

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MICRON TECHNOLOGY, INC.,
INTEL CORPORATION, GLOBALFOUNDRIES U.S., INC., and
SAMSUNG ELECTRONICS COMPANY, LTD.
Petitioner,

v.

DANIEL L. FLAMM,
Patent Owner.

Case IPR2017-00391¹
Patent 6,071,221

Before CHRISTOPHER L. CRUMBLEY, JO-ANNE M. KOKOSKI, and
KIMBERLY McGRAW, *Administrative Patent Judges*.

KOKOSKI, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

¹ Samsung Electronics Company, Ltd. was joined as a party to this proceeding via a Motion for Joinder in IPR2017-01746.

I. INTRODUCTION

We have jurisdiction to conduct this *inter partes* review under 35 U.S.C. § 6, and this Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons that follow, we determine that Petitioner has shown by a preponderance of the evidence that claims 1–7 of U.S. Patent No. 6,071,221 (“the ’221 patent,” Ex. 1001) are unpatentable.

A. *Procedural History*

Micron Technology, Inc., Intel Corporation, and GLOBALFOUNDRIES U.S., Inc. (collectively, “Petitioner”)² filed a Petition (“Pet.”) to institute an *inter partes* review of claims 1–7 of the ’221 patent. Paper 1. Daniel L. Flamm (“Patent Owner”) filed a Preliminary Response (“Prelim. Resp.”). Paper 9. Pursuant to 35 U.S.C. § 314(a), we instituted an *inter partes* review on the following grounds:

Reference(s)	Basis	Challenged Claim(s)
Lieberman ³	§ 103(a)	1, 5–7
Lieberman and Dible ⁴	§ 103(a)	1, 5–7

² On September 15, 2017, we granted the Motion for Joinder filed by Samsung Electronics Company, Ltd. (“Samsung”) in IPR2017-01746, and authorized Samsung to participate in this proceeding only on a limited basis. See Paper 14. We refer to Micron Technology, Inc., Intel Corporation, GLOBALFOUNDRIES U.S., Inc., and Samsung collectively as “Petitioner” throughout this Decision.

³ *Design of High-Density Plasma Sources for Materials Processing*, Plasma Sources for Thin Film Deposition and Etching (Physics of Thin Films Vol. 18, pp. 1–119), August 18, 1994 (Ex. 1006).

⁴ US 5,573,595, issued Nov. 12, 1996 (Ex. 1007).

Reference(s)	Basis	Challenged Claim(s)
Lieberman and Hanawa ⁵	§ 103(a)	2, 3
Lieberman, Dible, and Hanawa	§ 103(a)	2, 3
Lieberman and Collins ⁶	§ 103(a)	4
Lieberman, Dible and Collins	§ 103(a)	4
Qian ⁷	§ 103(a)	1, 5–7
Qian and Hanawa	§ 103(a)	2, 3
Qian and Collins	§ 103(a)	4

Paper 10 (“Dec. on Inst.”), 29.

After institution of trial, Patent Owner filed a Corrected Patent Owner Response (Paper 34, “PO Resp.”), and Petitioner filed a Reply (Paper 15, “Reply”). Petitioner relies on the Declaration of David B. Graves (“the Graves Declaration,” Ex. 1003) and the Reply Declaration of Dr. David Graves (“the Graves Reply Declaration,” Ex. 1034). Patent Owner relies on the Declaration of Daniel L. Flamm, Sc.D. (“the Flamm Declaration,” Ex. 2001) and the Second Declaration of Daniel L. Flamm (“the Second Flamm Declaration,” Ex. 2003). An oral hearing was held on March 7, 2018. A transcript of the hearing is included in the record. Paper 37.

B. Related Proceedings

Petitioner indicates that the ’221 patent is “at issue in five related patent infringement actions, in which [Patent Owner] sued Petitioners and other defendants, in the Northern District of California, Case Nos. 5:16-cv-

⁵ US 5,688,357, issued Nov. 18, 1997 (Ex.1010).

⁶ US 5,065,118, issued Nov. 12, 1991 (Ex. 1008).

⁷ US 5,683,539, issued Nov. 4, 1997 (Ex. 1009).

01578-BLF; 5:16-cv-01579-BLF; 5:16-cv-01580-BLF; 5:16-cv-01581-BLF; 5:16-cv-02252-BLF.” Pet. 3; *see* Paper 7, 2. The ’221 patent previously was the subject of IPR2015-01767 (terminated on December 15, 2016 at the joint request of the parties before a Final Written Decision was entered). *Lam Research Corp. v. Daniel L. Flamm*, Case IPR2015-01767, slip. op. at 3–6 (PTAB Dec. 15, 2016) (Paper 36).

C. *The ’221 Patent*

The ’221 patent, titled “Process Depending on Plasma Discharges Sustained by Inductive Coupling,” is directed to a process for fabricating a product using plasma discharge. Ex. 1001, 6:14–16. The process “relies upon the control of the instantaneous plasma AC potential to selectively control a variety of plasma characteristics,” such as “the amount of neutral species, the amount of charged species, overall plasma potential, the spatial extent and distribution of plasma density, the distribution of electrical current, and others.” *Id.* at 6:16–22. The process “can be used in applications including chemical dry etching (e.g., stripping), ion-enhanced etching, plasma immersion ion implantation, chemical vapor deposition and material growth, and others.” *Id.* at 6:22–26.

