

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MASIMO CORPORATION,

Petitioner,

v.

APPLE INC.,

Patent Owner

Case IPR2023-00634
U.S. Patent 10,627,783

**DECLARATION OF DR. BRIAN ANTHONY, PH.D. IN SUPPORT
OF PATENT OWNER RESPONSE**

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I, Brian W. Anthony, of Cambridge, MA, declare that:

I. QUALIFICATIONS AND BACKGROUND

1. My name is Dr. Brian W. Anthony and I have been retained as an expert witness by Apple Inc. in the matter of *Masimo Corporation v. Apple Inc.*, IPR2023-00634, in which Petitioner Masimo has challenged the patentability of U.S. Patent No. 10,627,783 (the “’783 Patent”).

2. My qualifications for forming these conclusions are summarized below.

3. 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.

4. 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.

5. 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. 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.

6. 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.

7. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example, image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers. My experience with these devices is directly applicable to the technology in the patent at issue.

8. 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.

9. 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.

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

11. 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.

12. 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 instrumentation technologies.

13. My curriculum vitae, included with this declaration, includes a list of publications on which I am a named author. It contains further details regarding my experience, education, publications, and other qualifications to render an expert opinion in connection with this proceeding.

14. In writing this Declaration, I have considered the following: my own knowledge and experience, including my work experience in mobile systems and networks; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed the following publications and materials, in addition to other materials I cite in my declaration:

- EX-1001: U.S. Patent No. 10,627,783 (the “’783 Patent”)
- EX-1002: File History of the ’783 Patent
- EX-1005: PCT Publication No. WO 2005/092182 A1 (“Kotanagi”)
- EX-1006: U.S. Patent No. 6,265,789 (“Honda”)
- EX-1012: U.S. Publication No. US 2015/0214749 A1 (“Park”)
- EX-1014: U.S. Publication No. 20120221254 A1 (“Kateraas”)
- EX-1015: U.S. Provisional Patent Application No. 61/932258
 (“Park Provisional”)
- EX-1016: U.S. Publication No. 20140135594 A1 (“Yuen”)

- EX-1017: PCT Patent Pub. WO2015116111 A1 (“Jabori”)
- EX-1041: U.S. Publication No. 20150355604 A1 (“Fraser”)
- EX-1023: Korean Patent Application No: 10-2013-0107833 (“Choi”)
- EX-2008: U.S. Patent Pub. No. 2007/0228404 to Tran et al. (“Tran”)
- EX-2009: U.S. Patent Pub. No. 2005/0274971 to Wang et al. (“Wang”)
- EX-2015: U.S. Patent Pub. No. 2010/0193804 to Brown et al. (“Brown”)
- EX-2016: U.S. Patent Pub. No. 2005/0030518 to Nishi et al. (“Nishi”)
- EX-2017: U.S. Patent No. 7,455,423 to Takenaka (“Takenaka”)
- EX-2023: S. Annam, “Scholar Works at UT Tyler Four-Coil Wireless Power Transfer Using Resonant Inductive Coupling,” Electric Engineering Theses, Paper 19 (2012).
- EX-2024: Z. Atrqchi et al., “Efficiency Examination of The Circular Coils with Two Types of Cross-Sections for WPT System,” UMDC-SDSP (2020).

- EX-2025: Y. Li et al., “Maximizing Transfer Distance for WPT via Coupled Magnetic Resonances by Coupling Coils Design and Optimization,” IEEE Access, vol. 8, pp. 74157–74166 (2020).
- EX-2026: Y. Li et al., “Influences of Coil Radius on Effective Transfer Distance in WPT System,” IEEE Access, vol. 7, pp. 125960–125968 (2019).
- EX-2027: Y. Li et al., “Directional characteristics of wireless power transfer via coupled magnetic resonance,” Electron., Vol. 9, No. 11, pp. 1–14 (2020).
- EX-2028: K. A. Mohamad et al., “Effect of Circular Coil Dimension on Resonant Coupling Wireless Power Transfer System,” J. Telecommun. Electron. Comput. Eng., Vol. 10, No. 2–6, pp. 19–23 (2018).
- EX-2029: A. P. Sample et al. “Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer,” IEEE Trans. Ind. Electron., Vol. 58, No. 2, pp. 544–554 (2011).
- EX-2030: G. Vigneau et al., “Design and modeling of PCB coils for inductive power charging,” Wirel. Power Transf., Vol. 2, No. 2, pp. 143–152 (2015).

- EX-2031: R. Vinge, “Wireless Energy Transfer by Resonant Inductive Coupling,” p. 83 (2015).
- EX-2032: F. Wen et al., “Research on optimal receiver radius of wireless power transfer system based on BP neural network,” Energy Reports, Vol. 6, pp. 1450–1455 (2020).

15. In addition to the above, I have reviewed the declaration of Dr. R. James Duckworth, Ph.D. (EX-1003) and the materials cited therein (some of which are referenced above as well). In addition, I have also reviewed the deposition testimony of Dr. Duckworth (EX-2020).

16. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the '783 patent at the time of the earliest possible priority date of the '783 patent, and I have done so during my review of the above-referenced materials (as well as any additional materials cited and discussed throughout this declaration). I have been informed that the '783 patent claims priority to an application filed on September 2, 2014 (“Critical Date”). I have used this Critical Date in my analysis below.

17. 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 this declaration.

18. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '783 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the fields 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 '783 patent and the materials discussed below.

II. LEGAL PRINCIPLES

A. Terminology

19. I have been informed by Counsel and understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by one of ordinary skill. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. Counsel has also informed me, and I understand that, the words of the claims should be interpreted as they would have been interpreted by one of ordinary skill at the time of the invention was made (not today). For my analysis, I

have used the September 2, 2014 (the Critical Date) as the point in time for claim interpretation purposes.

B. Legal Standards for Anticipation

20. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as anticipated. I have been informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art (POSITA).

21. I have been informed by Counsel and understand that a challenged claim is unpatentable as “anticipated” under 35 U.S.C. § 102 if it is determined that all the limitations of the claim are described in a single prior art reference. I have been informed by Counsel and understand that, to anticipate a claim, a prior art reference must disclose, either expressly or inherently, each and every limitation of that claim and enable one of ordinary skill in the art to make and use the invention.

22. I have been informed by Counsel and understand that in an *inter partes* review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of anticipation, “by a preponderance of the evidence.” 35 U.S.C. §316(e).

C. Legal Standards for Obviousness

23. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as obvious. I have been informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art at the time of the invention or the effective filing date, and that this viewpoint prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

24. I have been informed by Counsel and understand that a claim is unpatentable for obviousness under 35 U.S.C. § 103 “if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.” I have been informed by Counsel and understand that obviousness may be based upon a combination of references. I have been informed by Counsel and understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

25. However, I have been informed by Counsel and understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.

26. I have been informed by Counsel and understand that when a patented invention is a combination of known elements, a court must determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue by considering the teachings of prior art references, the effects of demands known to people working in the field or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art.

27. I have been informed by Counsel and understand that a patent claim composed of several limitations is not proved obvious merely by demonstrating that each of its limitations was independently known in the prior art. I have been informed by Counsel and understand that identifying a reason those elements would be combined can be important because inventions in many instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. I have been informed by Counsel and understand that it is improper to use hindsight in an obviousness analysis, and that a patent's claims should not be used as a "roadmap."

28. I have been informed by Counsel and understand that an obviousness inquiry requires consideration of the following factors: (1) the scope and content of the prior art; (2) the differences between the claims and the prior art; (3) the level of ordinary skill in the pertinent art; and (4) any objective indicia of non-

obviousness, such as commercial success, long-felt but unresolved need, failure of others, industry recognition, copying, and unexpected results. I understand that the foregoing factors are sometimes referred to as the “Graham factors.”

29. I have been informed by Counsel and understand that an obviousness evaluation can be based on a combination of multiple prior art references. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but that the nexus linking two or more prior art references is sometimes simple common sense. I have been informed by Counsel and understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

30. I have been informed by Counsel and understand that if a technique has been used to improve one device, and a person of ordinary skill at the time of invention would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

31. I have been informed by Counsel and understand that practical and common sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I have been informed by Counsel and understand that a person of ordinary skill looking to

overcome a problem will often be able to fit together the teachings of multiple prior art references. I have been informed by Counsel and understand that obviousness analysis therefore accounts for the inferences and creative steps that a person of ordinary skill would have employed at the time of invention.

32. I have been informed by Counsel and understand that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill at the time of invention, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention or effective filing date and addressed by the patent can provide a reason for combining the elements in the manner claimed.

33. I have been informed by Counsel and understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense of one of skill in the art.

34. I have been informed by Counsel and understand that secondary indicia of non-obviousness may include (1) a long felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success of processes covered by the patent; (3) unexpected results achieved by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the invention; (7) failure of others to

find a solution to the long felt need; and (8) skepticism by experts. I understand that evidence of secondary indicia of non-obviousness, if available, should be considered as part of the obviousness analysis.

35. I have been informed by Counsel and understand that there must be a relationship between any such secondary considerations and the invention, and that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

36. In sum, my understanding is that prior art teachings are properly combined where one of ordinary skill having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

37. I have been informed by Counsel and understand that in an *inter partes* review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of obviousness, “by a preponderance of the evidence.” 35 U.S.C. §316(e).

III. OVERVIEW OF CONCLUSIONS FORMED

38. This expert 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, it is my opinion that Kotanagi in view of Honda does not render obvious claim 9-11, 15, 19, and 20.
- Based upon my knowledge and experience and my review of the prior art publications listed above, it is my opinion that Kotanagi in view of Honda, and optionally, in further view of Park does not render obvious claim 16.
- Based upon my knowledge and experience and my review of the prior art publications listed above, it is my opinion that Kotanagi in view of Honda, and optionally, in further view of Kateraas does not render obvious claims 1-7 and 14.
- Based upon my knowledge and experience and my review of the prior art publications listed above, it is my opinion that Kotanagi in view of Honda, Jabori, and optionally in further view of Park does not render obvious claims 12-13 and 17-18.
- Based upon my knowledge and experience and my review of the prior art publications listed above, it is my opinion that Kotanagi in view of

Honda, Fraser, and optionally in further view of Kateraas, does not render obvious claims 3 and 14.

- Based upon my knowledge and experience and my review of the prior art publications listed above, it is my opinion that Kotanagi in view of Honda, and Jabori, and optionally, further in view of Kateraas and/or Park, does not render obvious claim 8.

IV. BACKGROUND KNOWLEDGE OF ONE OF SKILL IN THE ART

39. Based on the foregoing and upon my experience in this area, a person of ordinary skill in the art (“POSITA”) relating to the subject matter of the ’783 Patent as of September 2, 2014 (“Critical Date”) 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 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. *Id.*

40. Based on my background and experiences, I have a good understanding of the capabilities of a POSITA, as I was such an individual at the

time of the Critical Date. Moreover, I have taught, participated in organizations, and worked closely with many such persons over the course of my career.

41. In forming my opinions herein, I have applied the above proposed skill level of a POSITA.

42. I have been informed that Petitioner proposes a skill level of a person of ordinary skill in the art that requires “at least a bachelor’s degree in a discipline related to electrical engineering, mechanical engineering, physics, industrial design, or equivalent, and at least three years of experience working with or developing electronic medical or consumer devices.” Petition, 12; EX-1003, ¶¶39-42.

43. Based on my background and experiences, I have a good understanding of the capabilities of such a person of ordinary skill, as proposed by Petitioner, as I was such an individual at the time of the Critical Date. Additionally, my analysis presented herein remains unchanged even if this skill level is applied.

V. ’783 PATENT

A. Overview of the ’783 Patent

44. The ’783 Patent relates to “a wearable electronic device” that provides a “wide range” of features, including among others, “wireless power charging” and “health monitoring functionality.” EX-1001, 1:18-25, 1:39-41.

45. The ’783 Patent explains that traditional portable devices, particularly wearable electronic devices, had “relatively limited functionality or [were] only

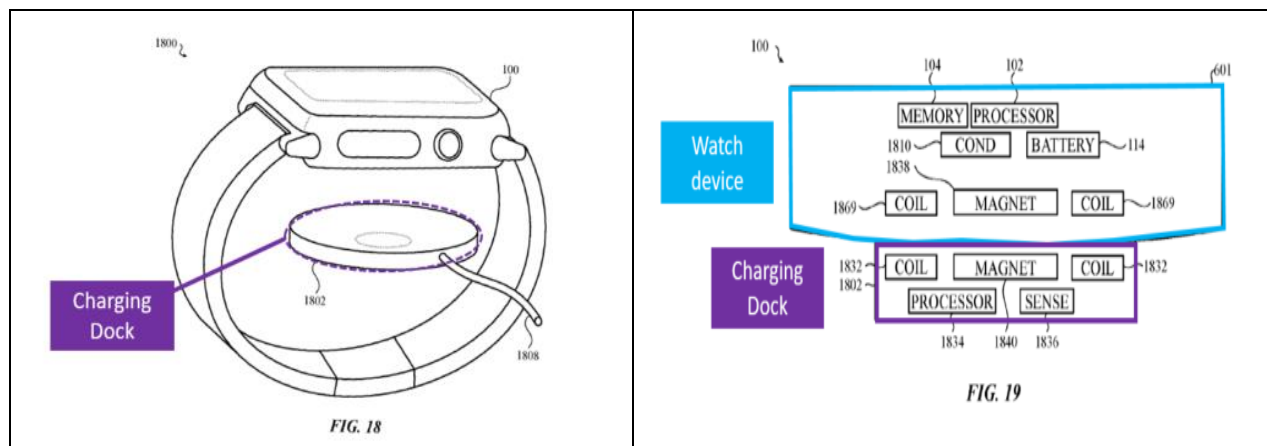
able to perform a specialized set of functions or tasks.” EX-1001, 1:32-36. “For example, some traditional electronic wristwatches” were “configured to perform a relatively limited set of functions, including displaying time, date, and performing basic timing functions.” *Id.*, 1:36-39.

46. In contrast, and “compared to some traditional wearable electronic devices,” the ’783 patent provides “an expansive feature set” that is “integrated into” the “relatively compact space of a wrist-worn device.” *Id.*, 1:39-42, 1:46-56. In some embodiments, the ’783 Patent provides a wrist-worn device that “integrate[s] or combine[s] multiple subsystems”—including a wireless charging receive coil operating in conjunction with a power conditioning circuit and biometric sensors—“into a single device” to provide a wrist-worn device with a wide range of features, including wireless charging and biometric sensing capabilities. *Id.*, 1:19-25, 1:46-56, 7:3-24, 5:25-40, 4:24-49.

47. The ’783 Patent discloses a device 100 that can facilitate wireless recharging of its rechargeable battery via a charging dock. *Id.*, 1:18-25, 8:50-59. A perspective view of the device 100 and the charging dock 1802 is shown in Fig. 18 (below left; annotated), with a simplified block diagram of the device and charging dock being shown in FIG. 19 (below right; annotated). *See id.*, 6:28-31, FIGS. 18-19.

Fig. 18

Fig. 19



48. As shown above, an “inductive power transmitter dock 1802 ... is configured to couple to and wirelessly transmit power to an inductive power receiver,” such as the watch device 100. *Id.*, 43:5-11. The charging of the device’s battery 114 is facilitated when “a bottom surface of the housing of the device 100 ... partially contact[s] a top surface of the dock housing.” *Id.*, 45:18-25.

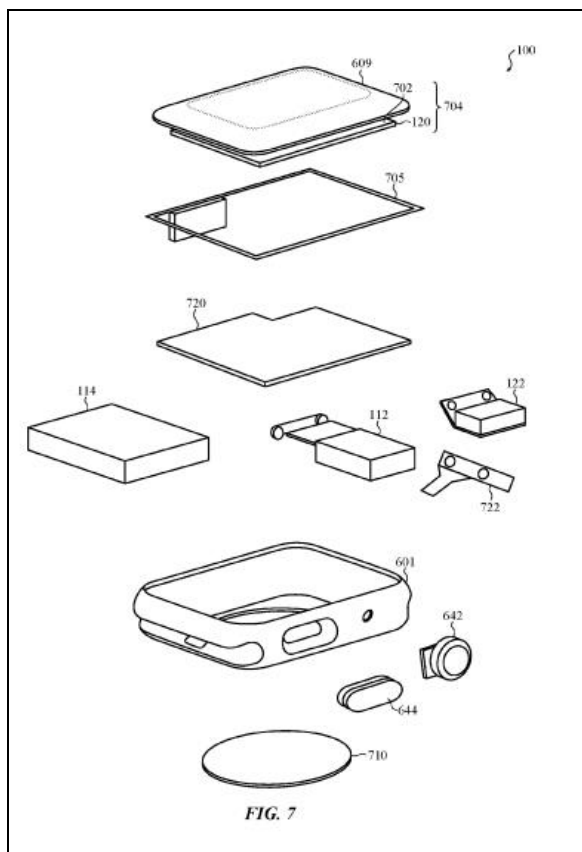
49. The device’s “internal battery 114 is operably connected to a receive coil 1869 via power conditioning circuit 1810” and the receive coil further includes “one or more windings for inductively coupling with a transmit coil 1832 of the dock 1802.” *Id.*, 44:36-44.

50. When the bottom surface of the housing of the device 100 (e.g., the rear cover) contacts the top surface of the dock housing, the “receive coil 1869” receives power from a transmit coil 1832 of the dock 1802 (where the power transfer is facilitated via “electromagnetic induction or magnetic resonance”) and “may pass the received power to [the] battery 114 ... via power conditioning

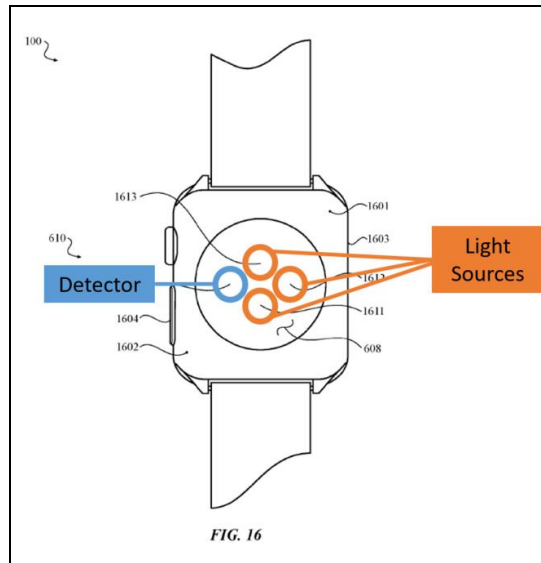
circuit 1810.” *Id.*, 44:38-62, 45:18-22. The ’783 Patent further explains that “the transmit coil 1832 may be shielded with a shield element that may be disposed or formed around portions of the transmit coil 1832” and similarly, “the receive coil 1869 may also include a shield element that may be disposed or formed around a portion of the receive coil 1869.” *Id.*, 44:54-60.

51. In addition to wireless charging, the device 100 can also facilitate biometric sensing using a “biosensor module” made up of “one or more sensors” that are “used to calculate a health metric,” such as “a heart rate, a respiration rate, blood oxygenation level, a blood volume estimate, blood pressure, or a combination thereof.” *Id.*, 37:48-55; 8:26-38, 13:24-42.

52. The figure below shows an exploded view of an example embodiment of the wearable device, with “a biosensor module 710 ... disposed in an opening formed in the rear surface of the housing 601.” *Id.*, Fig. 7, 28:7-24.



53. In some embodiments, and as depicted in further detail with reference to FIG. 16 (reproduced and annotated below), the “biosensor module 710 may include one or more light sources, one or more photodetectors, and one or more electrodes or conductive elements that are configured to detect and measure a physiological condition or property of the user.” *Id.*, 28:7-23, Fig. 16 (showing an array of light sources 1611-1613 and a photodetector 1614).



