stock World”, 2019.

Shirley Lu, “Fiber Manufacturing”, expected 2020

Sangwoon Kim, “Deep learning in manufacturing”, expected 2020.

MEng Theses

Su, Xiangyong, “Optimization of labor allocation at a syringe production facility: design proposals”, September 2008.

Liaw, Sze Sen, “Optimization of labor allocation at a syringe production facility using computer simulation”, September 2008.

Ng, Gar Yan, “Optimization of labor allocation at a syringe production facility: work study”, September 2008.

Linares, Rodrigo, “Manufacturability of lab on a chip devices: tolerance analysis and requirements establishment”, September 2010.

Selvakumar, Sivesh, “Manufacturing of Lab-On-a-Chip devices: variation analysis of liquid delivery using blister packs”, September 2010.

Namvari, Kasra, “Manufacturability of lab-on-chip devices: dimensional variation analysis of electrode foils using visual technology”, September 2011.

Donoghue, Linda, “Design of a micro-interdigitated electrode for impedance measurement performance in a biochemical assay”, September 2011.

Holmes, Jacklyn, “Robustness and repeatability of interdigitated electrodes on a substrate tested in an aqueous environment”, September 2011

Judge, Benjamin, “Electrode manufacturing for micro-fluidic devices”, September 2012

Jain, Nikhil, “Blister pack manufacturing for micro-fluidic devices”, September 2012

Inamdar, Tejas Satish, “Blister pack modeling for micro-fluidic devices”, January 2013

Saber, Aabed Saud, “Electrode modeling for micro-fluidic devices”, January 2013

Nguyen, Khanh Huy, “Microfluidic device manufacturing - tools”, September 2013

Ragosta, Nicholas Hiroshi, “Microfluidic device manufacturing - inspection”, September 2013

Kalsekar, Viren Sunil, “Microfluidic device manufacturing - process”, September 2013

Elise Xue, “Deep-learning in ultrasound”, June 2018

Engineer’s Theses

N/A

Doctoral Theses, Supervisor

Ljubicic, Dean, “Design of high-speed inspection system for micro-fluidic device manufacturing”, MechE, January 2013

Gilbertson, Matthew Wright, “Human in the loop design and modeling of force controlled ultrasound probes”, MechE, May 2014

Sun, Shih-Yu, “Real-time visual and ultrasound simultaneous localization and mapping (SLAM)”, EECS, August 2014

Zakrzewski , Aaron, “Real-time multi-scale pressure enhanced elastography”, MechE, 2017.

Roberts, Megan, “Advance manufacturing of flexible arrays for ultrasound probes”, MechE, 2018.

Lee, John, “Cell tracking and non-invasive ultrasound-based methods to diagnose neonatal and young infant meningitis”, EECS, 2015

Fincke, Jonathan Randall, "Ultrasonic quantification of human limbs (bone and tissue) using tomographic inversion techniques", 2018

Ranger, Bryan, “Prosthetic fitting”, HST, 2018

Ina Annesha Kundu, “Skin Imaging”, 2018

Rebecca Zubajlo, “Physical Measurement of Cells”, expected 2021

David Donghyun Kim, “Fiber Manufacturing Equipment”, expected 2020

Lauren Chai, “Radiation Force Manufacturing”, expected 2020

Jenny Wang, “Particle motion for acoustic radiation force characterization”, expected 2020

Anne Pigula, HST, “Image Based Biomarkers for Duchene Muscular Dystrophy”, expected 2020

Xiang Zhang, “Precision Tomography Platforms”, 2019

Alex Benjamin. “Volume Freehand Tomography”, expected 2020

Melinda Chen, “Liver Vascular Health Imaging”, expected 2020

Robin Singh, “Integrated Photonics Medical Sensors”, expected 2021

Alex Jaffe. EECS, “Venous and Blood Pressure in the extremities”, expected 2021

Yuwei Li, “Techniques for using AR/VR to measure physiological response”, expected 2022

Arjun Chandar, “Smart Manufacturing”, expected 2021

Doctoral Theses, Reader / Committee

Shi, Chuan, “Efficient Buffer Design Algorithms for Production Line Profit Maximization”, September 2011

Petrzelka, Joe, “On the contact fidelity and sensitivity of roll-based soft lithography”, June 2012

Smyth, Katherine, “Piezoelectric Micro-machined Ultrasonic Transducers for Medical Imaging”, October 2016

Athanasios G. Athanassiadis, “Optoacoustic Imaging”, 2019

Current Postdocs

<i>Name</i>	<i>Dates of Appointment</i>	<i>PhD Granting Institution</i>
Greg Ely	2019 -	MIT
Megan Roberts	2018 -	MIT
Shawn Zhang	2019 -	MIT

Previous Postdocs

<i>Name</i>	<i>Current Title</i>	<i>Current Employer</i>
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