The process comprises subjecting a substrate to a composition of entities, where “[a]t least one of the entities emanates from a species generated by a gaseous discharge excited by a high frequency field in which the vector sum of phase and anti-phase capacitive coupled voltages (e.g., AC plasma voltage) from the inductive coupling structure substantially balances.” *Id.* at 6:31–37. According to the ’221 patent, “[t]his process provides for a technique that is substantially free from stray or parasitic

capacitive coupling from the plasma source to chamber bodies (e.g., substrate, walls, etc.) at or near ground potential.” *Id.* at 6:37–41.

The '221 patent also describes a plasma discharge apparatus that includes a plasma source and a plasma applicator. *Id.* at 7:26–28. “A wave adjustment circuit (e.g., RLC circuit, coil, transmission line, etc.) is operably coupled to the plasma applicator” and “can selectively adjust phase and anti-phase potentials of the plasma from an rf power supply.” *Id.* at 7:30–34.

Figure 2A of the '221 patent is reproduced below.

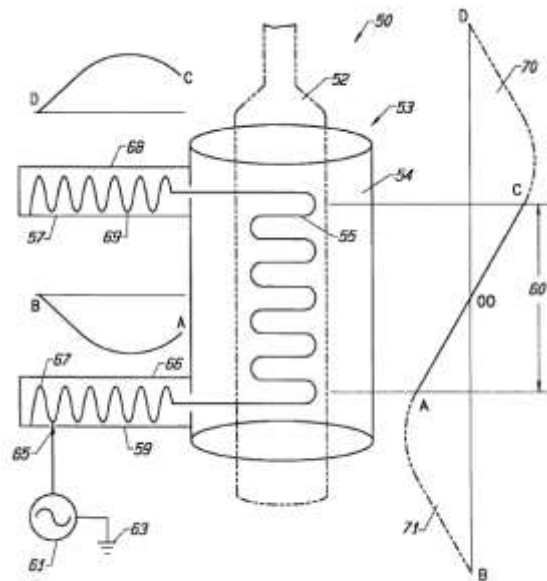


FIG. 2A

Figure 2A is a simplified configuration using wave adjustment circuits. *Id.* at 7:46–47. Embodiment 50 includes discharge tube 52, inductive applicator 55, exterior shield 54, upper wave adjustment circuit 57, lower wave adjustment circuit 59, plasma source region 60, and RF power supply 61. *Id.* at 10:3–8. “In this embodiment, the wave adjustment circuits are adjusted to provide substantially zero AC voltage at one point on the inductive coil (refer to point 00 in FIG. 2A),” providing “substantially equal phase 70 and

anti-phase 71 voltage distributions in directions about this point (refer to 00-A and 00-C in FIG. 2A)” and “substantially equal capacitance coupling to the plasma from physical inductor elements (00-C) and (00-A), carrying the phase and anti-phase potentials.” *Id.* at 10:14–22. According to the ’221 patent, “[s]ince the capacitive current increases monotonically with the magnitude of the difference of peak phase and anti-phase voltages, which occur at points A and C in FIG. 2A, this coupling can be lessened by reducing this voltage difference,” which is achieved by way of wave adjustment circuits 57 and 59. *Id.* at 10:31–37.

Claim 1 is the only independent claim, and is reproduced below.

1. A process for fabricating a product using a plasma source, said process comprising the steps of subjecting a substrate to entities, at least one of said entities emanating from a gaseous discharge excited by a high frequency field from an inductive coupling structure in which a phase portion and an anti-phase portion of capacitive currents coupled from the inductive coupling structure are selectively balanced;

wherein said inductive coupling structure is adjusted using a wave adjustment circuit, said wave adjustment circuit adjusting the phase portion and the anti-phase portion of the capacitively coupled currents.

Ex. 1001, 22:58–23:2. Claims 2–7 depend, directly or indirectly, from claim 1, and include additional limitations directed to the function of the wave adjustment circuit, and the identity and location of the processing, among others.

II. ANALYSIS

A. *Level of Ordinary Skill in the Art*

Petitioner argues that a person of ordinary skill in the art at the time of the ’221 patent would have had “a Bachelor’s degree in electrical,

mechanical, or chemical engineering, physics, chemistry, or a similar field, and three to four years of work experience in semiconductor manufacturing or related fields,” a Master’s degree in the same fields “and two to three years of work experience in semiconductor manufacturing or related fields,” or “a PhD in electrical, mechanical, or chemical engineering, physics, chemistry, or a similar field.” Pet. 16 (citing Ex. 1003 ¶¶ 48–51). Patent Owner does not dispute Petitioner’s assessment in its Response.

Petitioner’s assessment appears consistent with the level of ordinary skill in the art at the time of the invention as reflected in the prior art in this proceeding. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (explaining that specific findings regarding ordinary skill level are not required “where the prior art itself reflects an appropriate level and a need for testimony is not shown” (quoting *Litton Indus. Prods., Inc. v. Solid State Sys. Corp.*, 755 F.2d 158, 163 (Fed. Cir. 1985))). Accordingly, we adopt Petitioner’s assessment of the level of ordinary skill in the art.