54. The light sources 1611-1613 and the detector 1614 on the rear portion of the device “are configured to function as an optical sensor or sensors,” such as “a photoplethysmography (PPG) sensor or sensors.” *Id.*, 38:23-38. Additionally, the device can include “one or more electrodes” (e.g., electrodes 1601 and 1602 in FIG. 16 above) that can be used to “measure electrical properties of the user’s body.” *Id.*, 13:34-39, 39:40-46.

55. In some embodiments, the biosensor module (which integrates some or all of the above-described biosensors) is “separate from and attached to the housing 601 of the device 100.” *Id.*, 40:43-50. For example, and as illustrated with respect to Figs. 7 and 16 (shown above), “the biosensors” can be “disposed relative to or attached to a rear cover 608 that is formed from an optically transparent material and is configured to be positioned with the opening of the housing 601.” *Id.*, 40:43-50.

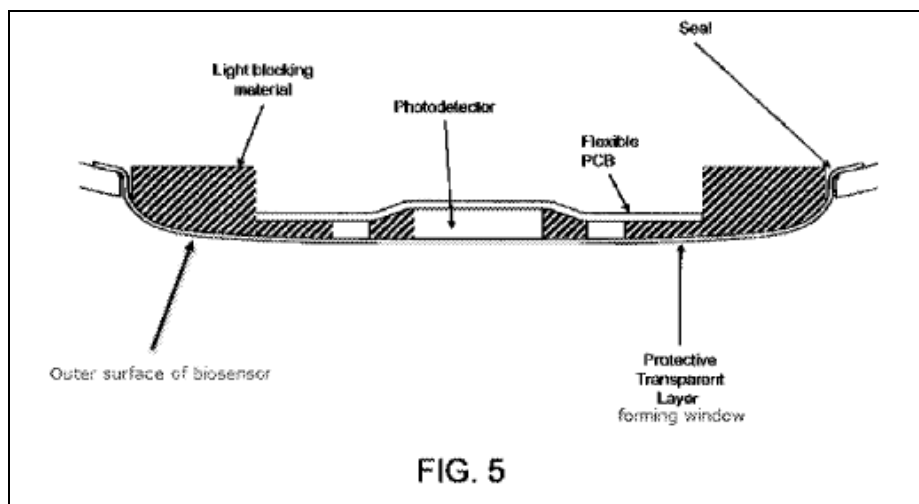
56. In this manner, the '783 Patent provides a wearable device with at least wireless charging capabilities and biometric sensing, and recites a specific configuration in which the same rear cover/opening of the device facilitates both wireless power transmission to the receive coil on the device 100 and optical signal transmission to/from the biosensor module. *See id.*, 1:19-25, 2:44-55, 13:34-39, 39:40-46, 40:43-50, 44:38-62, 45:18-22.

B. Prosecution History of the '783 Patent

57. The application for the '783 Patent was filed on September 10, 2016. EX-1001, p. 1. This application (App. No. 15/261,917) is a continuation of a non-provisional application (App. No. 14/842,617) filed on September 1, 2015, and further claims priority to a provisional application (App. No. 62/044,974) filed on September 2, 2014. EX-1002, 1965; EX-1001, pp. 1-2.

58. During prosecution, the Examiner issued an office action, rejecting the then-pending claims on multiple prior art-based grounds. EX-1002, 1475-1504. Specifically, the Examiner rejected the pending claims in view of multiple references, including (among others), Yuen (US Patent Pub. No. 2014/0107493; EX-2001), Mistry (US Publication No. 2014/0139486; EX-2005), Mensinger (U.S. Patent No. 8,229,535; EX-2006), and Burton (US Patent No. 7,682,070; EX-2007). EX-1002, 1478, 1487-1493. In support of these rejections, the Examiner provided the following pertinent findings and rationale:

- “Yuen et al. describes a wearable electronic device that includes biometric and biosensor monitoring (para 46-48).... Figures 3 and 4 show the *biosensor module protruding from the bottom side* of the device housing. Figure 5 is further relied on to show the rear cover for the biosensor module comprising an edge protruding outwardly from the bottom portion of the housing and *having an outer surface with a convex contour shape*.... [F]igure 5 also shows the wearable device with *an array of LED light sources and a photodetector within the biosensor protrusion and serving as one or more optical components of the biosensor module* (para 45, also see figures 8 and 9).”¹



EX-1002, 1478-1480 (citing EX-2001, FIGS. 3-5, ¶¶45-48); *see also id.*, 1488-1489.

¹ Emphasis added throughout unless otherwise noted.

- “Mistry et al. describes a **wearable wristwatch sensor** comprising a touch sensitive display and **an optical sensor**.” EX-1002, 1490-1491.
- “Burton describes a wrist worn device considered analogous to the other cited references. Burton is relied on to teach that wristwatches include a protective transparent cover ..., wherein the cover may be formed from a polymer, glass, or sapphire crystal (col 3 lines 41-57). ... [B]urton teaches that sapphire is a commonly employed material for watch crystals or covers.” EX-1002, 1493.

59. Applicant subsequently interviewed the Examiner, with the substance of the interview including a discussion of the cited prior art and Applicant’s proposal to add “structural features to the claim including features that facilitate wireless charging, such as a ... cover configured to allow **transmission of biosensor signals and wireless charging signals**.” EX-1002, 1269.

60. According to the Examiner, “[s]uch amendment” would “overcome the prior art of record.” *Id.*

61. Consistent with the discussion during the interview, Applicant filed a response that included claim amendments reciting a rear cover or opening configured to pass both optical signals and wireless power signals. *See* EX-1002, 1273-1278 (see pending claims 35, 43, and 49, reciting these features); 1279 (memorializing examiner’s agreement that “claims that include structural elements,

such as a rear cover, that allow transmission of both biosensor signals and wireless charging signals would overcome the current rejections”).

62. This response resulted in allowance of the claims (*see* EX-1002, 887, 707-708, 382-386, 200-201, 14-15), with the Examiner noting in his reasons for allowance that the “prior art fails to teach or suggest the ***specific arrangement and configuration of the claimed cover, opening in the housing, and wireless charging coil.***” EX-1002, 387. The application subsequently issued as the ’783 Patent on April 21, 2020. EX-1001, p. 1; EX-1002, 3.

C. Challenged Claims

63. It is my understanding that Petitioner Masimo challenged claims 1-20 of the ’783 Patent. Petition, 7. For ease of reference, I have reproduced these claims below.

1. *An electronic device, comprising:
a housing defining a first opening opposite to a second opening;
a band attached to the housing and configured to secure the electronic device to a user;
a display positioned in the first opening;
a ceramic cover disposed over the second opening and forming a portion of an exterior surface of the electronic device;
a biosensor module disposed within the second opening below the ceramic cover; and
a wireless charging receive coil aligned with the second opening and below the ceramic cover;
wherein:*

the ceramic cover is configured to pass optical signals generated by the biosensor module; and

the ceramic cover is configured to pass wireless power from an external wireless charging device to the wireless charging receive coil.

2. The electronic device of claim 1, wherein the biosensor module comprises:

a light source configured to emit light toward a region of skin of the user; and

a detector configured to receive light reflected from the region of skin.

3. The electronic device of claim 2, wherein:

the ceramic cover defines a first opening to transmit the light from the light source; and

the ceramic cover defines a second opening to receive the light reflected from the region of skin.

4. The electronic device of claim 2, wherein:

the light source and the detector are configured to measure changes in light absorption by the region of skin;

the electronic device is configured to compute a health metric using the measured change in light absorption; and

the display is configured to display information associated with the health metric.

5. The electronic device of claim 2, wherein the light source and the detectors are configured to operate as a photoplethysmogram (PPG) sensor.

6. The electronic device of claim 1, wherein:

the ceramic cover is a disk having a disk diameter that is greater than an opening diameter of the second opening; and

the ceramic cover forms a water-tight seal with the housing along a perimeter of the ceramic cover.

7. The electronic device of claim 1, wherein:

the second opening has an opening diameter;

the wireless charging receive coil has a coil diameter that is less than the opening diameter; and
the wireless charging receive coil is configured to receive the wireless power through the second opening.

8. *The electronic device of claim 1, wherein:*

the ceramic cover has a convex contoured shape that protrudes toward the user; and

the convex contoured shape facilitates alignment between the ceramic cover and a mating surface of the external wireless charging device.

9. *A wearable electronic device, comprising:*

a housing comprising a bottom portion defining an opening;

a biosensor module aligned with the opening;

a wireless charging receive coil positioned within the housing and aligned with the opening;

a battery operably coupled to the wireless charging receive coil; and

a cover disposed over the biosensor module; wherein:
the cover is configured to pass optical signals to and from the biosensor module; and

the cover is configured to pass wireless power to the wireless charging receive coil.

10. *The wearable electronic device of claim 9, wherein:*

the housing is formed from a metal material; and

the cover is formed from a non-metal material.

11. *The wearable electronic device of claim 9, wherein:*

the wireless charging receive coil has a coil diameter that is less than a diameter of the biosensor module; and

the wireless charging receive coil is configured to receive the wireless power through the biosensor module.

12. *The wearable electronic device of claim 9, wherein:*

the cover is a disk having a convex shape that protrudes away from the housing; and

the convex shape is configured to facilitate alignment with a concave surface of an external inductive power transmitter dock.

13. *The wearable electronic device of claim 12, wherein:*
 the wearable electronic device is magnetically coupled to the external inductive power transmitter dock through the cover and the biosensor module.
14. *The wearable electronic device of claim 9, wherein:*
 the biosensor module includes an array of optical components;
and
 the cover includes an array of windows, each window aligned with a corresponding optical component of the array of optical components.
15. *An electronic watch, comprising:*
 a housing defining an interior cavity and a bottom portion having an opening;
 a band attached to the housing and configured to secure the electronic watch to a user;
 a biosensor module positioned along the bottom portion of the housing and configured to transmit optical signals and receive reflected optical signals through the opening of the housing; and
 a wireless charging receive coil positioned within the interior cavity and configured to receive wireless power through the opening of the housing.
16. *The electronic watch of claim 15, wherein:*
 the wireless charging receive coil is configured to receive power from an external inductive power transmitter dock; and
 the electronic watch is configured to magnetically couple with the external inductive power transmitter dock.
17. *The electronic watch of claim 15, wherein:*
 the wireless charging receive coil is configured to receive power from an external inductive power transmitter dock;
 the electronic watch defines a convex contoured surface along the bottom portion; and
 the convex contoured surface is configured to facilitate alignment with a concave contoured surface of the external inductive power transmitter dock.

18. The electronic watch of claim 17, wherein the convex contoured surface is configured to protrude toward a portion of skin of the user when the electronic watch is worn.

19. The electronic watch of claim 15, wherein:

the electronic watch is configured to compute a health metric using the biosensor module; and

the health metric is one or more of: a heart rate, a respiration rate, a blood oxygenation level, a blood volume estimate, or blood pressure.

20. The electronic watch of claim 19, wherein:

the electronic watch includes a display; and

the display is configured to display information associated with the health metric.

D. Interpretations of the Claims at Issue

64. I have been informed by Counsel and understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by one of ordinary skill. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. Counsel has also informed me, and I understand that, the words of the claims should be interpreted as they would have been interpreted by one of ordinary skill as of the effective filing date of the '783 patent, which I have been informed by Counsel is September 2, 2014 (not today). As such, I have been

informed by Counsel that I should use September 2, 2014 as the point in time for claim interpretation purposes.

65. I understand the Petitioner is construing three terms: (1) “a ceramic cover,” (2) “biosensor module,” and (3) “ceramic cover defines a [first/second] opening to [transmit/receive] the light.”

66. With respect to ceramic cover, Petitioner states that “prior art having a rear cover of glass or sapphire or any other ceramic material satisfies this limitation.” Petition, 13, EX-1003, ¶¶45-49. With respect “ceramic cover defines a [first/second] opening to [transmit/receive] the light,” Petitioner states that this phrase should be construed as “ceramic cover that includes [first/second] locations that allow the passage of light.” Petition, 15-16; EX-1003, ¶¶54-56. I have been asked to apply these constructions for purposes of my analysis here.

67. Petitioner further construes “biosensor module” as “a portion of the device that includes one or more sensors and optionally includes a cover.” Petition, 14; EX-1003, ¶¶50-53. This construction is incorrect for the following reasons.

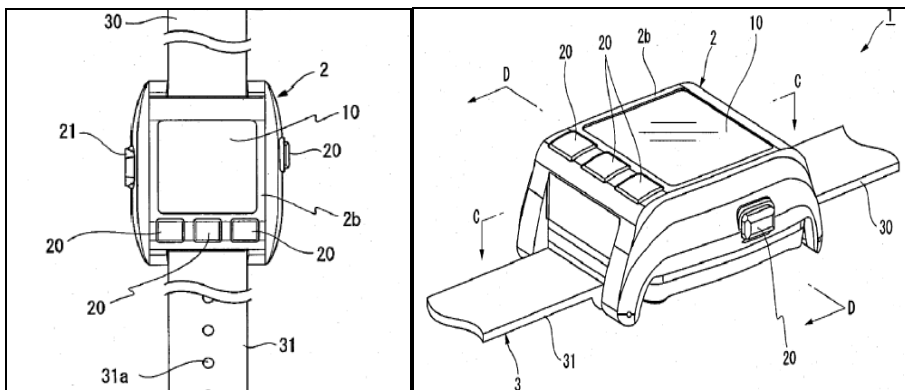
68. **First**, given that the claim recites “**biosensor**,” Petitioner’s construction is overbroad in its applicability to any type of “sensors.” **Second**, and as I explained with reference to my claim 11 analysis below (see §VII.B below, incorporated by reference here), the language of the claims requires that the cover is separate from the claimed biosensor module, and cannot be part of it.

69. Moreover, the specification teaches that the biosensor module “may include one or more light sources, one or more photodetectors, and one or more electrodes or conductive elements that are configured to detect and measure a physiological condition or property of the user.” *See, e.g.*, EX-1001, 28:17-24; *see also id.*, 40:43-50. It is my opinion that this is consistent with how the “biosensor module” would be understood by a POSITA in the context of the claims and the specification of the ’783 Patent.

VI. OVERVIEW OF THE PRIOR ART

A. Kotanagi (EX-1005)

70. Kotanagi discloses a “biological information measuring device” that is “capable of measuring biological information such as pulse rate while mounted to the wrist (arm).” EX-1005, ¶1, FIGS. 1-2. An example of Kotanagi’s biological information measurement device is shown in FIGS. 1 and 2:

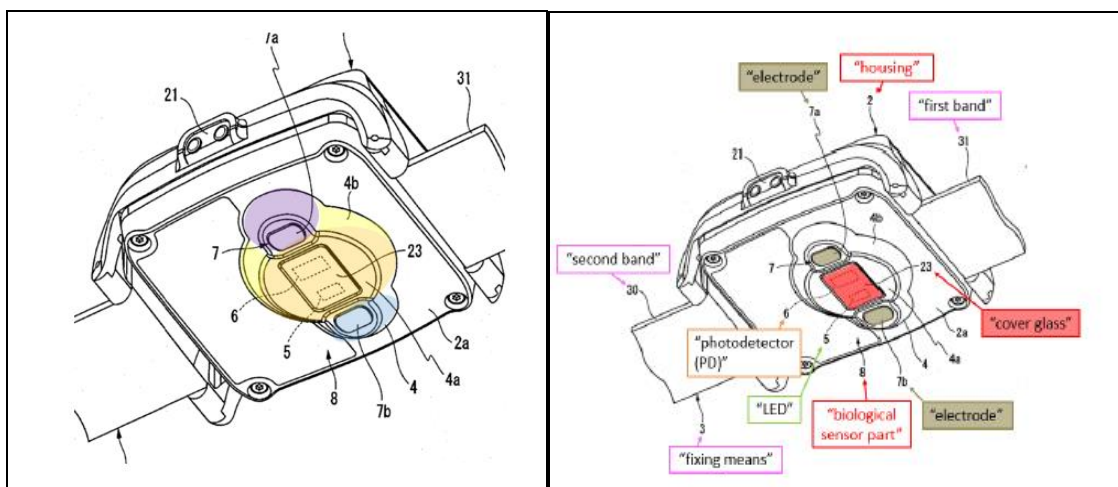


71. Kotanagi explains that, in “conventional” wrist-mounted devices, “movement of the user causes muscles to move” and “changes the thickness (diameter) of the wrist, which leads to the risk that a gap may be formed between” the device and the body surface. EX-1005, ¶4. “This diminishes adherence, which may prevent accurate biological information from being detected.” *Id.*

72. Moreover, Kotanagi explains that, because a device that “is fixed to the wrist, the feeling of pressure on the wrist increases when attached by a band ... , which makes it difficult to wear for long periods of time.” *Id.*

73. Kotanagi’s “invention” seeks to provide a “a biological information measuring device which enhances adherence and can be worn for a long time without causing discomfort.” EX-1005, ¶5.

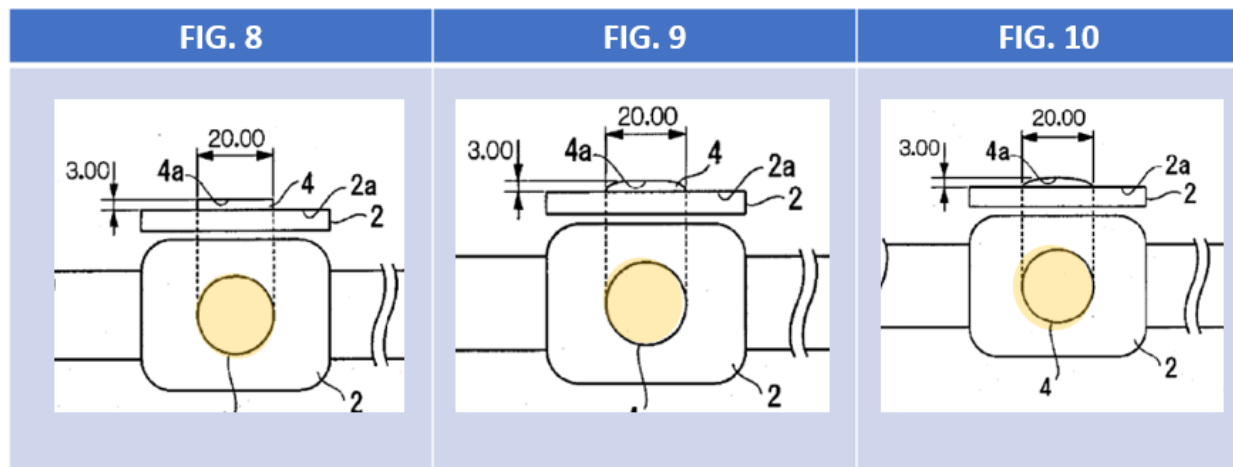
74. As shown below, Kotangi’s device provides a protruding part 4 (highlight in the image below on the left) formed in the lower surface 2a of the device’s housing 2. EX-1005, ¶7.



75. As shown in the image above on the right, the protruding part 4 includes components (as shown above on the right) such as a “biological sensor part includ[ed] [in] a main body” of the device, “a light-emitting part,” “a light receiving part,” and “a contact detection part means for detecting whether the light-emitting part and the light-receiving part are in contact with the living body surface.”

76. Also, as shown above (image on left), protruding part 4 “is formed into a shape combining three circles”—i.e., “by combining, with a central circle [yellow annotation, in figure above on the left], two circles having a smaller diameter than the central circle” [blue and purple annotations, in above figure on the left]. EX-1005, ¶54.

77. Kotanagi also contemplates additional configurations for protruding part 4. For example, instead of forming the protruding part 4 by combining three circles, Kotanagi provides examples in FIGS. 8-10 (shown below) where protruding part 4 is formed “so that the outer periphery is circular” (i.e., formed of a single circle). EX-1005, ¶¶76-81, FIGS. 8-10.