B. Claim Interpretation

The ’221 patent has expired. Ex. 1001 at [22] (application filed on May 30, 1997); see Pet. 16. For claims of an expired patent, the Board’s claim interpretation is similar to that of a district court, i.e., consistent with *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). *See In re Rambus, Inc.*, 694 F.3d 42, 46 (Fed. Cir. 2012). Under the *Phillips* standard, claim terms are given their ordinary and customary meaning as would be understood by a person of ordinary skill in the art at the time of the invention, and in the context of the entire patent disclosure and prosecution history. *Phillips*, 415 F.3d at 1312–14. Only those terms in controversy need to be construed, and only to the extent necessary to resolve the

controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“we need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy’”) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

For purposes of the Decision on Institution, we determined that, based on the record at the time, no claim term required express construction (Dec. on Inst. 6–7), and we see no reason to modify that determination in light of the record developed at trial.

C. Principles of Law

To prevail on its challenges to the patentability of the claims, a petitioner must establish facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). “In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”)). This burden of persuasion never shifts to the patent owner. *See Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378–79 (Fed. Cir. 2015) (discussing the burdens of persuasion and production in *inter partes* review).

A claim is unpatentable under 35 U.S.C. § 103 if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art to which the subject matter pertains. *KSR*

Int'l Co. v. Teleflex, Inc., 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of nonobviousness. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

A patent claim “is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.” *KSR*, 550 U.S. at 418. An obviousness determination requires finding “both ‘that a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.’” *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367–68 (Fed. Cir. 2016) (citation omitted); *see KSR*, 550 U.S. at 418 (for an obviousness analysis, “it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does”).

D. Overview of the Prior Art

1. Overview of Lieberman

Lieberman is a review article directed to plasma generation schemes, the purpose of which “is to (1) develop a unified framework from which all ‘high-efficiency’ sources may be viewed and compared; (2) outline key elements of source design that affect processing results; and (3) highlight areas where additional research and development is needed.” Ex. 1006, 6.⁸

⁸ The cited page numbers in Ex. 1006 refer to the numbers added by Petitioner in the bottom right corner of the page.

According to Lieberman, “[t]he advent of sub-micron electronic device fabrication has brought unprecedented demands for process optimization and control which, in turn, have led to improved plasma reactors for the etching and deposition of thin films.” *Id.* at 5 (internal citations omitted).

Lieberman describes two inductive source configurations, one using a cylindrical coil, the other a planar coil, for a low profile source. *Id.* at 55. “The planar coil is a flat helix wound from near the axis to near the outer radius of the source chamber (‘electric stovetop’ coil shape),” and can be united with a cylindrical coil “to give ‘cylindrical cap’ or ‘hemispherical’ coil shapes.” *Id.* Lieberman states that “inductive coils can be driven by a 13.56 MHz, 50 ohm rf supply through an L matching network,” and that “[t]he coil can be driven push-pull using a balanced transformer, which places a virtual ground in the middle of the coil and reduces the maximum coil-to-plasma voltage by a factor of two.” *Id.* at 55–56. Lieberman explains that “[t]his reduces the undesired capacitively coupled rf current flowing from coil to plasma by a factor of two.” *Id.* at 56.

Lieberman also teaches that “[p]lasma in an inductive source is created by application of rf power to a non-resonant, inductive coil, resulting in the breakdown of the process gas within or near the coil by the induced rf electric field,” and “[t]he plasma created in the source region streams toward a wafer holder that can be independently biased by application of rf power using a separate generator.” *Id.* at 56–57.

2. *Overview of Dible*

Dible is directed to methods and apparatus for inducing plasma in low pressure plasma systems that are typically used in semiconductor fabrication. Ex. 1007, 1:7–9. In particular, Dible “relates to methods and

apparatus for variable control of the plasma generating element to achieve combinations of inductive and/or capacitive coupling.” *Id.* at 1:9–12.

The Dible device includes “a first radio frequency excitation source for outputting a first excitation current having a first phase and a first amplitude” and “a second radio frequency excitation source for outputting a second excitation current having a second phase and a second amplitude” along with “a plasma generating element having a first end and a second end for receiving respectively the first excitation current and the second excitation current.” *Id.* at 2:30–37. The Dible device also “includes a control circuit having a control input for receiving a user-variable signal indicative of a desired phase difference between the first phase and the second phase.” *Id.* at 2:38–41. The control circuit, in response to the control input, outputs a control signal to one of the first or second radio frequency excitation sources, effectuating a phase difference between the first and second phases that substantially approximates the desired phase difference. *Id.* at 2:41–48.

The Dible device “becomes essentially an inductive coupling device when the first phase and the second phase are opposite in phase,” and “becomes essentially a capacitive coupling device” when the first and second phases are in phase. *Id.* at 2:48–52. When the first phase and second phase differ by an angle between in phase and opposite in phase, the Dible device “becomes a combination inductive and capacitive coupling device.” *Id.* at 2:52–55.

3. Overview of Hanawa

Hanawa is directed to “inductively coupled RF plasma reactors used in semiconductor processing” that employ “a coiled antenna to couple RF

power to the plasma reactor chamber, and in particular to methods for tuning the RF power circuit (including the coil antenna) in response to impedance changes in the plasma.” Ex. 1010, 1:8–13. Hanawa teaches a control circuit that is “connected to a control input of the variable frequency RF power source and responsive to the power sensor for changing the frequency of the variable frequency RF power source so as to either increase the transmitted power or decrease the reflected power,” in order “to provide an accurate RF match instantly responsive to changes in plasma impedance.” *Id.* at 2:3–9. Hanawa further teaches that the described control circuit “eliminates not only the need for variable capacitors and electric motor servos in the RF match circuit, but also eliminates the entire RF match circuit itself, exploiting the coil antenna 24 to obtain the needed reactance for an RF match between the chamber 10 and the RF source 26.” *Id.* at 4:20–25.