78. In each of these configurations, a “diameter of the protruding part is set to not greater than 20 mm ... so the protruding part can be easily pressed against the living body surface with light force.” EX-1005, ¶¶36-37, 76-81; FIGS. 8-10 (annotated above).

79. Additionally, the protruding part 4 “protrudes 2 to 4 mm from the lower surface of the main body,” and as a result, Kotanagi explains that the protruding part (and by extension, the device) can be “reliably brought into contact” with the body surface. EX-1005, ¶¶28, 40. “Therefore, unlike in conventional configurations, it is unnecessary to fix the main body so as to strongly press (so as to compress) the main body against the living body surface with the fixing part. Accordingly, the device does not cause discomfort, even when worn for a long time. Moreover, since the adherence of the biological sensor part is enhanced, light can be emitted and received efficiently, and biological information can be detected with high precision.” EX-1005, ¶40.

81. As shown below, the biological sensor part 8 is “formed in the center of the lower surface 4a of the

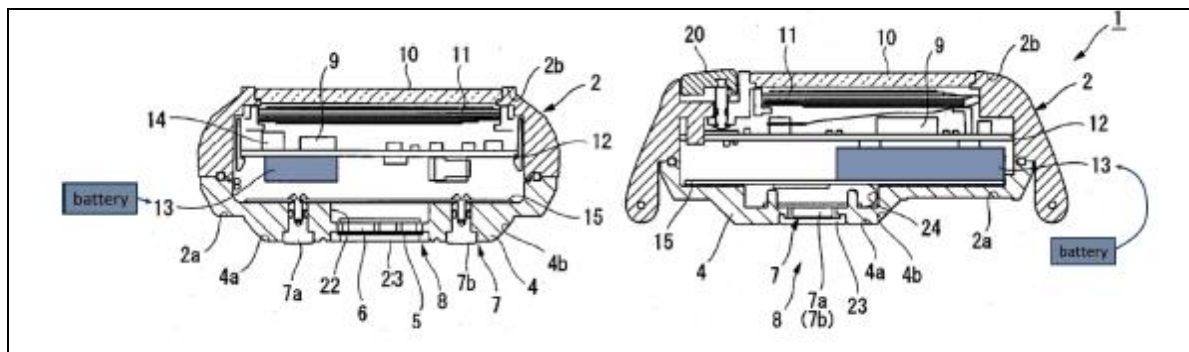
Diagram illustrating the cross-sectional structure of a biological sensor part 2. The components are labeled as follows:

- 2: Biological sensor part
- 2a: Bottom flange
- 2b: Top flange
- 4: Main body of the sensor part
- 4a: Left side of the main body
- 4b: Right side of the main body
- 5: Cover glass
- 6: Through-hole
- 7: Photodetector (PD)
- 7a: Left side of the photodetector
- 7b: Right side of the photodetector
- 8: LED
- 9: Top layer of the sensor part
- 10: Middle layer of the sensor part
- 11: Bottom layer of the sensor part
- 12: Outer casing
- 13: Inner casing
- 14: Top flange of the inner casing
- 15: Bottom flange of the inner casing
- 23: Central region of the sensor part

82. Additionally, electrodes 7a and 7b are also “disposed on the lower surface 4a of the protruding part 4 so as to sandwich the LED 5 and the PD 6.” ¶58. The electrodes are provided “so that the tips thereof protrude slightly more than lower surface 4a of the protruding part 4.” *Id.*

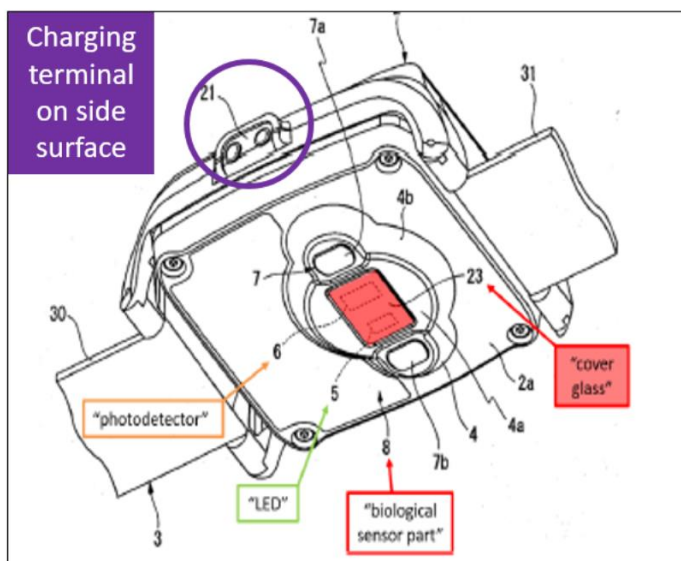
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84. Kotanagi's device further includes a battery 13 that powers up the device and its different subcomponents:



EX-1005, FIGS. 6-7 (annotated by Petitioner), ¶53.

85. Kotanagi discloses that the battery 13 can be recharged “by supplying power from an external device such as a recharger.” *Id.*, ¶53; *see id.*, ¶72 (“the rechargeable battery 13 can be charged with power by



connecting a recharging cord or the like connected to a recharger to the external connection terminal 21 that is provided on the side surface of the housing 2. EX-1005, ¶53, FIG. 5 (reproduced above; annotated by Patent Owner and Petitioner; showing connection terminal 21 for charging on the side surface of the device's housing).

86. “In addition, rather than the external connection terminal 21,” Kotanagi contemplates that “a transformer or the like for supplying power to a recharger and to the inside of the housing 2 may be provided so as to recharge the rechargeable battery in a contactless state.” *Id.*, ¶53. However, Kotanagi does not disclose how the rechargeable battery would be charged in the “contactless state” nor does it disclose the surface via which such charging would be performed. *See id.*

B. Honda (EX-1006)

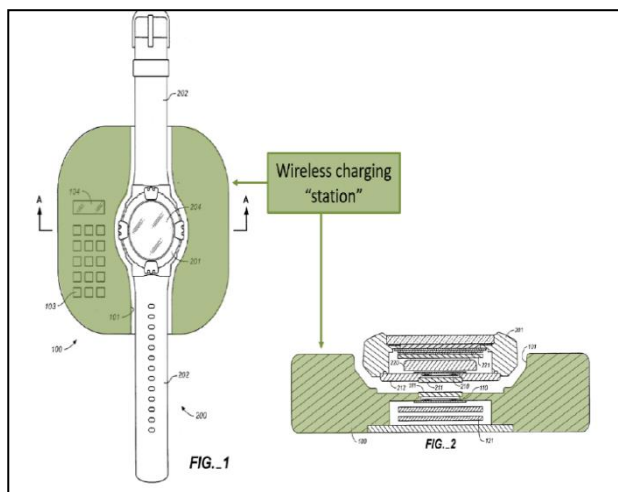
87. Honda provides an electronic apparatus (e.g., an electronic watch) that enables “efficiency of a power transmission from a charging unit to” the apparatus in a “non-contact” fashion. EX-1006, 1:5-16, 2:55-60.

88. In particular, Honda seeks to overcome deficiencies in prior contactless charging implementations. First, Honda recognizes that, when the gap between charging coils in the receiver device (e.g., the electronic watch) and the transmitting device (e.g., the charger) “is increased,” “the degree of magnetic coupling weakens, substantially reducing the charging current to the secondary battery for charging.” *Id.*, 2:39-44. Second, Honda recognizes that metal materials in the housing can create eddy currents, which in turn can “weaken[] the

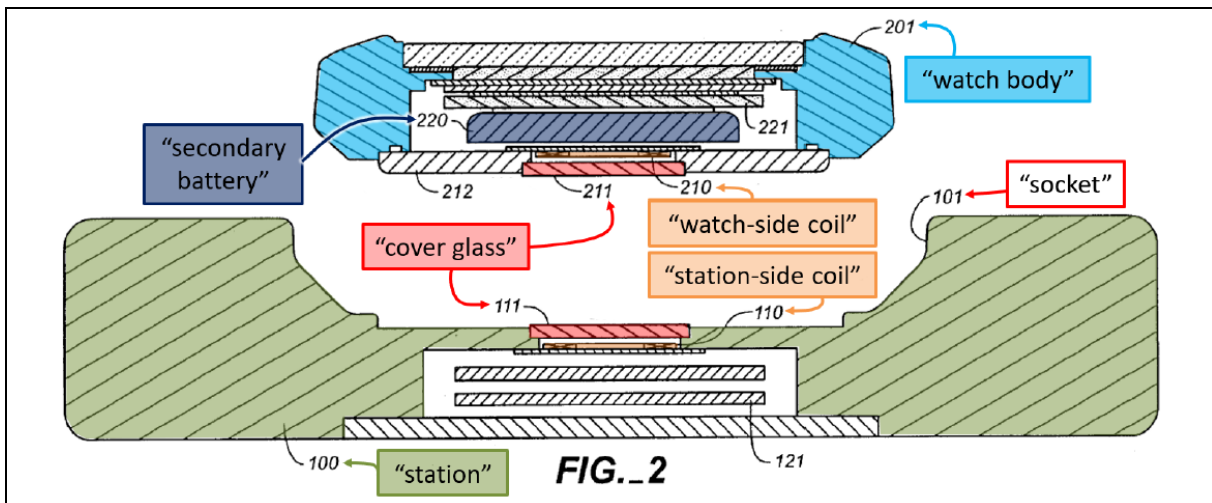
electromagnetic coupling” between the charging coils and limit the quick charging of the device’s battery. *Id.*, 2:44-52, 13:25-32.

89. Honda seeks to address these problems, with one of its goals being to enable “quick” and “efficien[t]” charging of the device’s battery. *Id.*, 2:55-60. To that end, Honda discloses “an electronic apparatus” that “includes a first device and a second device, which perform a power transmission ... through the electromagnetic coupling of coils which are arranged in mutually facing positions in the respective devices,” where the relative inner and outer diameters of coils in the first and second devices can vary by certain predetermined amounts without affecting charge efficiency. *See id.*, 2:66-4:26.

90. As shown in Figs. 1 and 2 (reproduced on right; annotated by Petitioner), an electronic watch 200 is shown seated in a socket 101 of a station 100 to facilitate a charging operation. *Id.*, 6:4-11.



91. An expanded version of FIG. 2 is reproduced below and provides a sectional view of the watch 200 shown in FIG. 1. *Id.*, 6:21-22, FIG. 2 (annotated by Petitioner).



92. As shown above, “a watch-side coil 210 for ... battery charging is arranged in a case back 212 of the watch body 201 and is covered with a cover glass 211. The watch body 201 includes a circuit board 221, connected to a secondary battery 220 and a watch-side coil 210.” EX-1006, 6:22-27. In the charging station 100, a station-side coil 110 is arranged in the portion of the socket 101” that faces “the watch-side coil 210, and is covered with a cover glass 111.” *Id.*, 6:28-35.

93. “The station 100 includes a circuit board 121, to which the station-side coil 110, the input section 103, the display section 104, and a primary power source (unshown) are connected.” *Id.*

94. “When the electronic watch 200 is placed onto the station 100, the station-side coil 110 and the watch-side coil 210 are physically out of contact with each other, but magnetically coupled with each other because the surfaces of coil winding of both coils are generally ... parallel to each other.” *Id.*, 6:36-40. Honda

also teaches that the “station side coil 110 and the watch side coil are of an air-core type without any core, to limit the magnetization of a watch mechanism, to avoid an increase in the weight of the watch, and to prevent the exposure of a magnetic metal.” *Id.*, 6:41-49.

95. Additionally, to reduce the charging inefficiencies stemming from the use of metal materials in the device’s housing, Honda contemplates “the use of an insulating material,” such as glass, for “the external housing” that “results in a transmission efficiency ten times as high as the one achieved by a stainless steel product.” *Id.*, 13:45-48, FIG. 15 (and associated description). Honda, however, recognizes that transparent glass cover are “not preferred from the aesthetic point of view” and “electronic components are subject to deterioration by light, particularly by ultraviolet lights.” *Id.*, 13:53-67. To “resolve these problems,” Honda teaches that the inner surface of the glass includes a “deposited surface,” “coat[ing] with a plated surface, a printed surface, or foiled surface” or the glass may be “colored with a pigment.” *Id.*, 13:59-64.

96. In addition to its charging capabilities and associated descriptions, Honda additionally discloses that the watch 200 “detects biological information including the pulse rate or the heart rate of the body through an unshown sensor and stores it.” *Id.*, 6:17-20, 8:40-42. Honda, however, does not explain where the “unshown sensor” would be provided or positioned in the device, nor does it

disclose or suggest such an “unshown sensor” would facilitate transmission of biometric signals through the rear cover/opening in the described device. *See id.*

VII. THE CHALLENGED CLAIMS (CLAIMS 1-20) ARE NOT RENDERED OBVIOUS BY PETITIONER’S PROPOSED COMBINATIONS OF REFERENCES

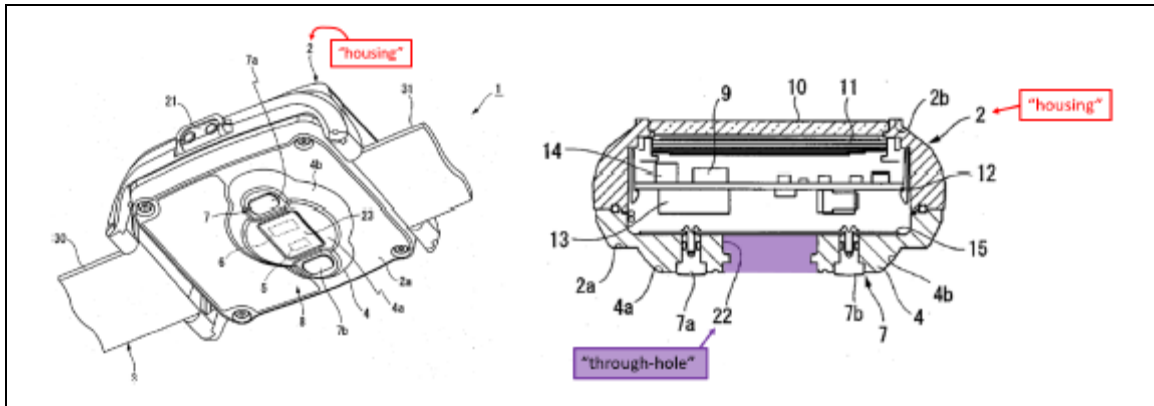
A. The Proposed Kotanagi-Honda Combination Does Not Render Obvious Independent Claim 9

97. Independent claim 9 is reproduced below:

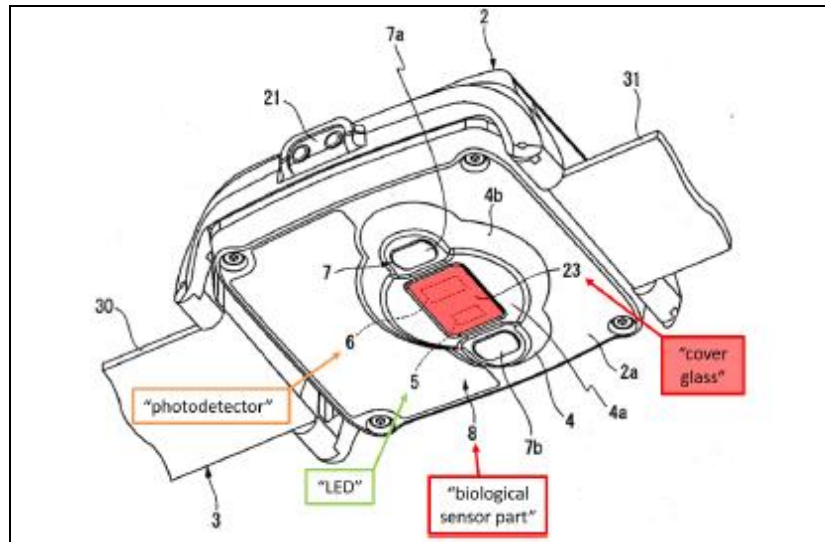
*9. A wearable electronic device, comprising:
a housing comprising a bottom portion defining an opening;
a biosensor module aligned with the opening;
a wireless charging receive coil positioned within the housing and aligned with the opening;
a battery operably coupled to the wireless charging receive coil; and
a cover disposed over the biosensor module; wherein:
the cover is configured to pass optical signals to and from the biosensor module; and
the cover is configured to pass wireless power to the wireless charging receive coil.*

98. As shown above, claim 9 recites a “housing comprising a bottom portion defining an opening,” with a “biosensor module” and “wireless charging receive coil” “aligned with the opening.” The claim further recites a “cover disposed over the biosensor module,” and that the “cover is configured to” (1) “pass optical signals to and from the biosensor module” and (2) “pass wireless power to the wireless charging receive coil.”

99. Petitioner alleges that the claimed “opening” maps to Kotanagi’s through-hole 22 formed in the bottom/rear portion of housing 2 in Kotanagi’s device. Petition, 21-22; EX-1003, ¶116; EX-1005, FIG. 5 and 7 (reproduced below; annotated by Petitioner).



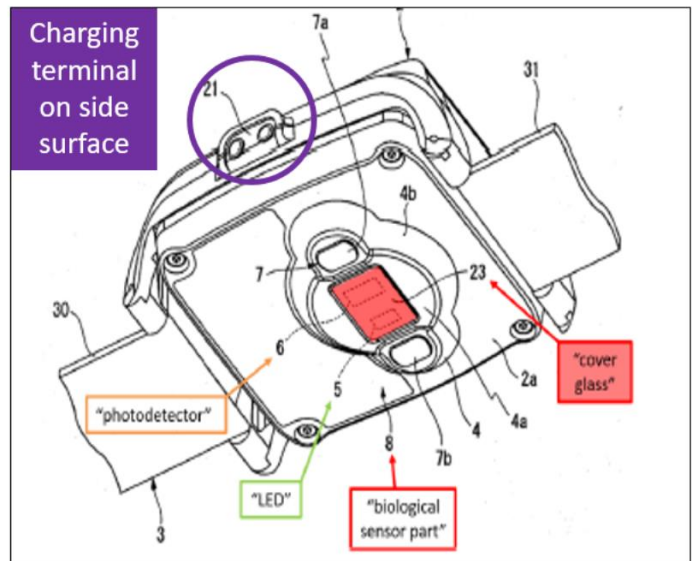
100. Petitioner further alleges that the claimed “cover disposed over the biosensor module” maps to Kotanagi’s cover glass 23 (shown in red below), and optical signals pass “through the cover glass” and to the LED 5 and photodetector 6 (alleged “biosensor module”). Petition, 26-27; EX-1003, ¶¶125-126; EX-1005, FIG. 5 (reproduced below; annotated by Petitioner)



101. Kotanagi states that “an external connection terminal (recharging means) 21 for recharging the rechargeable battery 13 by supplying power from an external device such as a recharger is provided on the side surface of the housing 2.” EX-1005, ¶53. “In addition, rather than the external connection terminal 21,” Kotanagi states that “a transformer or the like for supplying power to a recharger and to the inside of the housing 2 may be provided so as to recharge the rechargeable battery 13 in a contactless state.” *Id.*

102. Even if Kotanagi’s disclosure of battery recharging in a “contactless state” is interpreted as suggesting wireless charging (see EX-1005, ¶53), Kotanagi does not disclose where any alleged wireless charge receiving coil that would facilitate wireless charging would be positioned in the device nor does Kotanagi disclose that wireless power could or would pass through rear cover glass 23 (i.e., the alleged cover).

103. The only positional reference for charging in Kotanagi is in the context of its disclosure of wired charging via the “side surface of the housing” EX-1005, ¶53 (“an external connection terminal (recharging means) 21 for recharging the rechargeable battery 13 ... is provided on *the side surface of the housing 2*”), Fig. 5 (reproduced above; annotated by Patent Owner and Petitioner; showing connection terminal 21 for charging on the side surface of the device’s housing).

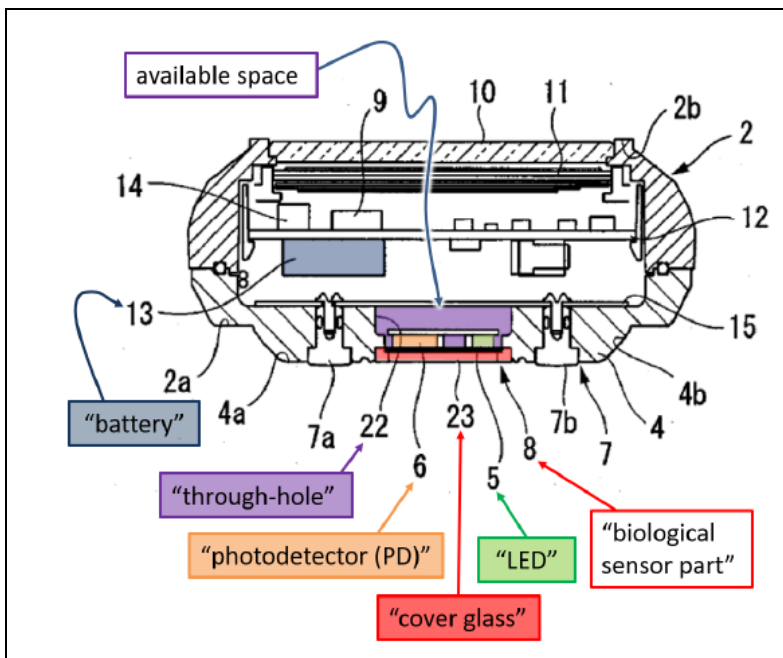


104. Petitioner therefore turns to Honda’s teachings and argues that Kotanagi’s device in view of these teachings would have led a POSITA to modify Kotanagi’s device to enable wireless power transmission through Kotanagi’s cover glass 23 to a device-side wireless charge receiving coil. See Petition, 28-33, 23-25; EX-1003, ¶¶130-134, 119-121, 128-129.

105. Specifically, Petitioner states that a POSITA would have found it obvious to include Honda’s wireless charge receiving coil within certain allegedly “available space” of through hole 22 formed in the rear protruding part 4 of Kotanagi’s device (as shown below), and that “power could pass through” cover

glass 23 to this wireless charge receiving coil positioned within the through hole 22.

See id.



Petition, 32 (citing EX-1005, Fig. 7 (annotated by Petitioner)).

106. This argument is incorrect for multiple reasons and ignores critical teachings of Kotanagi and Honda that not only preclude the combination proposed by Petitioner but would have counseled against it.

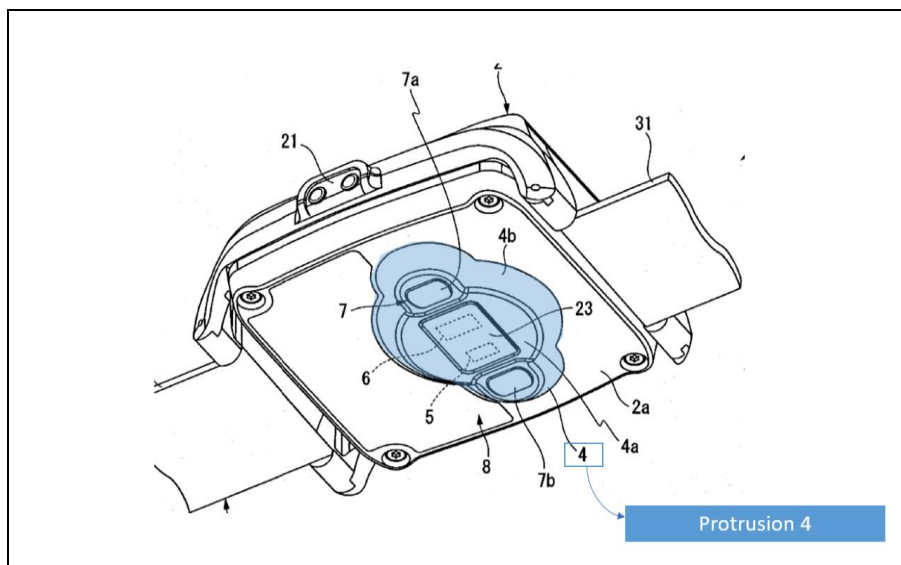
107. As explained below, Kotanagi imposes size restrictions on the protruding part 4 (to which rear cover glass 23 is fixed, with the cover glass 23 covering through hole 22). This in turn limits the size and positioning of the wireless charging receive coil in a manner that is contrary to Honda's teachings and its stated goals and purpose of achieving quick and efficient wireless charging. A POSITA would have therefore not been motivated nor would have a reasonable

expectation of success in providing a size-limited wireless charging receive coil in the allegedly available space in Kotanagi's device, particularly given the detrimental impact to wireless charging stemming from injecting distance between the transmit and receive coils, and power transfer reducing eddy currents and magnetization from metallic materials between the coils—as called for by Petitioner's combination.

108. Given these issues in the proposed Kotanagi-Honda configuration (which I have explained in further detail in the following sections), Petitioner has failed to demonstrate that a POSITA would have configured the device in this manner—particularly when considering that the POSITA would have been aware of other well-known and actually functioning configurations of biometric sensing and wireless charging devices (as corroborated by the Fraser reference) that provide a large wireless charging receive coil around optical elements within the device housing and thereby avoid the detrimental impact to wireless charging that Petitioner's combination injects and ignores.

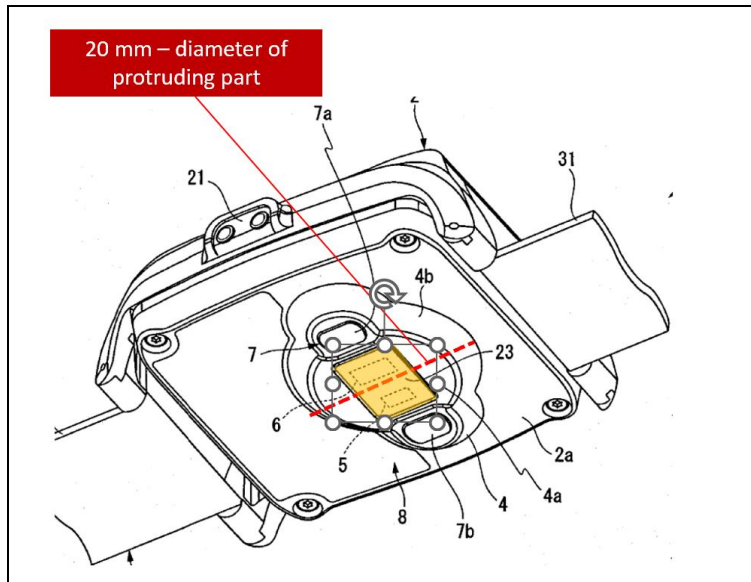
1. Petitioner ignores the physical restrictions imposed by Kotanagi on its rear protruding part 4 that would limit the size and positioning of the alleged wireless charging receive coil

109. Kotanagi sets an upper bound on the diameter of the protruding part 4 shown on the rear surface of its device (annotated in blue below in FIG. 5).



110. Specifically, Kotanagi states that the device “*according to [its] ... invention*” has a diameter of its protruding part 4 “set to **not greater than 20 mm.**” EX-1005, ¶¶36, 37 (emphasis added). Indeed, Kotanagi discloses that the diameter of the protruding part is set to “not greater than 20 mm, so the protruding part can be easily pressed against the living body surface with light force. See *id.*, ¶¶36-37, 76-77.

111. I have reproduced Kotanagi’s Fig. 5 below, with a red dashed line annotation added to show the 20 mm diameter of protruding part 4’s outer periphery, and orange annotation added to show cover glass 23 positioned within the protruding part 4. See also EX-1005, FIGS. 8-10 (showing 20 mm diameter of outer periphery of protruding part 4).

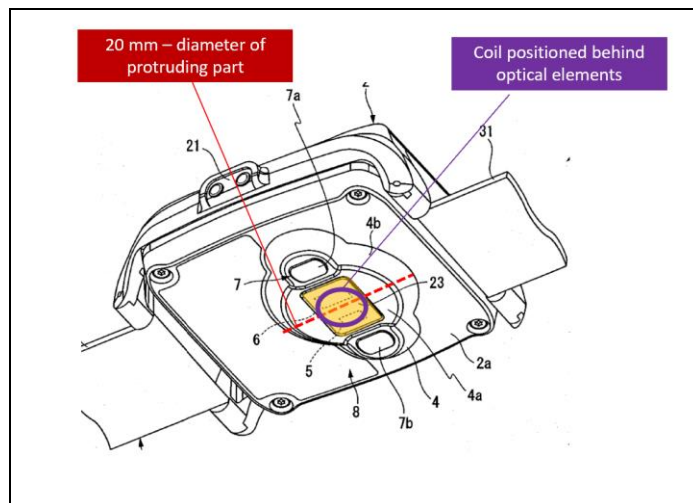


112. The rectangular cover glass 23 (orange) in the above image has a width that is roughly half (or less than half) of the diameter of the protruding part’s diameter, which would be about 10 mm (if not less).

113. Petitioner contends that the coil would be provided in the “available space” of through hole 22 behind cover glass 23, so as to allow wireless “power to pass through” Kotanagi’s cover glass 23 (the alleged “cover”). Petition, 27-32. Similarly, I understand that Petitioner’s expert, Dr. Duckworth, similarly testified that the charging coil in the proposed combination would be provided entirely behind the cover glass 23. EX-2020, 47:21-48:6, 26:19-27:7, 51:20-52:8, 55:20-56:7, 42:5-10, 47:21-48:6.

114. A POSITA would have thus understood that, for Honda’s wireless charging receiving coil to fit within the available space behind cover glass 23, the

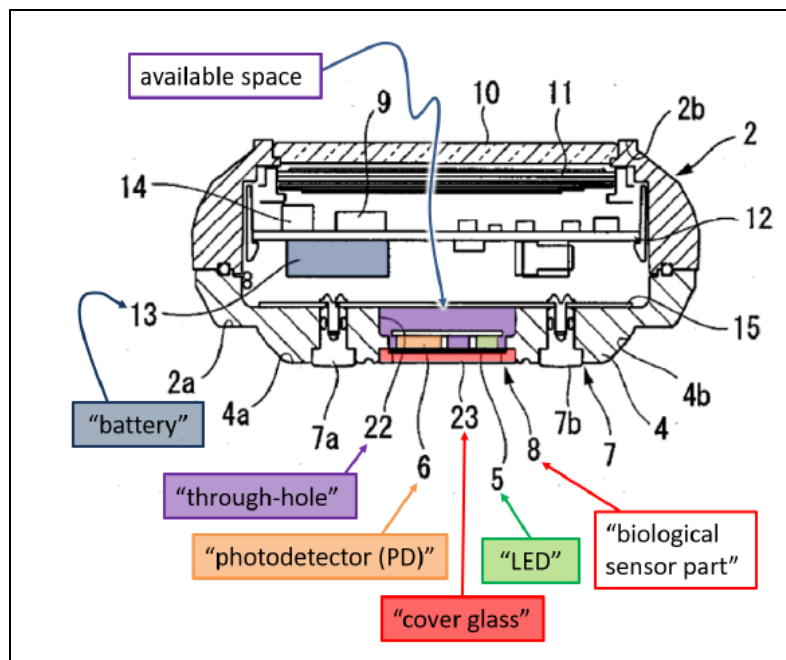
coil would have a maximum diameter no greater than the width of the rectangular cover glass (~10 mm; contemplated coil shown below in purple)



115. In this configuration, a POSITA would have further understood that the coil would be positioned behind the optical elements and the flexible board 24 to which they are affixed. EX-1005, ¶¶55-57 (“the LED 5 and the PD 6 are mounted to one end side of a flexible board 24 that is electrically connected to the sub-board 15, and are disposed in a state in which they are pushed toward the lower surface 2a side of the housing 2 by the elasticity of the flexible board 24”). Therefore, the optical elements do not overlie (and thereby interfere) with the optical transmission path of the LED 5 and PD 6 (referred to herein as the optical elements). *See id.* As discussed below, the additional distance and interfering metal structures significantly decreases power transfer, thus further making this configuration an unlikely design choice or implementation for a product.

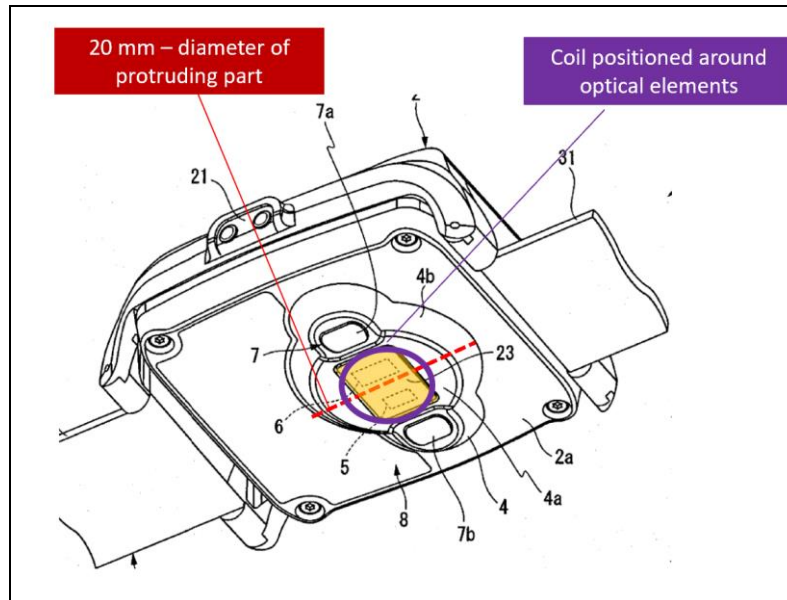
116. That is because Kotanagi explains the importance of these optical elements being positioned so that they “touch the inside of the glass cover 23” and in doing so, are “as close to the living body surface ... as possible.” EX-1005, ¶55. Thus, a POSITA would have recognized that the coil would be provided behind the optical elements so as not to frustrate Kotanagi’s goal of providing optical elements as close to the living body surface as possible. *See id.*

117. This is also consistent with Petitioner’s identification of the alleged “available space” behind the optical elements (as shown in Petitioner’s annotated image of Kotanagi below).



118. On the other hand, if Petitioner contends that the coil would fit around the optical elements, the coil would need to have a relatively larger diameter to encircle the optical elements. In such a configuration, Petitioner has failed to

demonstrate that the coil would fit behind the cover glass 23. As shown in an example depiction below, in such a configuration, the coil would extend into the protruding part 4 beyond cover glass 23.

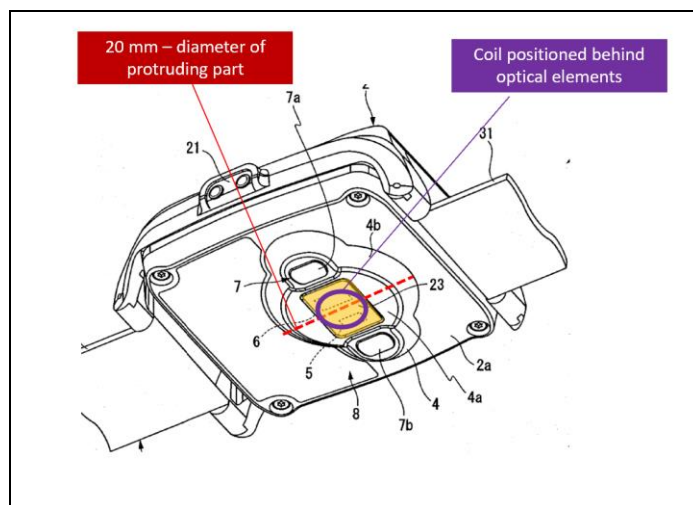


119. A POSITA would not have been motivated nor would have had a reasonable expectation of success in implementing the proposed combination in either of these configurations, as I have further explained in the following sections.

2. *A POSITA would have avoided the significant wireless charging degradation that occurs from positioning the wireless charging receive coil behind Kotanagi's optical elements*

120. As explained above, Kotanagi imposes a size restriction on the protruding part 4 formed in the rear portion of its device, within which the cover glass 23 is positioned over the through hole 22. This size restriction and Petitioner's desired provisioning of the wireless charging receive coil behind the

cover glass 23 would require the coil to be positioned behind the optical elements and the flexible board to which these elements are affixed, as explained above.



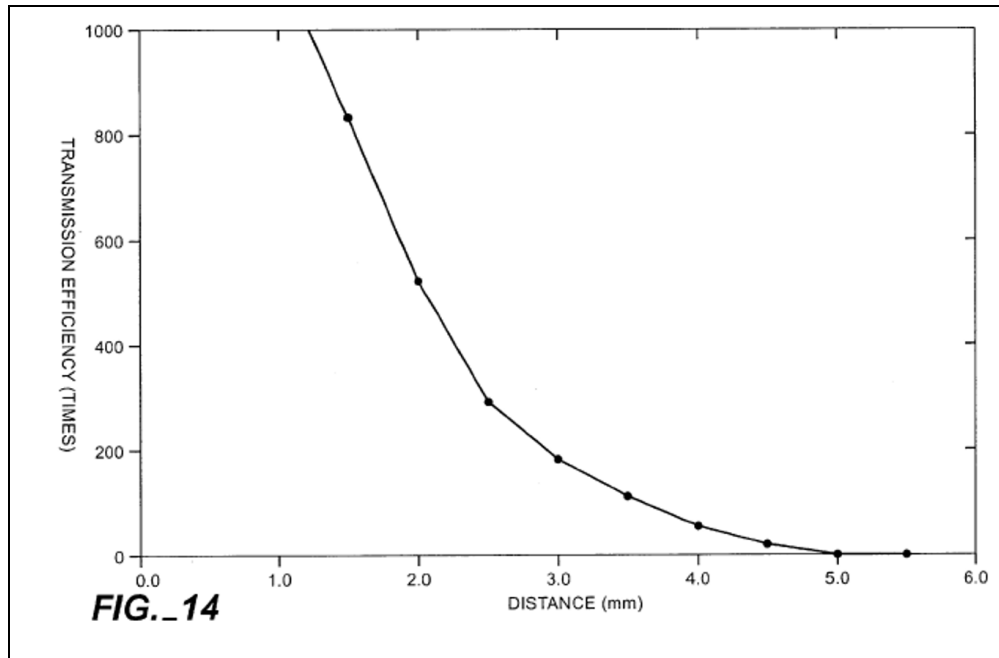
121. Petitioner proposes implementing a wireless charging receive coil in the allegedly available space in Kotanagi’s device would frustrate Honda’s goals and intended purpose. Specifically, Honda’s express goals and intended purpose are to enable “quick” and “efficien[t]” wireless charging by reducing distance between wireless charging coils and avoiding magnetic field degrading materials in the transmission path between the coils. EX-1006, 2:39-3:8, 6:41-45, 13:3-52, 5:9-15, FIGS. 14-15; *see id.*, 3:9-4:32.