Hanawa Figure 1 is reproduced below.

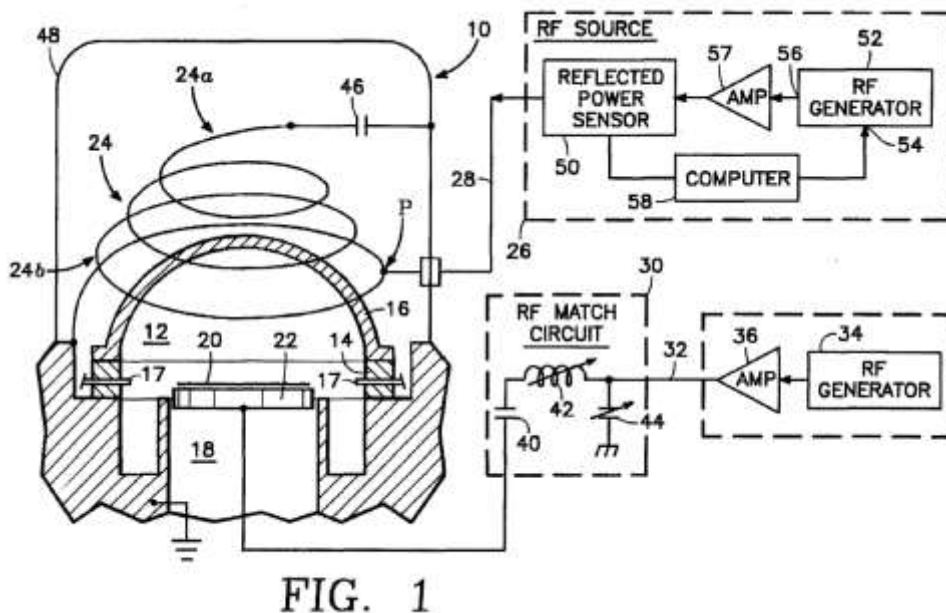


Figure 1 is a schematic diagram of an RF plasma reactor system including Hanawa’s control circuit. *Id.* at 2:13–14. Inductively coupled RF plasma

reactor 10 includes chamber 12 bounded by side wall 14 and ceiling 16. *Id.* at 2:37–40. Wafer pedestal 18 supports semiconductor wafer 20 on isolated conductive top 22. *Id.* at 2:43–44. RF power is coupled to the plasma in chamber 12 by coiled antenna 24 wound around the exterior of ceiling 16. *Id.* at 2:45–47. Coiled antenna 24 is connected to matched RF source 26 via cable 28. *Id.* at 2:47–48. Conductive top 22 is connected through RF match circuit 30 and cable 32 to RF generator 34 and amplifier 36. *Id.* at 2:48–51.

In order to compensate for plasma impedance fluctuations after a plasma is ignited in chamber 12, RF source 26 employs conventional variable-frequency RF generator 52 having frequency control input 54 and power output 56 with amplifier 57 and computer 58. *Id.* at 3:24–31. Computer 58 monitors the reflected power level measured by reflected power sensor 50 and applies a control signal to frequency control input 54 of RF generator 52. *Id.* at 3:31–34. Computer 58 is programmed to vary the frequency of RF generator 52 so as to continuously minimize the amount of reflected power measured by reflected power sensor 50. *Id.* at 3:43–47.

4. *Overview of Collins*

Collins is directed to the connection of a first electrical circuit (the source) to a second electrical circuit (the load) using a matching network in order to provide maximum power transfer between the source and the load. Ex. 1008, 1:6–10. Collins teaches a matching network that matches an output impedance of a source with an input impedance of a load, wherein the matching network includes a plurality of transmission line stubs. *Id.* at 2:40–44. Collins states that “[e]ach transmission line stub includes a first transmission line conductor, a second transmission line conductor running parallel to but not in electrical contact with the first transmission line

conductor, and ferrite dielectric material between the first transmission line conductor and the second transmission line conductor.” *Id.* at 2:45–50.

Collins Figure 1 is reproduced below.