122. For reasons explained below, Petitioner’s proposed configuration significantly degrades expected performance because it (1) limits the size of the wireless charging receive coil—which has a direct impact on wireless power transmission strength, (2) further introduces distance between the wireless charging receive and transmit coils, and (3) includes metallic materials in the

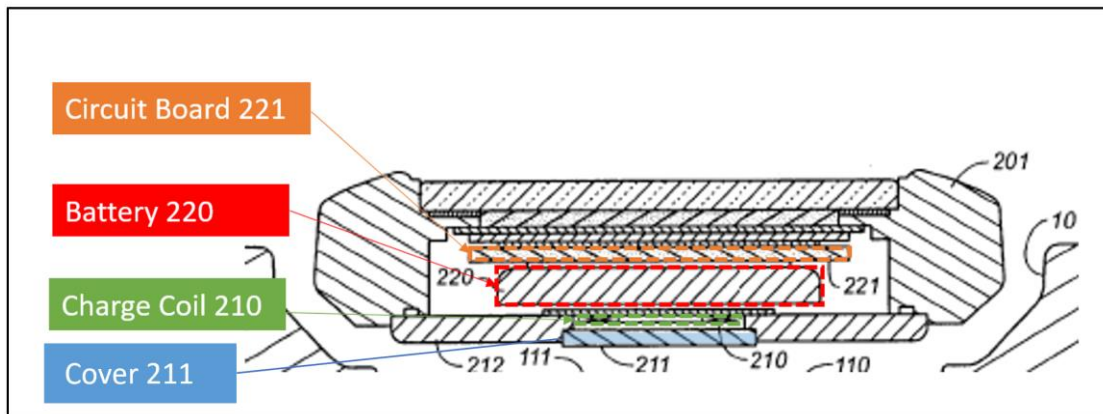
transmission path between the wireless charging receive and transmit coils—each of which significantly degrade wireless charging efficiency of the already-limited wireless charging receive coil in precisely the manner that Honda seeks to avoid.

123. **First**, Petitioner’s proposed configuration frustrates Honda’s stated goal of quick and efficient charging achieved by reducing the space between the charging receive and transmit coils. See EX-1006, 2:38-43, 2:55-60 (explaining that, as gap between coils is increased, “the degree of magnetic coupling weakens, substantially reducing the charging current to the secondary battery”), FIGS. 14-15 and associated description at 13:3-64, 5:9-15.

124. Honda recognizes that, as the distance between the coils decreases, the “transmission efficiency increases in accordance with a quadratic curve.” EX-1006, 13:14-16. In fact, Honda teaches that, “at a distance of 3 mm or less” between the transmit and receive coils, “the transmission efficiency is approximately 100 times the one in the conventional art having a distance of 5 mm.” *Id.*, 13:17-19. In other words, a 2 mm increase in distance between the transmit and receive coils can result in a 100 times charging efficiency degradation. See *id.*, EX-1006, FIG. 14 (reproduced below).



125. A POSITA would have therefore recognized that Honda achieves this high charging efficiency by positioning the wireless charging receive coil (in the wrist-worn device) directly adjacent to the cover glass, as shown below:

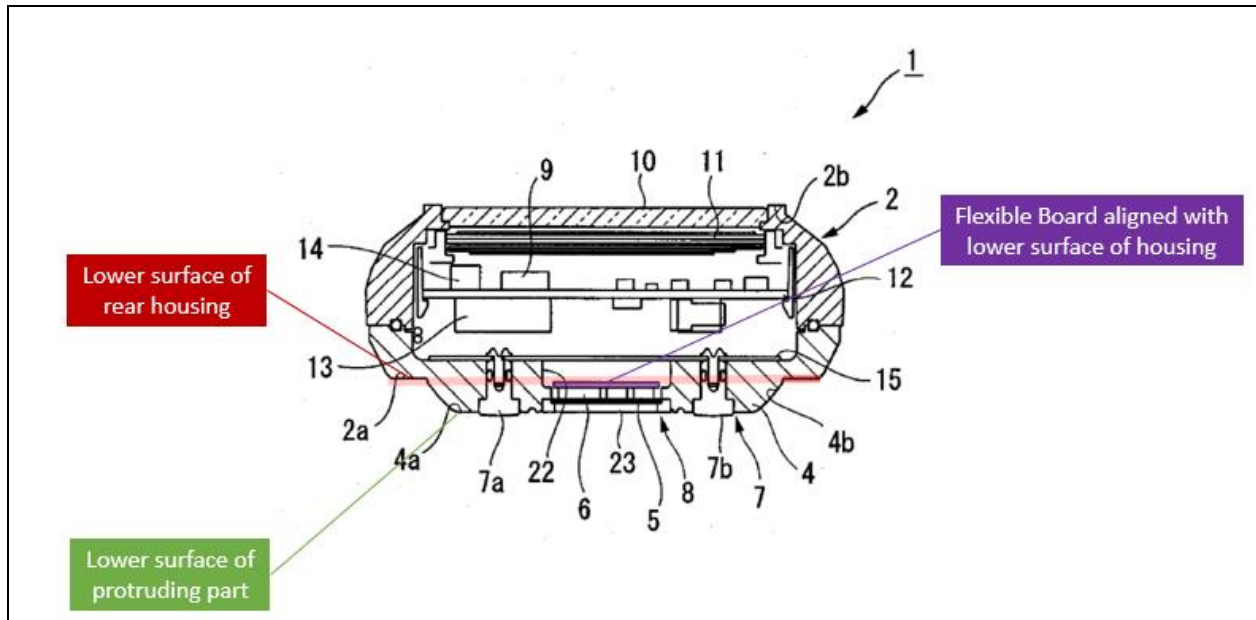


See EX-1006, Fig. 2 (annotated; showing Honda's watch embodiment with its wireless charging receive coil (green annotation) positioned directly adjacent to the watch's cover 211 (blue annotation)); FIG. 15 and associated text (describing

transmission efficiency in view of materials between coils, when distance between coils is 3 mm).

126. Petitioner's proposed configuration, however, calls for the wireless charging receive coil to be positioned spaced away (i.e., increased distance between coils) from cover glass 23 with optical elements and a flexible board 24 present therebetween—thus resulting in the increased spacing between the wireless charging receive and transmit coils that Honda seeks to avoid. See EX-1006, 2:38-43, 2:55-60, FIGS. 14-15 and associated description at 13:3-64.

127. Relatedly, Kotanagi states that the protruding part 4 has a lower surface 4a that is 2-4 mm lower than rear housing surface's lower surface 2a (EX-1005, ¶¶27-28) and further shows flexible board 24 (to which the LED 5 and photodetector 6 are connected) positioned within protruding part 4 at a location that is aligned with rear housing surface. See *id.*, FIG. 6, ¶¶55-57; FIG. 7 (reproduced below; annotated).



128. Honda in turn seeks to increase wireless power transmission efficiency and provides examples showing transmission efficiency when the spacing between wireless charging receive and transmit coils (including the thickness of materials interposed therebetween) would be 3 mm (which accounts for a cover glass thickness of 1 mm). EX-1006, 13:3-54, FIGS. 14-15, 2:39-60.

129. Indeed, assuming that Kotanagi's above-depicted figure (FIG. 5) is drawn to representative relative dimensions, a POSITA would observe that the flexible board 24 is roughly aligned with rear housing's lower surface 2a. And because the distance between the rear housing surface 2a and the lower surface 4a of protruding part 4 is at least 2 mm, elements placed behind this board would be at least 2 mm away from the extent of the protruding part's lower surface, thereby increasing the contemplated space between the coils from 3 mm to 5 mm or more.

Moreover, a POSITA would have recognized that the optical elements would span 2 mm or more in depth/vertical dimension.

130. And as noted above, an increase in distance from 3 mm to 5 mm results in a 100 times decrease in wireless charging efficiency, which is similar to the amount of charge degradation that Petitioner's proposed configuration would encounter as well. Thus, this provides another reason for why positioning the coil elements behind Kotanagi's optical elements would be significantly detrimental to wireless power transmission and efficiency, and would be counter to Honda's stated goals that are geared toward increasing/improving wireless charging efficiency. *See* EX-1006, 2:38-43, 2:55-60, 13:3-64, FIGS. 14-15.

131. **Second**, positioning Honda's wireless charging receive coil behind Kotanagi's optical elements and the flexible board is also contrary to Honda's goal of quick and efficient power transmission because such a configuration would inject the type of noise and interference that Honda expressly seeks to avoid. Specifically, Honda teaches that presence of metal materials between the transmitting and receiving coils, gives rise to eddy currents, which reduce charging efficiency. *See* EX-1006, 2:48-59 ("eddy currents take place in the electrically conductive metal material, weakening the electromagnetic coupling"), 13:3-32.

132. This is also why Honda provides glass for its rear cover (EX-1006, 13:3-64, FIGS. 14-15). A POSITA would have also recognized that this is also

why Honda contemplates air-core type coils (i.e., coils “without any core”) given that such coreless coils “limit the magnetization of a watch mechanism ... and ... prevent the exposure of a magnetic metal.” EX-1006, 6:41-46.

133. Thus, to achieve its goal of quick and efficient charging, a POSITA would have recognized that Honda seeks to reduce eddy currents and magnetization from metallic materials in the transmission path between the receive and transmit coils.

134. Given these teachings in Honda, a POSITA would have also recognized that Kotanagi’s optical elements and the flexible board 24 to which they are connected—behind which the coil would be positioned in the proposed combination—are typically made of metal-based materials. This is corroborated by multiple references from the relevant timeframe:

- a. EX-2008, Abstract, ¶¶11, 23-25, 29 (light emitting diode (LED) is made from metal-based materials, including among other components, “a metal substrate,” “a metal layer,” “a mirror layer,” and “electrode[s]”);
- b. EX-2009, ¶¶24, 25, 27, 29 (describing use of metal in LEDs, where the LED includes semiconductor layers, electrodes, metal-based carriers, and a reflective layer made of metal);

- c. EX-2015, ¶¶14-15, 29-30 (describing a photodetector that, includes among other components, “a metal layer,” a photodiode having a semiconductor region, and an electrode);
- d. EX-2016, ¶¶1-2, 21-22, 79, 82, 84 (describing a photodetector for portable communication tools as including semiconductor elements and electrodes made of, at least in part, metal);
- e. EX-2017, 3:37-42, 4:6-17, 4:28-32 (describing components of the LED, including electrodes made at least in part of metal, and a metal-based reflector).

135. Thus, positioning elements made of such materials between the transmit and receive coils, per Petitioner’s proposed combination, significantly reduces power transfer efficiency and would be counter to Honda’s teachings and express goals of achieving “quick” and “efficien[t]” wireless charging by avoiding metallic materials in the wireless power transmission path and added spacing between coils. See EX-1006, 2:38-43, 2:55-60, 13:3-54, FIGS. 14-15.

3. *A POSITA would have turned to other actually functioning wireless charging configurations to avoid the signal degradation issues in Petitioner’s proposed configuration*

136. In view of the above-described degradations in wireless signal transmission issues, a POSITA would not implement wireless charging in

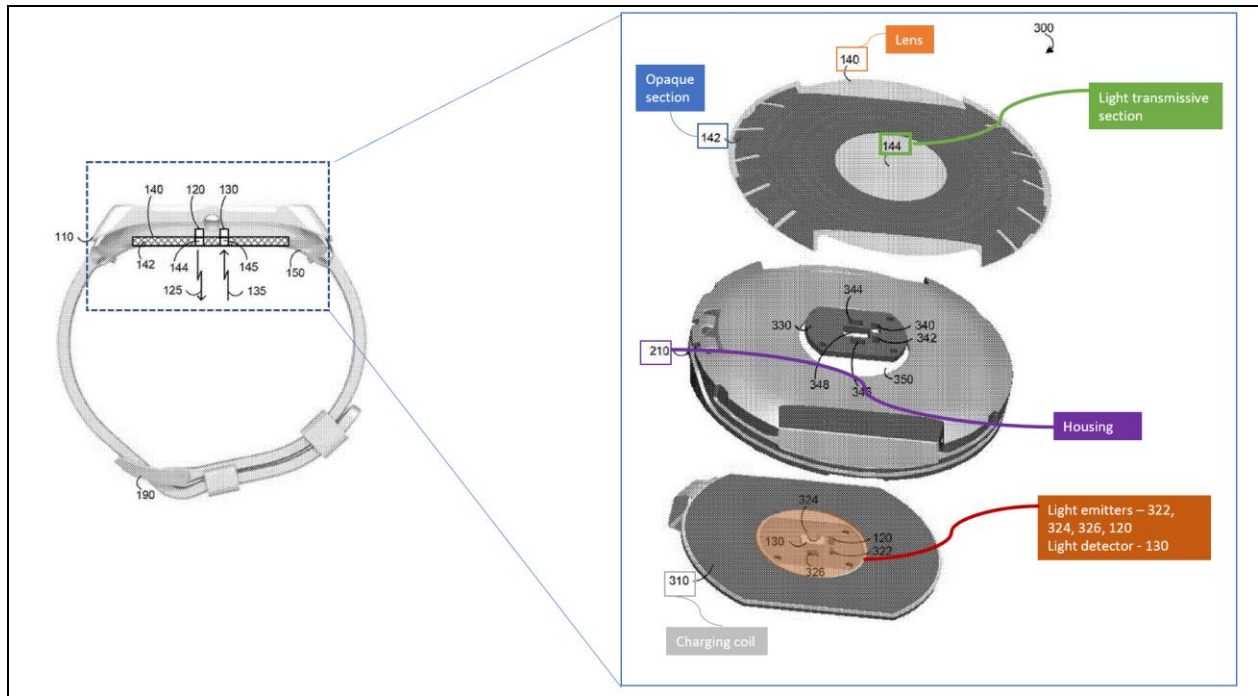
accordance with Petitioner's proposed configuration—particularly when the POSITA would have known of other actually functioning configurations of wireless charging coils and optical elements in rear portions of wrist-worn devices that counteract the signal degradation issues that Honda seeks to avoid or mitigate.

137. A POSITA would have been aware of a wrist-worn device—such as the device disclosed in Fraser—that implements a larger wireless charging receive coil covering a substantial portion of the rear watch surface and in doing so, counteracts the signal degradations that come from interposing materials and/or spacing between the wireless charging receive and transmit coils (as Petitioner's proposed configuration demands).

138. However, if Kotanagi's device were so configured to have a larger coil that extends beyond the cover to overlie the rear housing surface in Kotanagi, wireless power transmission that would pass to the wireless charging receive coil, as the claim requires in view of the intrinsic record, would pass through the rear housing surface and not the cover (e.g., due to the relatively small area of the cover and interfering metal components).

139. Specifically, a POSITA in the relevant timeframe would have been confronted with devices, such as those disclosed by Fraser, which provide wireless charging and biometric sensing capabilities, and which describe an express configuration of wireless charging coil and optical elements to enable these dual

capabilities. EX-1041, FIGS. 1, 3, ¶¶24-30. A side view and a corresponding exploded view of Fraser's device is provided below (EX-1041, FIGS. 1 and 3 annotated below):



140. As shown in the exploded view (on the right), Fraser's device includes a lens 140 making up the device's rear surface that is directly adjacent to the wearer's wrist/body. EX-1041, ¶¶24-25, FIG. 3. This lens 140 surface includes an opaque section 142 and a light transmissive section 144. *Id.* The housing 210 is provided next and above the lens 140, and the charging coil 310 with the optical elements (120, 130, 322-326) it encircles are provided above the housing 210. *Id.*, ¶¶24-26, FIG. 3.

141. Thus, Fraser's charging coil 310—much like in Petitioner's proposed combination—is spaced away from a wireless transmit coil (i.e., the lens 140

surface), given that Fraser's device coil is positioned behind the device's housing and the rear device surface (i.e., lens 140), thereby resulting in increased distance between coils. Additionally, Fraser's charging coil includes optical elements in the core section of this coil—which, at least in part, are made from metallic materials (as explained and corroborated above).

142. The main differences between Fraser's device and Petitioner's proposed configuration are that (1) the charging coil is not confined to a ~10mm size and instead extends to cover a substantial portion of the rear device surface (which, in the context of the Kotanagi device would therefore cover the regions beyond the protruding part 4 within which the optical elements are provided) and (2) the charging receive coil is provided behind the device's rear surface that extends beyond the central portion of the lens 140 behind which the optical elements (photodetectors and LEDs) are provided.

143. A POSITA would have recognized that this large coil configuration in Fraser counteracts the above-described degradation in wireless power transmission caused by increasing distance between transmit and receive coils and power transfer reducing eddy currents and magnetization from metallic materials within their transmission path, as further illustrated using the following modeling and simulations I described in the following sections.

(a) *Modeling Methodology and Simulation of Different Wireless Charging Receive Coil Configurations*

144. In the following sections, I have modeled wireless power transmission of a coil as per Petitioner's combination (which is limited to ~10 mm in diameter) with a coil of the type shown in Fraser that would cover a substantial portion of the rear housing surface. For purposes of this modeling, I have made the following conservative assumptions:

145. For purposes of simulation and modeling, I have assumed a device with rear surface that is in the range of 30 to 40 mm wide. In the context of Kotanagi's device, when accounting for the 20 mm diameter of the protruding part 4, I have assumed a Fraser-like coil would extend centrally from the outer extent of the protruding part 4 (at 20 mm) to the extents of the device (at 30 to 40 mm). As such, one example of a coil that could fit in this space would be a ring-shaped coil with an inner radius for a central core spanning 12.5 mm in inner radius (i.e., 25 mm in inner diameter) and extending from there to 30 mm extent of the device (i.e., outer radius of 15mm and outer diameter of 30 mm). Another example of a coil that could fit in this space would be a ring-shaped coil with an inner radius for a central core spanning 17.5 mm in inner radius (i.e., 35 mm in inner diameter) and extending to the 40 mm extent of the device (i.e., outer radius of 20 mm and outer diameter of 40 mm). In this modeling, I have used a 20-loop coil (and have also considered a 10-loop coil) with a distance between the transmit and receive coils of 3-5 mm.

146. For the 10 mm diameter called for by Petitioner's proposed configuration, I have assumed a coil with an air core type core with a 10 mm outer diameter (i.e., 5 mm outer radius) and a 5 mm inner diameter (i.e., 2.5 mm inner radius). I note that, in my modeling, using a 2.5 mm inner radius achieved a better performance than that of a coil with a smaller radius (e.g., 1 mm). As such, to be conservative, I have used the 2.5 mm inner radius because of its relatively better performance. In this modeling, I have used a 20-loop coil (and have also considered a 10-loop coil) with a distance between the transmit and receive coils of 3-5 mm.

147. I performed my modeling using the methodology and approaches highlighted in the references describing and relating to wireless transfer modeling. *See, e.g.,* EX-2023 to EX-2032. In particular, for the modeling and associated simulations, I employed the method of moments computation technique for the analysis of coil antennas. The initial stage in solving electromagnetic problems involves discretizing Maxwell's equations, leading to a matrix-vector system that correlates the applied voltage vector (V) to the current vector (I) representing the surface current on the antenna. The matrix Z , known as the interaction or impedance matrix, serves as the intermediary linking V to I . The overall modeling and simulation is formulated in three key segments:

- a. **Discretization of Metals:** Discretization, achieved through meshing, which facilitates the transition from the continuous antenna geometry to the discrete domain. The metal surface of the antenna is subdivided into triangles.
- b. **Basis Functions:** For the computation of surface currents on the antenna structure, I use Rao-Wilton-Glisson basis functions. These functions encompass pairs of adjacent triangles, resembling small spatial dipoles with linear current distribution. Each triangle is associated with a positive or negative charge.
- c. **Interaction Matrix:** The interaction matrix is a complex dense symmetric matrix, forming an N -by- N square matrix, where N represents the number of basis functions (interior edges in the structure). Completing the interaction matrix involves calculating the free-space Green's function between all basis functions on the antenna surface. To compute the interaction matrix, I excite the antenna by applying a voltage at the feeding edge. Consequently, the voltage vector assumes zero values everywhere except at the feeding edge. Solving the resultant system of equations yields the unknown currents. Once these

currents are determined, I calculated the field and surface properties of the around the antenna or antenna array.

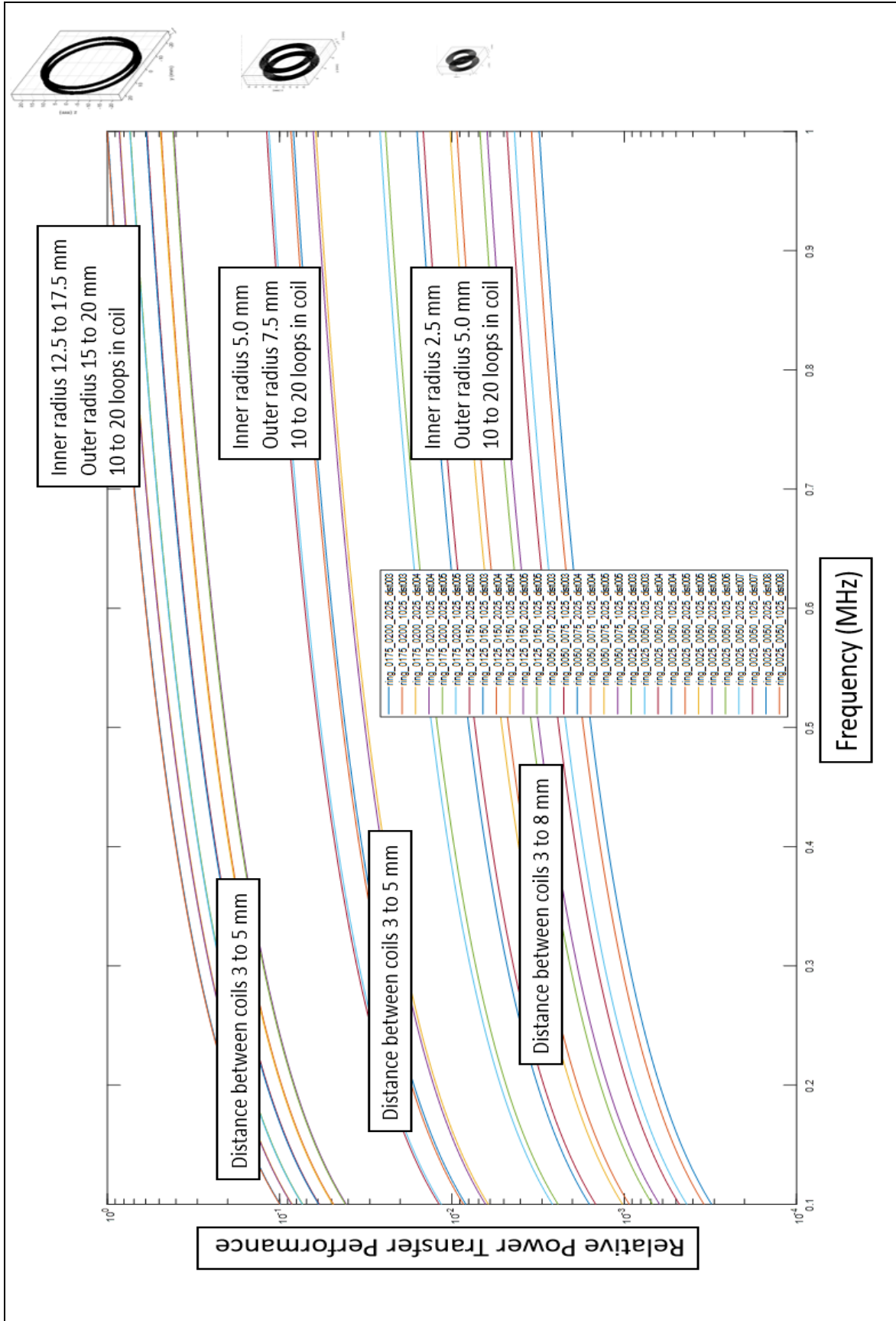
148. Using this methodology and approach:

- a. I compare coils of a size of the proposed combination and Fraser-like device (as described above) at the same distance (i.e., same distance between wireless charging transmit and receive coils).
- b. I also show the detrimental impact on power transmission when distance between coils is increased in the context of the smaller coil of the proposed combination..
- c. I also explored a reasonable range of configurations, e.g., with different wire size, number of loops, and inner diameter in order to highlight the dominant implications of diameter.

149. As shown and described below,

- a. when modeling the wireless power transmission of device of such devices, the difference in wireless signal transmission is ***roughly 2 orders of magnitude more*** in a device with a larger coil (i.e., akin to Fraser's device) relative to the proposed combination's device (when assuming that each configuration

has transmit and receive coils that have the same distance between them).



- b. This disparity in wireless power transmission indicates that if the Fraser-like device takes **1 hour** to charge the device's battery, Petitioner's proposed configuration would take **100 hours** to charge the same battery.
- c. This modeling does not account for the impact of interfering metal, which would be more detrimental to the smaller coil, nor does it account for the detrimental impact of increased sensitivity to misalignment, which again would be more significant in the smaller coil in Petitioner's combination.
- d. This modeling also show the negative impact on wireless power transmission as the distance between the transmit and receive coils increases, as called for by Petitioner's proposed configuration. As shown above, when the distance between the coils is increased, the power transmission in the context of the smaller coil would be **over 2 orders** of magnitude (**~2.5 orders of magnitude**) less than in a device with a larger coil (i.e., akin to Fraser's device). This disparity in wireless power transmission indicates that if the Fraser-like device takes **1 hour to charge** the device's battery, Petitioner's proposed

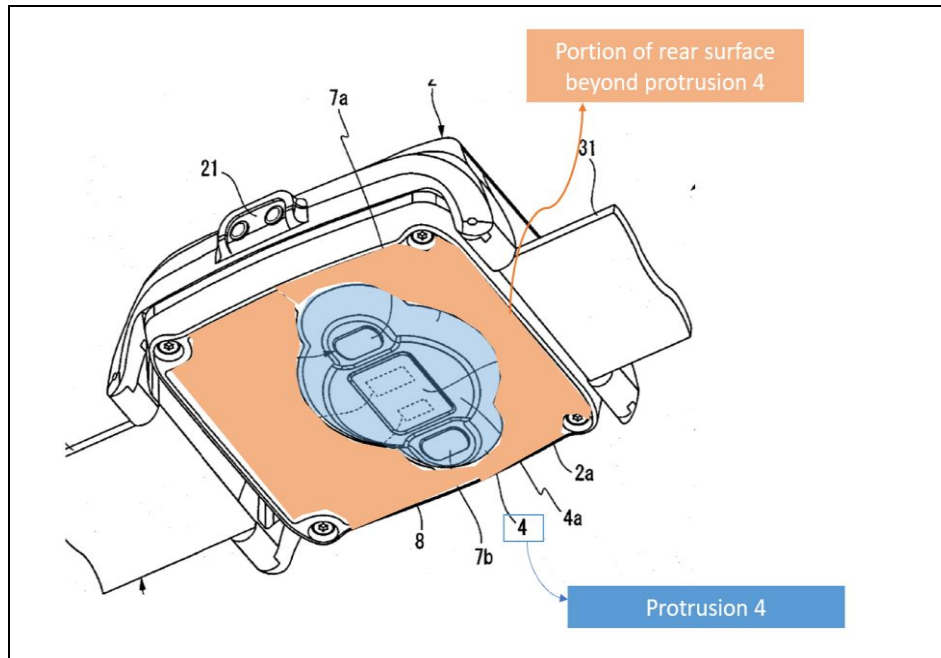
configuration in view of the added distance between the coils would ***take about 500 hours to charge the same battery.***

- e. Consistent with this modeling and simulation, Honda similarly contemplates such a substantial impact to wireless power transmission, noting that as the distance between the coils increases, the transmission efficiency decreases in accordance with a “quadratic curve.” See EX-1006, 13:13-21 (100 times reduction in transmission efficiency as distance between coils increase from 3 to 5 mm).
- f. This modeling therefore indicates the substantially weaker wireless power transmission in the smaller coil in Petitioner’s combination relative to a larger, Fraser-like coil. Note that this modeling still does not account for the impact of interfering metal, which would be more detrimental to the smaller coil, nor does it account for the detrimental impact of increased sensitivity to misalignment, which again would be more significant in the smaller coil in Petitioner’s combination.
- g. A POSITA would have thus recognized and understood the significant detrimental impact to wireless power transmission—e.g., due increased distance between coils and the detrimental

impact of power transfer reducing eddy currents and magnetization from metallic materials in the wireless power transmission path, as required by Petitioner's combination—would be more pronounced and not as readily counteracted in the smaller coil (relative to the larger, Fraser-like coil).

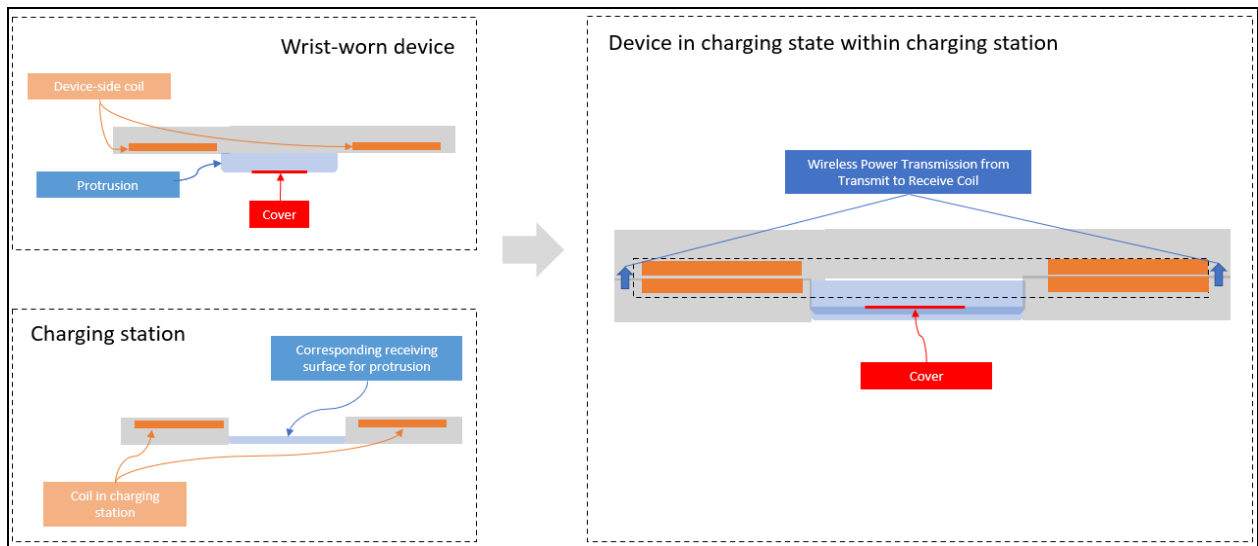
150. Therefore, if a POSITA were to provide the wireless charging receive coil in the rear portion of Kotanagi's device, as Petitioner seeks via its combination, the POSITA would have recognized that such a coil would be much larger and would encompass a larger portion of the device's rear surface—as in Fraser—to counteract the limited wireless power transmission of the smaller coil called for by Petitioner's combination, and the wireless power transmission degradation issues caused by the added spacing and power transfer reducing eddy currents and magnetization from metallic materials in the transmission path between the wireless charging receive and transmit coils

151. Moreover, as shown below, when configuring the wireless charging coil similar to that of Fraser, a POSITA would have recognized that the wireless charge receiving coil would extend beyond the space provided behind Kotanagi's cover glass 23 and even the protruding part 4 of Kotangi's device (because of the space constraints imposed by electrodes 7a and 7b that sandwich the rear cover 23 and optical elements 5 and 6 within the protruding part 4):



152. In such a configuration, a POSITA would have recognized that any wireless power that passes to the wireless charging receive coil (from a charging transmit coil), in the context of claim 9 as understood in view of the intrinsic record, would not pass through the alleged “cover” (i.e., cover glass 23 in Kotanagi)—and instead would pass through the device’s rear housing surface beyond the protrusion 4 (as annotated in orange above).

153. This is also illustrated using the following mockups of the combination’s device and charging station:



154. As shown in the above sectional mockups of the device and the charging station (on left), (1) the device's larger coil would surround protruding part/protrusion 4 and extend to overlie the areas of the rear surface beyond the protrusion and (2) the charging station would be shaped to receive the rear surface of such a device, including a shaping that accommodates the device's protruding part 4 (see Petition, 88-90 (discussing use of complementary shaping of charging station)).

155. When such a device is inserted into the complementary-shaped charging station (as illustrated above on the right), the device-side coils and the station-side coils are adjacent to each other, and separated by the respective device and charging station's housing

156. In this configuration, Kotanagi's protrusion, and the rear cover 23 disposed within it, would not be the conduit for the wireless power transmission

passing to the wireless charging receive coil. Instead, and as shown above, the cover (annotated red above) would be spaced away from the coils and therefore beyond the associated field that conveys wireless power to the wireless charging receive coil.

157. In summary, a POSITA would have recognized that positioning the coil in the allegedly available space behind the optical elements would limit the size of the coil, and by extension, reduce the device's wireless power transmission rate and efficiency. Moreover, such a configuration would be contrary to Honda's goals of enabling quick and efficient wireless charging, which are achieved by avoiding the very structural aspects mandated by Petitioner's proposed configuration—namely, (1) spacing between the coil and the rear device cover and (2) from power transfer reducing eddy currents and magnetization from metallic materials in the wireless power transmission path.

158. When considering the above-described issues in the combination's proposed configuration, Petitioner has failed to demonstrate that a POSITA would have configured the device in this manner—particularly when considering that the POSITA would have been aware of other well-known and actually functioning configurations of biometric sensing and wireless charging devices (as corroborated by the Fraser reference) that provide a large wireless charging receive coil around

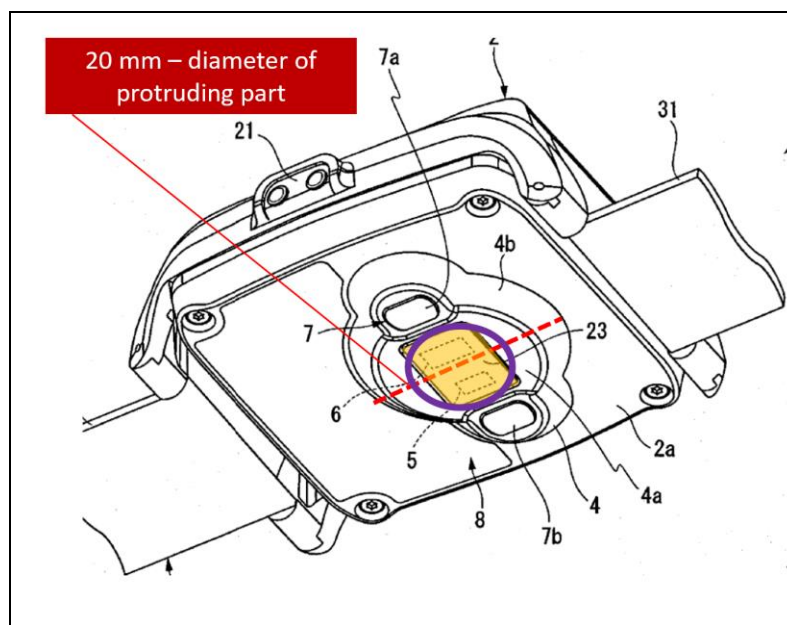
optical elements within the device housing and thereby avoid the above-described issues that Petitioner's combination injects.

159. Indeed, as Fraser corroborates, a POSITA would have also recognized that such a large coil would expand beyond the identified cover of the combination's device. And in that case, any wireless power transmission that occurs, as the claim requires in view of the intrinsic record, would not pass through the cover or the alleged opening behind it (e.g., due to the relatively small area of the cover and interfering metal components)—and instead, would pass via the portions of the rear surface/housing beyond the cover.

160. In summary, Petitioner has, at best, presented a device configuration in which a wireless charging coil **could** be provided in Kotanagi's through hole 22. However, Petitioner has not demonstrated that a POSITA **would** have configured the device in the proposed manner when considering the detrimental impact to wireless charging stemming from this configuration and given the order of magnitude alternative available that avoids those issues. On this record, Petitioner has failed to demonstrate why or how Petitioner's proposed combination would render obvious claim 9.

4. A POSITA would have also avoided the significant wireless charging degradation that occurs from positioning the wireless charging receive coil around Kotanagi's optical elements

161. Even if Petitioner's configuration contemplates positioning the wireless charging receive coil around Kotanagi's optical elements (as depicted below), the above-described issues (see §VII.A.2-3 *supra*) are also present in such a configuration.



162. I understand that Petitioner's expert testified that the coil would only be provided behind the cover glass (EX-2020, 47:21-48:6; 26:19-27:7, 51:20-52:8, 55:20-56:7, 42:5-10). A POSITA would have recognized that providing the coil to surround the optical elements would require a larger diameter coil (than the one required to provide the coil behind the optical elements). However, Petitioner and its expert have not explained or offered analysis to show that such a larger wireless

charging receive coil, when positioned around the optical elements 5 and 6, would or could still fit behind cover glass 23, as the proposed configuration would require. *See id.*

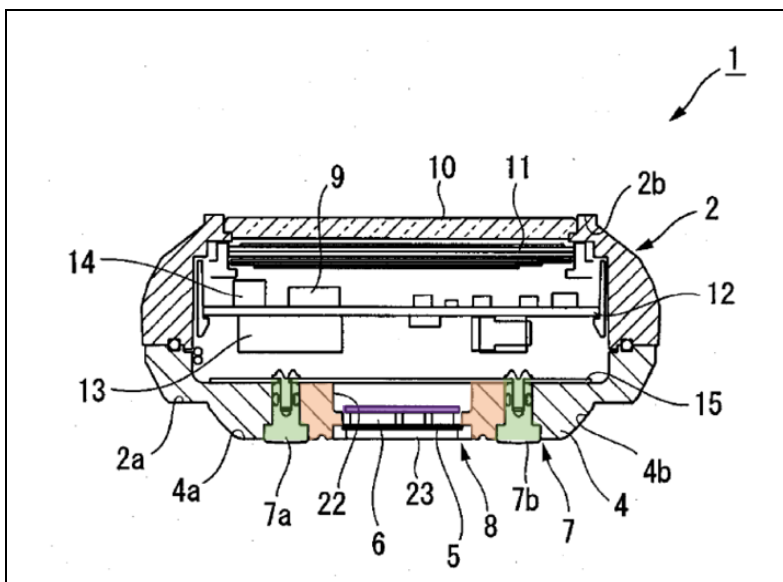
163. In fact, as shown above, when the coil surrounds the optical elements, a POSITA would have understood the coil would expand to overlie portions of the housing/protruding part 4, which then would result in similar power transmission degradations stemming from interposing metal housing materials between coils, as contemplated by Petitioner's combination (as described above in §VII.A.2-3 *supra*). EX-2020, 20:15-22:2, 45:13-19, 55:20-56:7 (Petitioner's expert testifying that the proposed Kotanagi-Honda combination would have a metal housing and that the protruding part is formed in the housing), 47:21-49:7, 28:17-20, 30:20-32:1 (Petitioner's expert testifying that if coil expands beyond the cover glass and is "behind conductive material," then there would be "weakening of the electromagnetic coupling," which would "degrade the transfer of power from a transmit coil to a receive coil").

164. Even assuming for argument's sake that that is the case, such a configuration would be counter to and in fact, would frustrate Honda's goals of seeking to enable quick and efficient charging of the device, as further explained below.

165. **First**, positioning the coil around Kotanagi’s optical elements would not avoid the above-described signal degradation stemming from providing metallic materials in the core of the coil—which again are counter to Honda’s teachings. EX-1006, 6:41-45, 13:25-32, 2:43-65.