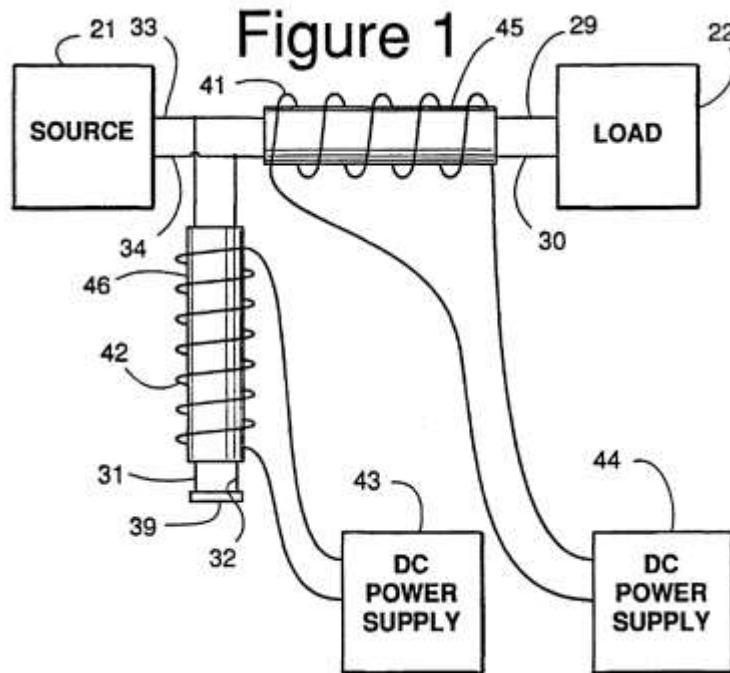


Figure 1 “shows an electronically tuned VHF/UHF matching network in accordance with the preferred embodiment” described in Collins. *Id.* at 3:23–25. Source 21 is connected to load 22 through an electronically tuned VHF/UHF matching network consisting of transmission line stubs 45 and 46. *Id.* at 3:44–49. Transmission line stub 45 consists of transmission line conductor 30 separated by a ferrite dielectric material. *Id.* at 3:59–62. A magnetic field is applied to transmission line stub 45 by a current generated by DC power supply 44 through wire 41, which is wrapped around transmission line stub 45. *Id.* at 3:62–65. Collins teaches that “[v]arying the current through wire 41, and thus the magnetic field applied to transmission line stub 45, varies the relative permeability of transmission line stub 45.” *Id.* at 3:65–68. Collins also describes an embodiment where “a matching

network of the type shown in FIG. 1” is “applied to a system which is used in a plasma process inside a plasma chamber 2.” *Id.* at 4:35–37.

5. *Overview of Qian*

Qian is directed to “improvements in inductively coupled radio frequency (RF) plasma reactors for reducing capacitive coupling from the coil antenna to the semiconductor wafer.” Ex. 1009, 1:9–12. Qian teaches that such capacitive coupling “is reduced by isolating the coil antenna from the RF power source by an isolation transformer, so that the coil antenna has a floating potential.” *Id.* at 1:49–51. According to Qian, this “reduction in capacitive coupling has been quantitatively measured to be more than a factor of two, a significant advantage.” *Id.* at 1:55–57.

Qian Figures 1 and 2 are reproduced below.

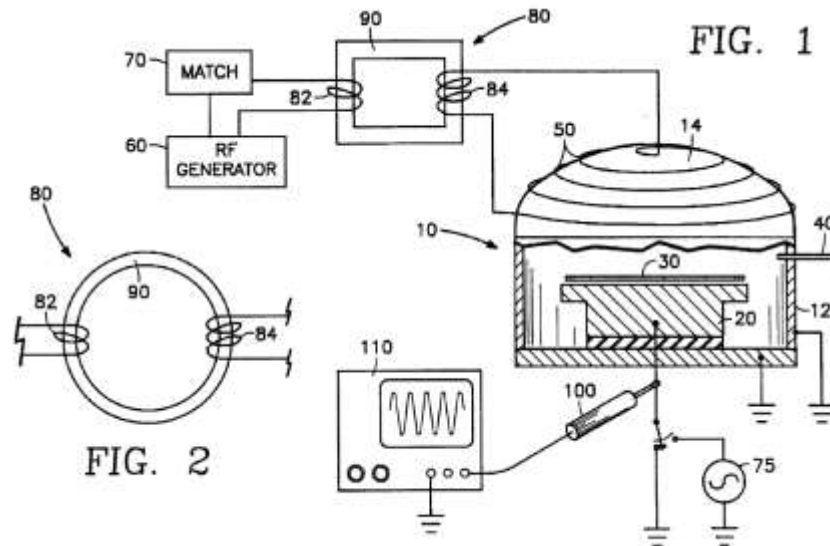


Figure 1 is a schematic diagram illustrating a plasma reactor embodying the Qian invention, and Figure 2 is a schematic diagram of a preferred embodiment of the isolation transformer described by Qian. *Id.* at 1:60–64. The inductively coupled RF plasma reactor shown in Figure 1 includes grounded reactor chamber 10 having grounded side wall 12 and ceiling 14

that encloses wafer pedestal 20. *Id.* at 2:8–11. Wafer pedestal 20 supports semiconductor wafer 30. *Id.* at 2:11. Processing gas is introduced into chamber 10 via gas inlet 40, and the gas ionizes to produce a plasma over wafer 30 by RF power inductively coupled to the plasma from inductive coil antenna 50 wound over ceiling 14 of chamber 10. *Id.* at 2:12–16. Coil antenna 50 is coupled to RF generator 60 through RF impedance match network 70. *Id.* at 2:16–17.

Isolation transformer 80 is interposed between match network 70 and inductive coil 50 in order to isolate inductive coil antenna 50 from RF power generator 60. *Id.* at 2:21–24. Isolation transformer 80 (also shown in Figure 2) has primary winding 82 and secondary winding 84; match network 70 and RF generator 60 are connected across primary winding 82, and inductive coil antenna 50 is connected across secondary winding 84. *Id.* at 2:24–29. Qian teaches that “isolation transformer 80 reduces or virtually eliminates any D.C. potential between” generator 60 and inductive coil antenna 50, so that the electric potential of inductive coil antenna 50 is floating with respect to wafer pedestal 20. *Id.* at 2:30–34. Qian states that “[t]he advantage is that capacitive coupling between” inductive coil antenna 50 and “pedestal 20/wafer 30 is reduced as well,” and, therefore, inductive coil antenna 50 “has less effect upon plasma ion energy at the wafer surface, namely less broadening of the plasma ion energy distribution.” *Id.* at 2:34–38. Qian further teaches that isolation transformer 80 may include ferrite core 90 around which primary and secondary windings 82, 84 are wound. *Id.* at 2:44–46.