166. **Second**, a POSITA would have recognized that wireless charging efficiency is directly related to the size and number of turns of the charging coil. In the proposed configuration, however, the space limitations imposed by Kotanagi around the optical elements and between the cover and the flexible board (to which the optical elements are affixed) would reduce the number of possible turns of the charging coil, which in turn would place significant constraints on the wireless charging capability of the coil and the device as a whole.

167. For example, Kotanagi discloses and shows electrodes 7a and 7b that are “disposed on the lower surface 4a of the protruding part 4 ... sandwich[ing] the LED 5 and the PD 6.” EX-1005, ¶58. Additionally, Kotanagi’s device includes (1) portions of housing in the remaining lateral/horizontal space between the optical elements and the electrodes (shown in orange below) and (2) flexible board 15 (shown in purple below) that restricts the vertical space between cover 23 and this board (to which the optical elements are affixed).



168. Thus, under Petitioner’s proposal for the combination, if the wireless charging receive coil is positioned around the optical elements 5 and 6, a POSITA would have recognized that such a coil could not extend much further—horizontally or vertically—given the presence of housing, electrodes, and the flexible board adjacent to the optical elements 5 and 6

169. As a result, the coil, while slightly larger in diameter than 10 mm (as discussed above in the context of §§ VII.A.2-3), would nevertheless have significantly fewer turns/winding in the horizontal and vertical directions, which would directly impact wireless power transmission. Also, as explained below, the wireless power transmission of such a coil would be at least **1 order of magnitude less in power transmission relative to a larger coil** as in Fraser device (see §§ VII.A.2-3 *supra*).

170. In more detail and as explained in the following paragraphs, I have modeled wireless power transmission of a coil as per Petitioner's combination with a coil of the type shown in Fraser that would cover a substantial portion of the rear housing surface.

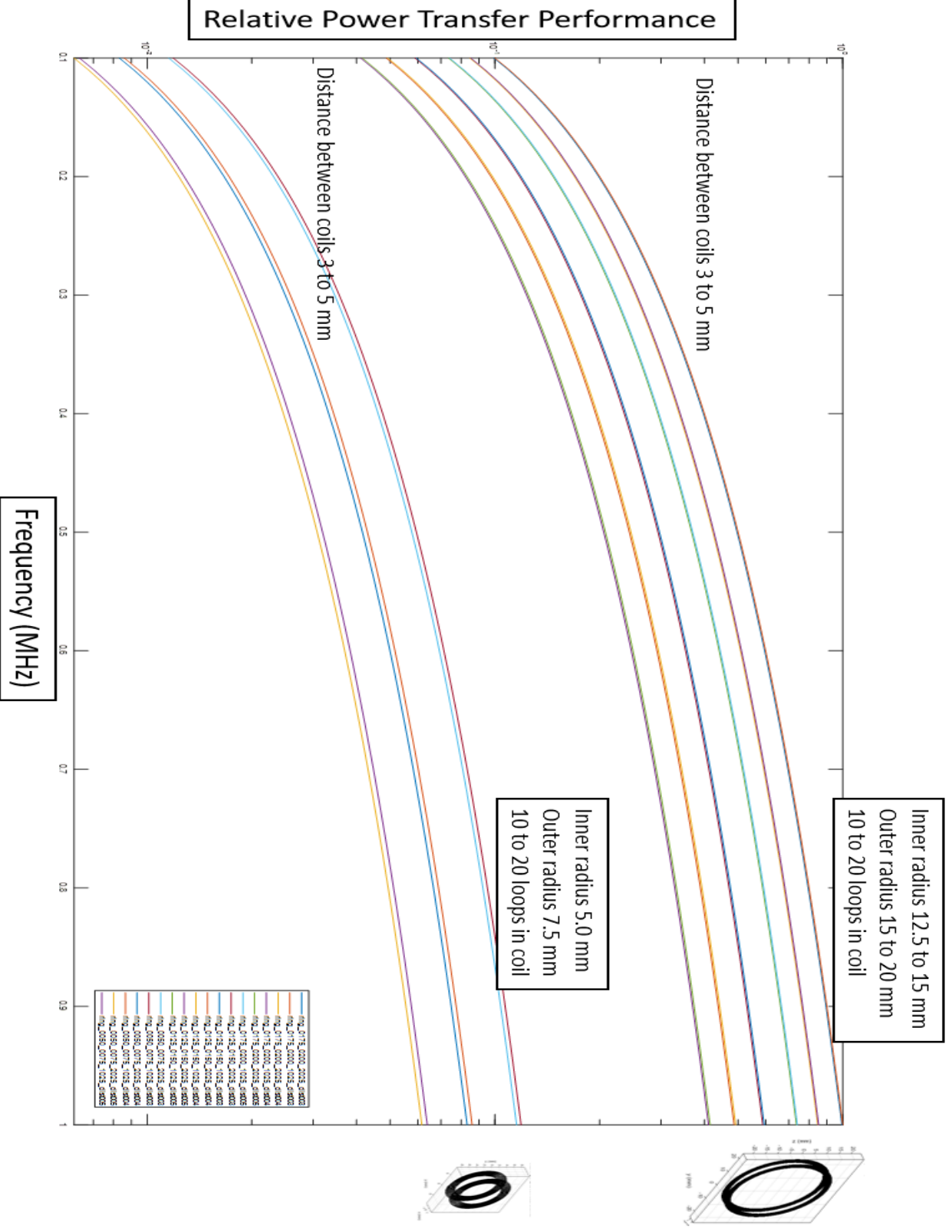
- a. For purposes of this modeling, I have applied the similar conservative assumptions as those described above with respect to the configuration discussed in §§VII.A.3.a. Specifically, I have assumed a Fraser like coil as noted above. I have assumed a Fraser-like coil would extend centrally from the outer extent of the protruding part 4 (at 20 mm) to the extents of the device (at 30 to 40 mm). As such, one example of a coil that could fit in this space would be a ring-shaped coil with an inner radius for a central core spanning 12.5 mm in inner radius (i.e., 25 mm in inner diameter) and extending from there to 30 mm extent of the device (i.e., outer radius of 15mm and outer diameter of 30 mm). Another example of a coil that could fit in this space would be a ring-shaped coil with an inner radius for a central core spanning 17.5 mm in inner radius (i.e., 35 mm in inner diameter) and extending to the 40 mm extent of the device (i.e., outer radius of 20 mm and outer diameter of 40 mm). In this

modeling, I have used a 20-loop coil (and have also considered a 10-loop coil) with a distance between the transmit and receive coils of 3-5 mm.

- b. For the coil to encircle/surround the optical elements in Petitioner's proposed configuration, I have conservatively assumed a coil with an air core of inner diameter 10 mm (i.e., inner radius of 5 mm) so as to at least span the extent of the optical elements (although Kotanagi's configuration suggests a greater diameter would be needed to encircle the elements). Given the presence of housing, electrodes, and flexible board adjacent to the optical elements, the number of windings possible are limited for this particular space. Nevertheless, I have assumed in this configuration, I have used a 20-loop coil (and have also considered a 10-loop coil) with a distance between the transmit and receive coils of 3-5 mm.
- c. Moreover, in this configuration, I have estimated the coil as having an outer diameter of 15 mm (i.e., outer radius of 7.5 mm). That is because, when accounting for the fact that the extent of the protruding part is 20 mm, there would likely be enough space for the coils to extend 5 mm laterally (i.e., from

inner diameter extent to an outer diameter extent) but not to the 20 mm extent of the protruding part 4 given the above described space constraints.

- d. And when modeling the wireless power transmission of such devices (in the manner described above with reference to §VII.A.3.a), the difference in wireless signal transmission is **1 order of magnitude** more in a Fraser-like device relative to the proposed combination's device.



- e. This disparity in wireless power transmission indicates that if the Fraser-like device takes **1 hour** to charge the device's battery, Petitioner's proposed configuration would take **10 hours** to charge the same battery given the above-described sizing and coil separation considerations.
- f. This modeling/simulation does not account for the significant detrimental impact to wireless power transmission and charging efficiency, from power transfer reducing eddy currents and magnetization from metallic materials in the wireless power transmission path—which would be more pronounced in the already-weak power transmission/efficiency of the smaller coil (relative to a Fraser-like device that has a substantially higher signal transmission rate and efficiency that can more readily offset the detrimental of such charge-degrading factors). Nor does this modeling/simulation account for the detrimental impact of increased sensitivity to misalignment, which again would be more significant in the smaller coil in Petitioner's combination.

171. Given the above-described issues in this proposed configuration, Petitioner has failed to demonstrate that a POSITA would have configured the device in this manner—particularly when considering that the POSITA would have been aware of other well-known and actually functioning configurations of biometric sensing and wireless charging devices (as corroborated by the Fraser reference) that provide a larger wireless charging coil around optical elements within the device housing that is more capable of avoiding or counteracting the detrimental impact to wireless charging that Petitioner’s combination injects.

172. A POSITA would have also recognized—in view of Fraser—that such a large coil would expand beyond the identified cover of the combination’s device. And in that case (and as explained above in §VII.A.3), any wireless power transmission that occurs, as the claim requires in view of the intrinsic record, would not pass through the cover or the alleged opening behind it (e.g., due to the relatively small area of the cover and interfering metal components)—and instead would pass via the portions of the rear surface/housing beyond the cover.

173. Again, Petitioner has presented a device configuration in which a wireless charging coil **could** be provided in Kotanagi’s through hole 22. However, Petitioner has not demonstrated that a POSITA **would** have configured the device in the proposed manner when considering the detrimental issues stemming from

this configuration and given the substantially better alternative available that avoids those issues.

174. On this record, Petitioner has not shown why or how Petitioner's proposed combination would render obvious claim 9.

B. The Proposed Kotanagi-Honda Combination Does Not Render Obvious Claim 11

175. Claim 11 is reproduced below:

*11. The wearable electronic device of claim 9, wherein:
the wireless charging receive coil has a coil diameter that is less than a diameter of the biosensor module; and
the wireless charging receive coil is configured to receive the wireless power through the biosensor module.*

176. I understand that Petitioner construes "biosensor module" as including the cover (Petition, 13). In the context of the claim 11 analysis, the Petition states that "[b]ecause in the '783 Patent the 'biosensor module' includes both biosensors and a cover glass, Kotanagi's cover glass, LED 5, and PD 6 teach the claimed biosensor module." Petition, 36.

177. Petitioner further contends that Kotanagi's "cover glass" is part of the claimed "biosensor module" that, in the presented combination, would allegedly have a diameter that is more than the diameter of the wireless charging receive coil.

Petition, 36-38. Notably, Petitioner contends that Kotanagi's and Honda's rear cover glass as the claimed "cover." Petition, 26-32, 36-41.

178. Petitioner recognizes that Kotanagi's cover glass is not circular as shown in Kotanagi's FIG. 5 (Petition, 37). Petitioner appears to argue that the cover glass "could" be round because according to Petitioner, the protruding part 4 illustrated in FIG. 8 is circular. *Id.* ("Although the 'cover glass' in Kotanagi's Figure 5 is not circular, Kotanagi teaches a round disk in its Figure 8: 'the protruding part 4 may be formed so that the outer periphery is circular' and Kotanagi describes its diameter: 'the diameter of the protruding part 4 illustrated in FIG. 8 is set to 20 mm.'" (citing EX1005 ¶(0076)). However, As I describe below with reference to claims 6 and 12, Kotanagi's cover glass 23 is separate from the protruding part 4 shown in FIG. 8 and Kotanagi does not disclose or suggest that the cover glass is/would be circular. See §§VII.F and G *infra*.

179. The language of claim 9 provides that the claimed "cover" is different and separate from the claimed "biosensor module." Claim 9 recites that "a cover" is "disposed over the biosensor module" and "the cover is configured to pass optical signals to and from the biosensor module." Given this claim language, the "cover" cannot be "disposed over the biosensor module" if that "cover" is itself part of the biosensor module. Therefore, a POSITA would have understood that the claim limitation here requires that the claimed "biosensor module" and "cover"

are physically separate and distinct elements, with the cover being “disposed over” the biosensor module.

180. Moreover, Petitioner does not allege that the diameter of any of the other components identified as the “biosensor module” in Kotanagi (i.e., the photodetector or LED – see Petition, 36-41), alone or in combination, have a greater diameter than that of the charging receive coil. *See id.*

181. Therefore, Petitioner has failed to demonstrate that the diameter of the alleged biosensor module in the combination is larger than that of the combination’s wireless charging receive coil, as required by the claim.

182. Petitioner also argues that, in combination, “wireless power would be received through at least the cover glass that forms part of the biosensor module.” Petition, 41. Even assuming for argument’s sake that in the combination wireless power is received through the cover, the cover is separate and distinct from the biosensor module (for the above described reasons) and thus, does not form part of the biosensor module.

183. Thus, when properly interpreting “biosensor module” as not including the cover, Petitioner has not and cannot demonstrate that the “wireless charging receive coil has a coil diameter that is less than a diameter of the biosensor module and the wireless charging receive coil is configured to receive the wireless power through the biosensor module,” as required by claim 11.

C. The Proposed Kotanagi-Honda Combination Does Not Render Obvious Independent Claim 15

184. Independent claim 15 is reproduced below:

*15. An electronic watch, comprising:
a housing defining an interior cavity and a bottom portion having an opening;
a band attached to the housing and configured to secure the electronic watch to a user;
a biosensor module positioned along the bottom portion of the housing and configured to transmit optical signals and receive reflected optical signals through the opening of the housing; and
a wireless charging receive coil positioned within the interior cavity and configured to receive wireless power through the opening of the housing.*

185. Independent claim 15 recites, in relevant part, an electronic watch that has “a housing defining ... a bottom portion having an opening” and that “a wireless charging receive coil” is “configured to receive wireless power through the opening.” Similar to its analysis for claim 9, Petitioner alleges that the claimed “opening” maps to through hole 22 in Kotanagi’s device (Petition, 42-43) and that wireless power signals would be received by a wireless charging receive coil “through the opening” (identified as through hole 22) in Kotanagi’s housing. Petition, 46-50.

186. As described with reference to claim 9, a POSITA would not have been motivated nor would have had a reasonable expectation of success in

providing the wireless charging receive coil in this alleged opening in the manner proposed by Petitioner given the significant wireless signal degradation issues stemming from this proposed configuration. *See §VII.A supra.*

187. Additionally, and as explained above, Petitioner has failed to demonstrate that a POSITA would have configured the device in this manner—particularly when considering that the POSITA would have been aware of other well-known and actually functioning configurations of biometric sensing and wireless charging devices (as corroborated by the Fraser reference) that provide a large wireless charging receive coil around optical elements within the device housing and thereby avoid the detrimental issues that Petitioner’s combination injects and ignores. *See §VII.A supra.*

188. Indeed, as Fraser corroborates, a POSITA would have also recognized that such a large coil would expand beyond the identified cover of the combination’s device. And in that case, any wireless power transmission that occurs, as the claim requires in view of the intrinsic record, would not pass through the alleged opening—and instead, would pass via the portions of the rear surface/housing beyond the cover/opening. *See §VII.A supra.*

189. Petitioner has thus presented a device configuration in which a wireless charging coil **could** be provided in Kotanagi’s through hole 22. However, Petitioner has not demonstrated that a POSITA **would** have configured the device

in the proposed manner when considering the detrimental impact to wireless charging stemming from this configuration and given the substantially better alternative available that avoids those issues. On this record, Petitioner has failed to demonstrate why or how Petitioner's proposed combination would render obvious claim 15. *See §VII.A supra.*

D. The Proposed Combination of Kotanagi and Honda, or Optionally of Kotanagi, Honda, and Park Does Not Render Obvious Claim 16

190. Claim 16 is reproduced below:

*16. The electronic watch of claim 15, wherein:
the wireless charging receive coil is configured to receive
power from an external inductive power transmitter dock; and
the electronic watch is configured to magnetically couple with
the external inductive power transmitter dock.*

191. Claim 16 depends from Claim 15 and adds “the wireless charging receive coil is configured to receive power from an external inductive power transmitter dock; and the electronic watch is configured to magnetically couple with the external inductive power transmitter dock.”

192. Claims 15 and 16, when taken together, recite wireless charging/power signals received by the wireless charging receive coil and from an external inductive power transmitter dock. A POSITA would have understood that these recited features call for electromagnetic coupling of the dock with the

wireless charging receive coil and the coil of the “inductive power transmitter dock.”

193. A POSITA would have therefore recognized that, when claim 16 *additionally* recites that the “watch is configured to *magnetically couple* with the ... dock,” this feature would necessitate a separate or additional magnetic coupling. In particular, the ’783 Patent’s specification explains use of magnets in the watch device to facilitate such additional magnetic coupling and alignment of the watch device with the underlying dock. See EX-1001, 5:37-40, 43:36-41, 45:29-51.

194. The proposed Kotanagi-Honda combination does not disclose or suggest such additional magnetic coupling, as Petitioner appears to recognize. Petition, 53-56. To address this deficiency, Petitioner proposes a combination of the Kotanagi and Honda references, in further view of the additional teachings of the Park reference. Petition, 55-57.

195. However, a POSITA would not have been motivated to implement Park’s teaching in the combination nor would have had a reasonable expectation of success in doing so, for the reasons described below

196. *First*, Honda already provides alignment mechanisms to address misalignment issues between charge and transmit coils, and Petitioner has offered no evidence that these mechanisms would be deemed insufficient by a POSITA,

thereby leading a POSITA to look to additional or different mechanisms to address any misalignment concerns. Honda already provides an effective alignment mechanism in the form of the design of its socket into which the watch body is seated in alignment, as the Petition recognizes. Petition, 56 (citing EX-1006, 6:4-11). Honda further defines acceptable misalignment and variations in dimensions between transmit and receive coils without impacting wireless charging efficiency (see, e.g., EX-1006, 2:66-4:20), further confirming that its system already contemplated and accounted for alignment issues.

197. Petitioner has not identified any other evidence in Honda or in Park that discloses or suggests that the alignment mechanisms used in Honda are deficient or otherwise negatively impact wireless charging efficiency. A POSITA would have therefore had no reason or motivation to depart from Honda's alignment teachings and replace, modify, or add to them by incorporating Park's teachings

198. **Second**, because magnets were known in view of Park to achieve alignment of device with its charger is not a sufficient reason or motivation to implement the same in other devices, particularly in a device (as disclosed in Honda) that already discloses alignment mechanisms.

199. **Third**, Petitioner’s identified motivations for the proposed combination are inapplicable in the context of the Kotanagi-Honda (or the Kotanagi-Honda-Park) combination.

200. For example, Petitioner contends that Park teaches use of magnets to optimize “wireless power transfer efficiency.” Petition, 55-56 (citing EX-1012, ¶204). Paragraph 204 of Park is reproduced below:

[0204] For example, a user may incorrectly place the terminal on the cradle 10 such that a change width α of the flux density sensed by the hall sensor 16 is less than a predetermined critical value. At this time, attractive force may be generated between the first magnet 12 and the second magnet 30 since the polarity of the outer circumference of the first magnet 12 is different from that of the outer circumference of the second magnet 30 and the polarity of the section of the first magnet 12 is different from that of the section of the second magnet 30. The distance between the first magnet 12 and the second magnet 30 may be reduced due to the generated attractive force. As a result, the change width α of the flux density sensed by the hall sensor 16 may increase to the predetermined critical value or more. In addition, wireless power transfer efficiency may be optimized due to the reduced distance between the first magnet 12 and the second magnet 30.

201. As shown above, this disclosure in Park discusses “incorrect place[ment]” of a “terminal” in a charging “cradle” such that the magnets help pull the terminal and charger into alignment and thereby reduce the displacement between the terminal and the cradle. See EX-1012, ¶204. A POSITA would have

recognized in view of this disclosure, that Park’s device does not have any other alignment mechanism and therefore relies on the magnets to achieve the alignment between the terminal and the cradle

202. In contrast, Honda provides a particular alignment mechanism—a socket that avoids incorrect device placement therein and helps align the device with the charging station. EX-1006, 6:8-11, FIGS. 1-2. Therefore, the problem that Park seeks to solve with its magnets is already solved by Honda’s device, and Petitioner has failed to explain why any further modification of the device is necessary to achieve functionality already provided by the device.

203. As another example, Petitioner cites to “disadvantages of existing wireless charging schemes” as further reasons to implement permanent magnets in Kotanagi’s device. See Petition, 56 (citing EX-1012, ¶8 (“limited distance ... efficiency is somewhat low”), ¶192 (permanent magnets reduce distance and “thereby improv[e] wireless power efficiency”)). Paragraphs 9 and 192 of Park are reproduced below.

[0008] The electromagnetic resonance scheme is characterized by using an electric field or a magnetic field instead of
--

utilizing an electromagnetic wave or current. The electromagnetic resonance scheme has an advantage in that the electromagnetic resonance scheme is not affected by the electromagnetic wave and is thus safe for other electronic devices and human bodies. However, the electromagnetic resonance scheme has a disadvantage in that the electromagnetic resonance scheme is utilized within a limited distance and space and energy transfer efficiency is somewhat low.

[0192] Consequently, the hall sensor **16** may more rapidly and accurately sense that the terminal **20** is placed on the cradle **10**. In addition, the distance between the transmitting coil and the receiving coil **32** may be reduced due to the attractive force between the first magnet **12** and the second magnet **30**, thereby improving wireless power transfer efficiency.

204. The description relating to low “efficiency” at “limited distance” is provided in the context of an “electromagnetic resonance” charging scheme (see EX-1012, ¶¶9, 192 – reproduced above) and not in the context of inductive charging scheme, as is the case in Honda. *See, e.g.*, EX-1006, 2:66-4:29, 13:22-63. Moreover, Honda already provides an alignment mechanism to reduce distance between the transmit and receive coils, with the further recognition that use of thinner housing materials (e.g., metal) together with a cover made of glass assists with improved wireless power transmission and that a certain amount of displacement between the coils does not have a negative impact on such power

transmission. *See id.* On this record, there is no reason or suggestion to supplant, replace or supplement Honda's alignment mechanism with another one, as provided in Park

205. ***Fourth***, Petitioner has not explained or identified where in the alleged device the magnet would be positioned and how such positioning of the magnet would avoid interfering with the wireless charging contemplated by the proposed combination. Indeed, Honda expressly seeks to "limit the magnetization of a watch mechanism" and "to prevent exposure of a magnetic metal." EX-1006, 6:41-47. Petitioner offers no explanation for why or how providing magnets in the Kotanagi-Honda device would not run afoul of these concerns, which Honda's device seeks to avoid in a watch mechanism and as part of its overall goal to achieve "quick" and "efficient" charging.

206. For at least the foregoing reasons, the proposed combination of Kotanagi, Honda, and/or Park does not render obvious claim 16.

E. The Proposed Kotanagi-Honda or Kotanagi-Honda-Kateraas Combination Does Not Render Obvious Independent Claim 1

207. Independent claim 1 has been reproduced below:

1. *An electronic device, comprising:
a housing defining a first opening opposite to a second opening;
a band attached to the housing and configured to secure the electronic device to a user;*

*a display positioned in the first opening;
a ceramic cover disposed over the second opening and forming
a portion of an exterior surface of the electronic device;
a biosensor module disposed within the second opening below
the ceramic cover; and
a wireless charging receive coil aligned with the second
opening and below the ceramic cover;
wherein:
the ceramic cover is configured to pass optical signals
generated by the biosensor module; and
the ceramic cover is configured to pass wireless power
from an external wireless charging device to the wireless charging
receive coil.*

208. Independent claim 1 recites in relevant part that an electronic device has “a housing defining ... a second opening,” that “a wireless charging receive coil” is “aligned with the second opening and below the ceramic cover,” and that the ceramic cover is “configured to pass wireless power from an external charging device to the wireless charging receive coil.”

209. Similar to its analysis for claim 9, Petitioner alleges that the claimed “cover” maps to Kotanagi’s cover glass 23 (Petition, 60-63), through hole 22 maps to Kotanagi’s second opening (Petition, 57), and that wireless power signals would be received by a wireless charging receive coil positioned in the through hole 22 (Petition, 65-68). *See* Petition, 57-69.

210. As described with reference to claim 9, a POSITA would not have been motivated nor would have had a reasonable expectation of success in providing the wireless charging receive coil in the alleged opening and behind the

alleged cover in the manner proposed by Petitioner given the significant wireless signal degradation issues stemming from this proposed configuration. See §VII.A *supra*.

211. And, as explained above, in view of these issues, Petitioner has failed to demonstrate that a POSITA would have configured the device in this manner—particularly when considering that the POSITA would have been aware of other well-known and actually functioning configurations of biometric sensing and wireless charging devices (as corroborated by the Fraser reference) that provide a larger wireless charging receive coil around optical elements within the device housing and thereby avoid the detrimental issues that Petitioner’s combination injects. See §VII.A *supra*.

212. As Fraser corroborates, a POSITA would have also recognized that such a large coil would expand beyond the identified cover of the combination’s device. And in that case, any wireless power transmission that occurs, as the claim requires in view of the intrinsic record, would pass through the device’s rear housing surface beyond the protruding part 4 and not via the cover or the alleged opening behind it (e.g., due to the relatively small area of the cover and interfering metal components). See §VII.A *supra*.

213. At best then, Petitioner has presented a device configuration in which a wireless charging coil **could** be provided in Kotanagi’s through hole 22.

However, Petitioner has not demonstrated that a POSITA **would** have configured the device in the proposed manner when considering the detrimental impact to wireless charging stemming from this configuration and given the substantially better alternative available that avoids those issues. On this record, Petitioner has failed to demonstrate why or how Petitioner's proposed combination would render obvious claim 1.

F. The Proposed Kotanagi-Honda-Kateraas Combination or Kotanagi-Honda Combination Does Not Render Obvious Claim 6

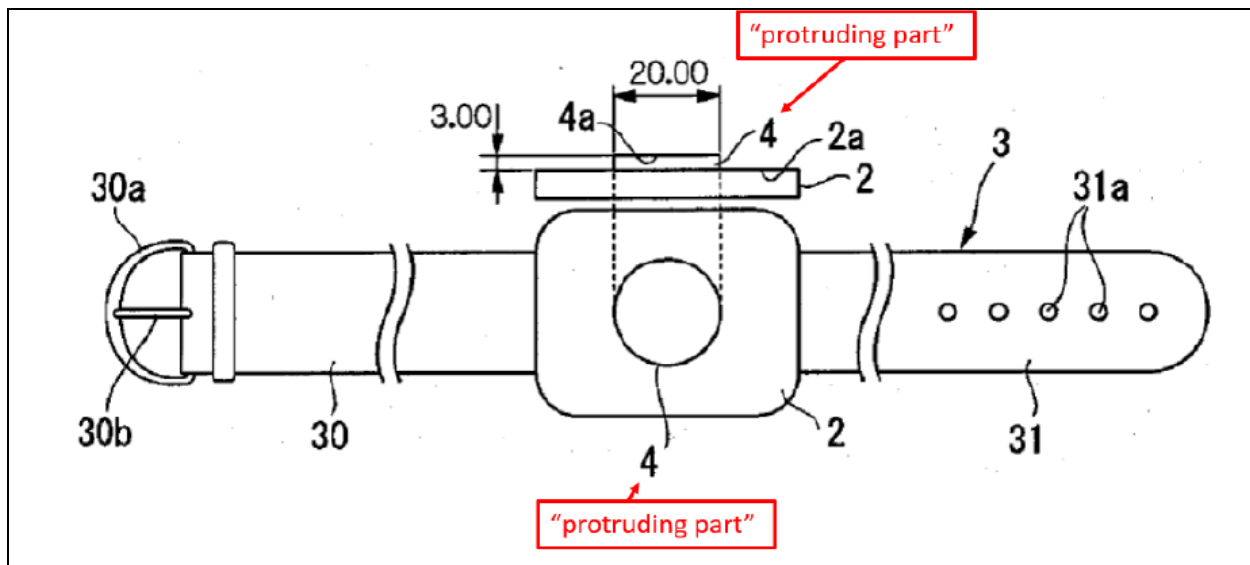
214. Claim 6 is reproduced below:

*6. The electronic device of claim 1, wherein:
the ceramic cover is a disk having a disk diameter that is
greater than an opening diameter of the second opening; and
the ceramic cover forms a water-tight seal with the housing
along a perimeter of the ceramic cover.*

215. Claim 6 depends from claim 1 and adds “the ceramic cover is a disk having a disk diameter that is greater than an opening diameter of the second opening; and the ceramic cover forms a water-tight seal with the housing along a perimeter of the ceramic cover.”

216. Petitioner contends that Kotanagi provides a “protruding disk in its Figure 8” (reproduced below) and that this disk covers the opening and “therefore

has at least the same diameter, if not a larger diameter, than the opening.” Petition, 77-78.

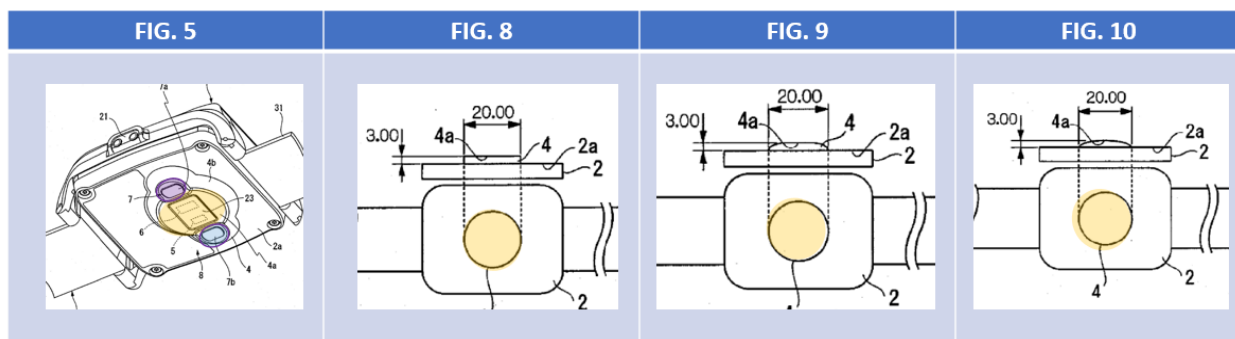


217. This argument is incorrect for the following reasons.

218. **First**, “protruding part 4” in Kotanagi, which Petitioner characterizes as a “protruding disk,” is not the claimed cover (which Petitioner maps to Kotanagi’s cover glass 23) nor is it a disk. Specifically, Petitioner’s above analysis conflates Kotanagi’s protruding part 4 with cover glass 23. Petition, 77-78. However, as Kotanagi explains, the protruding part 4 is formed as part of the device’s housing, and cover glass 23 is a separate component that is fixed to the protruding part 4/housing. See EX-1005, ¶45 (“protruding part 4 ... **is formed** on the lower surface 2a of the housing 2”), ¶55 (“**cover glass 23 is fixed to the housing 2**”); FIG. 5 (showing cover glass fixed to lower surface 4a of protruding part 4). I understand that Petitioner’s expert confirmed that the “protruding part 4

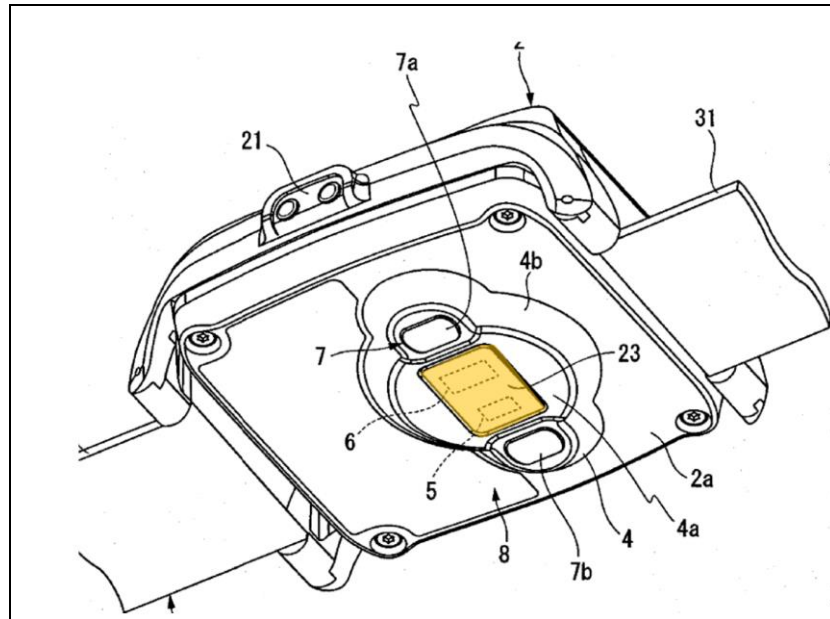
is part of” Kotanagi’s housing and that “cover glass would be within th[e] protruding part 4” shown in FIG. 8. See EX-2020, 62:13-22, 79:12-18.

219. **Second**, Kotanagi provides different configurations for protruding part 4 formed in the housing, none of which suggest changes or modifications to the rectangular cover glass affixed thereto. In the embodiment shown and described in Kotanagi’s FIGS. 1-7 (FIG. 5 is representative of this embodiment and is provided below), protruding part 4 is formed so that the outer periphery is formed by combining three circles. EX-1005, ¶¶54. And, in the embodiments shown in figs. 8-10, protruding part 4 is formed so that its outer periphery is a single circle (annotated yellow in FIGS 8-10 below), instead of the three circle configuration shown in FIG. 5 below (showing three circles, annotated as purple, yellow, and blue). See *id.*, ¶¶54, 75.

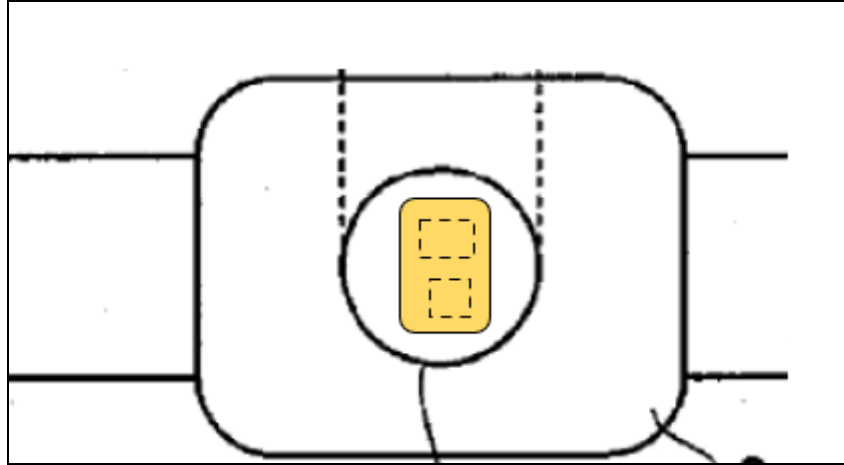


220. These configurations and the associated descriptions in Kotanagi address the shape of **protruding part 4**—**not of cover glass 23** that is fixed to protruding part 4 in the housing.

221. Thus, although the protruding part in Kotanagi's FIG. 8 is circular (as shown above), neither FIG. 8 nor its associated description teaches or suggests that the cover glass 23, which Petitioner alleges is the claimed ceramic cover (see Petition, 60) and which is affixed to protruding part 4 (see EX-1005, Fig. 5), is a disk. Instead, as shown below, the cover glass included in the surface 4a of Kotanagi's protruding part 4 is rectangular, as shown in yellow annotation added to Kotanagi's FIG. 5 below.



222. Similarly, a POSITA would have understood that the same cover glass 23 (in its rectangular configuration) would be formed in the protruding part 4 of the embodiments of FIGS. 8-10, as illustrated below:



See *id.*, FIGS. 8-10 (annotated to reflect cover glass positioned within protruding part 4 formed using a single circle as provided in this embodiment; not drawn/annotated to scale).

223. **Third**, to the extent Petitioner is asserting that the entire protruding part 4 could form the claimed “ceramic cover,” there is no disclosure in Kotanagi or Kateraas to that effect. This also disregards critical aspects of the design of Kotanagi’s device—including the electrodes that are affixed to the device housing (adjacent to the optical elements) and that extend beyond the lower surface 4a of protruding part 4. EX-1005, ¶58 (“The contact detection means 7 has a pair of electrodes 7a and 7b, and ***the pair of electrodes 7a and 7b are disposed on the lower surface 4a of the protruding part 4*** so as to sandwich the LED 5 and the PD 6.... In addition, the pair of electrodes 7a and 7b are provided ***so that the tips thereof protrude slightly more than lower surface 4a of the protruding part 4*** and

are provided so that the base end sides are electrically connected to the sub-board 15.”).

224. A POSITA would have recognized that a cover disposed over the entire protruding part 4 would therefore frustrate Kotanagi’s goal of having a contact detection means by virtue of its electrodes that are designed to be fixed to the protruding part 4 and are intended to extend past the lower surface of protruding part

225. In summary, Kotanagi’s protruding part 4 that is formed in the device’s housing, does not meet the claim requirement that the “**cover** is a **disk**.” Moreover, cover glass 23 (which Petitioner alleges is the claimed “ceramic cover”) is a rectangular component that would not be understood as a “**disk** having **a disk diameter**.”

G. The Proposed Combination of Kotanagi, Honda, Jabori (and optionally, Park) Would Not Have Rendered Obvious Claim 12

226. Claim 12 is reproduced below:

*12. The wearable electronic device of claim 9, wherein:
the cover is a disk having a convex shape that protrudes away from the housing; and
the convex shape is configured to facilitate alignment with a concave surface of an external inductive power transmitter dock.*

227. Claim 12 depends from Claim 9 and adds “the cover is a disk having a convex shape that protrudes away from the housing; and the convex shape is configured to facilitate alignment with a concave surface of an external inductive power transmitter dock.” The proposed combination(s) do not render obvious claim 12 and in particular, do not disclose or suggest that “the cover is a disk,” for reasons similar to those described above with reference to claim 6.

228. In particular, Petitioner alleges that Kotanagi’s FIGS. 8 and 10 show a “disk-shaped protruding part” and that includes “a cover glass.” Petition, 87 (citing EX-1005, ¶¶55, 80, FIGS. 8, 10); *see id.* (acknowledging that cover glass is within a protruding part 4). These assertion are flawed. In particular, and as I explain above with reference to claim 6, protruding part 4 formed in the device’s housing is not a cover nor is it a disk, and the rectangular cover glass 23 affixed to protruding part is also not a “disk.” *See* §VII.G *supra*.

229. If Petitioner and Dr. Duckworth are contending that the entire circular protruding part 4 can form the cover glass (*see* Petition, 87; EX-1003, ¶244), there is no disclosure to that effect in Kotanagi or the descriptions associated with FIG. 10 that Petitioner cites. *See, e.g.*, EX-1005, ¶80, FIG. 10.

230. As also explained above with reference to claim 6, modifying Kotanagi’s protruding part 4 to have a cover formed over the entire surface would frustrate Kotanagi’s goal of skin contact detection by virtue of electrodes that are

designed to be fixed to the protruding part 4 and are intended to extend past its lower surface to make contact with the body surface of the device wearer.

H. The Proposed Combinations Do Not Render Obvious Claims 2-5, 7-8, 10, 13-14, and 17-20

231. Claims 2-5, 7-8, 10, 13-14, and 17-20 are not rendered obvious by the presented combination for at least the reasons described above with reference to independent claims from which these claims depend. *See §III supra.*

VIII. ADDITIONAL REMARKS

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 and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Dated:

12/18/2023

By:



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.textron.com/newsroom/news-releases/press-release-details/2003/Textron-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., Finche, 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