E. Obviousness over Lieberman

Petitioner contends that the subject matter of claims 1 and 5–7 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over Lieberman. Pet. 27–40; Reply 4–11, 15–18. Petitioner relies on the Graves Declaration and the Graves Reply Declaration in support of its contentions. *Id.* Patent Owner disagrees with Petitioner’s assertions, and relies on the Flamm Declaration and the Second Flamm Declaration. PO Resp. 3–19, 26–27.

The parties focus their arguments on two elements in independent claim 1: (1) “a phase portion and an anti-phase portion of capacitive currents coupled from the inductive coupling structure are selectively balanced”; and (2) “wherein said inductive coupling structure is adjusted using a wave adjustment circuit, said wave adjustment circuit adjusting the phase portion and the anti-phase portion of the capacitively coupled currents.” As to the other elements of claims 1 and 5–7, we have reviewed the entirety of the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that those elements are disclosed as arranged in the claims. Pet. 27–40. We, therefore, adopt Petitioner’s analysis as to those elements, and address the arguments regarding the disputed claim elements in turn.

1. *a phase portion and an anti-phase portion of capacitive currents coupled from the inducting coupling structure are selectively balanced*

Petitioner contends, with supporting testimony from Dr. Graves, that Lieberman discloses this element of claim 1 because it “discloses choosing to drive an inductive coil push-pull via a balanced transformer (i.e., a wave adjustment circuit), which creates a phase configuration that makes the

phase and anti-phase portions selectively balanced (i.e., substantially equally distributed.)” Pet. 30. Petitioner contends that a person having ordinary skill in the art “would have understood Lieberman’s choice to drive the inductive coil ‘push-pull’ to correspond to the claimed ‘a phase and an anti-phase portion of capacitive currents . . . are selectively balanced’” because “the phase voltages ‘push’ capacitively coupled current into the plasma while the anti-phase voltages ‘pull’ capacitively coupled current out of the plasma.” *Id.* (citing Ex. 1003 ¶ 90). According to Petitioner, “[d]riving the coil push-pull with” Lieberman’s “wave adjustment circuit (the inductively-coupled push-pull arrangement, e.g., a toroidal balun) causes a midpoint on the coil to be effectively RF grounded, adjusting the phase portion and the anti-phase portion of the capacitively coupled currents so that they are selectively balanced about the midpoint.” *Id.* at 32–33 (citing Ex. 1003 ¶¶ 91–94, 100–102); *see also* Reply 4 (arguing that Lieberman teaches “that its balanced transformer drives the current on the inductive coil in a push-pull arrangement, such that a virtual ground is placed in the middle of the coil”).

Patent Owner argues that “Lieberman does not teach balancing any currents, where there are capacitively coupled and/or phase and anti-phase portions as claimed,” and “does not disclose or distinguish phase and anti-phase capacitively coupled currents as claimed.” PO Resp. 9 (citing Ex. 2001 ¶ 16). Patent Owner states that Lieberman “makes it very clear that the ‘balanced transformer’ means an isolation transformer that isolates the output side from ground. . . .” *Id.* at 3 (citing Ex. 2003 ¶ 9). Patent Owner also argues that “Lieberman apparently teaches that the midpoint of the coil is at ground potential (‘ . . . places a virtual ground in the middle of

the coil’)” and “contends that the coil to plasma voltage is supposed to be half of the total voltage applied across the coil by the transformer,” but “the center of a coil connected in this manner is [not] necessarily at ground potential.” *Id.* at 5 (quoting Ex. 1006, 56).

Patent Owner further argues that Lieberman’s capacitive currents “are not the same thing as the capacitive currents referenced in the ’221 patent,” because “[t]he ‘capacitive current’ Lieberman refers to is only the magnitude of that portion of capacitive current which flows from the coil to the plasma and returns to the coil.” PO Resp. 4 (citing Ex. 2003 ¶ 11). Patent Owner argues that “claim 1 concerns selectively balancing the vector sum of phase and anti-phase currents flowing from the coil as a whole to the plasma—to obtain a selected difference current, if any, flowing through the plasma to grounded chamber bodies, the wafer chuck, etc.” *Id.* at 5–6 (citing Ex. 2003 ¶ 12). According to Patent Owner, “[t]he magnitude of current flowing from and returning to an isolated coil from the plasma and the vector sum of differently phased currents flowing to chamber bodies are quite different things,” and “[t]he magnitude of the current taught by Lieberman is not susceptible to selective balancing.” *Id.* at 6 (citing Ex. 2003 ¶ 12).

Petitioner replies that Patent Owner’s “arguments rest on mischaracterizations of the 221 Patent, the prior art, and [Patent Owner’s] own exhibits.” Reply 1. Petitioner also asserts that the Second Flamm Declaration “simply parrots [Patent Owner’s] attorney argument” and “does not provide any explanation or elaboration on anything” in the Patent Owner Response, and, therefore, “should be given no weight.” *Id.* at 1-2.

Based on our review of the record, we find Petitioner’s argument that Lieberman discloses “a phase portion and an anti-phase portion of capacitive

currents coupled from the inductive coupling structure are selectively balanced” as required by claim 1 to be persuasive. Pet. 30–36; Reply 4–11. Lieberman teaches driving an inductive coil push-pull using a balanced transformer. Ex. 1006, 56. Petitioner explains that a person having ordinary skill in the art “would have understood that choosing to drive the inductive coil ‘push-pull’ using a ‘balanced transformer’ meant choosing to set the ends of Lieberman’s inductive coil at equal and opposite voltages.” Pet. 33 (citing Ex. 1003 ¶¶ 93, 102). In that regard, Dr. Graves testifies that “the output of the Lieberman transformer produces a balanced signal with the phases of the signals applied to each end of the coil having a phase difference of 180° ,” and, therefore, Lieberman’s push-pull arrangement “corresponds to the claimed ‘phase and an anti-phase portion of the capacitively coupled currents.’” Ex. 1003 ¶ 90 (citing Ex. 1022, 3; Ex. 1023, 1). We further credit Dr. Graves’s testimony that

Lieberman’s disclosure of a choosing to drive the coil push-pull with a balanced transformer mirrors the disclosure of the 221 Patent. Specifically, the 221 Patent teaches that one way to selectively balance the capacitive currents from the inductive coupling structure is to transfer power to a plasma applicator (for example, the inductive coil 132 in Fig. 4) “with a balanced feed . . .” means that the terminals of the inductive coil, one of each being connected to one of the outputs of the “coupled inductors” of the transformer, are at equal and opposite voltages. That is, if the voltage at one of the outputs/terminals is +V, the voltage at the other output/terminal is –V. It was well known that a balanced push-pull arrangement provides this symmetry.

Ex. 1003 ¶ 93 (citing Ex. 1001, 16:17–20; Ex. 1015, 2; Ex. 1016, 5).

We have considered Patent Owner’s arguments to the contrary and do not agree with them for the following reasons. Patent Owner contends that Lieberman’s capacitive currents “are not the same thing as the capacitive

currents referenced in the '221 patent” (PO Resp. 4), but does not provide sufficient objective analysis or evidence demonstrating why that is the case. As Petitioner notes, claim 1 does not limit the claimed capacitive currents coupled from the inductive coupling structure to a specific type of capacitive current, the '221 patent does not provide a definition of “capacitive current,” and Patent Owner “has not provided any proposed construction for the term.” Reply 6 (citing Ex. 1034 ¶ 6). Moreover, we do not credit Dr. Flamm’s supporting testimony on this issue because it is conclusory in nature. Ex. 2003 ¶ 11; see 37 C.F.R. § 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”); *Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 294 (Fed. Cir. 1985) (stating a lack of objective support for an expert opinion “may render the testimony of little probative value in [a patentability] determination”). In particular, Dr. Flamm’s testimony is identical to Patent Owner’s argument as it appears in the Patent Owner Response, and does not provide objective support for his statements. Absent underlying facts or data to support Dr. Flamm’s opinion, we are not convinced that Lieberman’s capacitive currents are different than those encompassed by claim 1 of the '221 patent. See Reply 6 (“Lieberman expressly contradicts [Patent Owner’s] argument by teaching that the transformer ‘reduces the undesired capacitively coupled rf current flowing from coil to plasma by a factor of two.’” (citing Ex. 1006, 56; emphasis omitted)).

Next, we do not agree with Patent Owner that “Lieberman merely suggests lowering the magnitude of a current that flows in a closed path within the plasma source by itself (*e.g.*, coil to plasma and return)” and thus

does not teach “selectively balancing the vector sum of phase and anti-phase currents flowing from the coil as a whole to the plasma—to obtain a selected difference current, if any, flowing through the plasma to grounded chamber bodies, wafer chuck, etc.” PO Resp. 5–6 (citing Ex. 2003 ¶ 12). Neither Patent Owner nor Dr. Flamm provide sufficient explanation or objective evidence to support this contention. *Id.*; Ex. 2003 ¶ 12. As set forth above, Petitioner, in contrast, provides reasoning as to why a person having ordinary skill in the art would have understood Lieberman as teaching a symmetrical distribution of voltages and corresponding capacitively coupled currents, and, thus, balancing the vector sum of the currents. *See* Pet. 30–36; Reply 7–8.

Lastly, we do not agree with Patent Owner that Lieberman’s virtual ground is not necessarily at ground potential. PO Resp. 5. As Petitioner explains, “Lieberman’s teaching that the middle of the coil is a virtual ground means that the voltage distribution is symmetric about this midpoint.” Reply 9. We credit Dr. Graves’s testimony that

because Lieberman teaches “voltage magnitudes being at equal and opposite maxima at the end points of the coil” and because “the waveform is a half-wave multiple along the coil”, the voltage “crosses the zero at the midpoint.” Ex. 1003 ¶ 115. As I explained, this means that the virtual ground is effectively at ground potential, because the voltage waveform crosses zero volts at the midpoint. *See id.* Lieberman uses the term “virtual ground” because the coil is not physically wired to ground at that point; hence, it is a virtual ground and not a hard-wired ground.

Ex. 1034 ¶ 10. Although Dr. Flamm testifies that Lieberman’s “coil is floating, there is NO ground, period” and that “[t]he currents and voltage distribution will not be symmetric, and certainly never on the spiral coil,” Dr. Flamm provides little, if any, support for these statements, and no

explanations as to why a person having ordinary skill in the art would understand Lieberman's disclosures in this way. Ex. 2003 ¶ 14.

Dr. Flamm's conclusory opinions are not persuasive.

Accordingly, we determine that Lieberman teaches "a phase portion and an anti-phase portion of capacitive currents coupled from the inducting coupling structure are selectively balanced" as recited in independent claim 1.

2. *wherein said inductive coupling structure is adjusted using a wave adjustment circuit, said wave adjustment circuit adjusting the phase portion and the anti-phase portion of the capacitively coupled currents*

Petitioner contends, with supporting testimony from Dr. Graves, that Lieberman discloses this element of claim 1 because "Lieberman's balanced transformer results in a 'virtual ground in the middle of the coil,' and therefore corresponds to the claimed 'wave adjustment circuit' that adjusts 'the phase and anti-phase portion of capacitive currents.'" Pet. 37 (citing Ex. 1006, 56; Ex. 1003 ¶¶ 107–109). Petitioner contends that a person having ordinary skill in the art would have understood that Lieberman's balanced transformer is "a balun that results in a voltage distribution on the inductive coil that is symmetric about the midpoint, which the 221 Patent discloses as a wave adjustment circuit that produces balanced phase and anti-phase potentials and currents." *Id.* at 30–31 (citing Ex. 1006, 56; Ex. 1001, 16:18–45; Ex. 1003 ¶¶ 90–94).

Patent Owner argues that Lieberman suggests the use of "a radiofrequency isolation transformer to apply voltage to a coil used to induce inductive current in a plasma source," and that Lieberman "makes it very clear that the 'balanced transformer' means an isolation transformer that

isolates the output side from ground.” PO Resp. 3 (citing Ex. 2003 ¶¶ 8–9; Ex. 1006, 6). Patent Owner argues that Lieberman’s balanced transformer is not a balun because a balun “means a transformer with a grounded center tap on its secondary winding.” *Id.* at 14 (citing Ex. 2003 ¶ 22). Patent Owner further argues that “Lieberman teaches a conventional magnetic flux coupled isolation transformer” that “transmits input energy to the output circuit th[r]ough magnetic flux linkage, and the conventional transformer is capable of DC isolation.” *Id.* (citing Ex. 2003 ¶ 26; Ex. 2001 ¶ 10). Patent Owner argues that “the balun transition line transformer, unlike the conventional transformer, is not capable of DC isolation because a balun requires a conductive co[n]nection to ground to be functional.” *Id.* at 15 (citing Ex. 2001 ¶ 11). According to Patent Owner, Lieberman is mistaken about the function of its described transformer as “[t]he coil cannot be driven push pull by an isolation transformer because doing so requires the transformer to have a grounded center tap on its secondary winding to effectuate balance to ground” and, “[b]y definition” Lieberman does not teach a push-pull configuration. *Id.*

Petitioner replies that the ’221 patent teaches that a “wave adjustment circuit” is “a ferrite or powdered iron core ‘balun’ (balanced-unbalanced) toroidal transformer” along with “open circuits.” Reply 15 (quoting Ex. 1001, 16:27–36). Petitioner argues that the ’221 patent further teaches that “the wave adjustment circuit can comprise ‘an inductively-coupled push-pull arrangement such as coupled inductors’” and that “wave adjustment circuits ‘provide substantially zero AC voltage at one point on the inductive coil,’” which “provides substantially equal phase 70 and anti-phase 71 voltage distributions.” *Id.* (quoting Ex. 1001, 10:14–19).

According to Petitioner, because “Lieberman teaches a push-pull arrangement using a balanced transformer (i.e. a balun),” Lieberman teaches the claimed wave adjustment circuit. *Id.* at 16.

Based on the record developed during trial, we agree with Petitioner that Lieberman teaches “wherein said inductive coupling structure is adjusted using a wave adjustment circuit, said wave adjustment circuit adjusting the phase portion and the anti-phase portion of the capacitively coupled currents” as required by claim 1. *See* Pet. 30–38; Reply 13–18. In particular, we credit Dr. Graves’s testimony that

it would have been understood that Lieberman’s transformer was a flux linked balun transformer known in the art to function at frequencies from a few kilohertz to over 200MHz with minimal losses. Moreover, because of the frequency of the power source in Lieberman, a balun transformer with a ferrite or powdered iron core would be applicable in this context. Specifically, a balanced transformer in Lieberman’s setup with a RF power application of 13.56 MHz would employ a ferrite or powdered iron core, as in the 221 Patent. *See* Ex. 1023 at p. 1 (describing Ruthroff balun with such configurations with citations to 1940s-50s references).

This balun transformer results in “a virtual ground in the middle of the coil,” and therefore corresponds to the claimed “wave adjustment circuit” that adjusts “the phase and anti-phase portion of the capacitively coupled currents” in order to create an effective ground in the middle of the coil and signals on the coil ends with a phase difference of 180°. Ex. 1006 at p. 56; *see also* above at ¶¶ 99–102. Creating a virtual ground in the middle of the coil by driving the coil push-pull with a balun is consistent with how the 221 Patent describes an exemplary wave adjustment circuit: “the wave adjustment circuits are adjusted to provide substantially zero AC voltage at one point on the inductive coil,” such wave adjustment circuits including a “(balanced-unbalanced) toroidal transformer.” Ex. 1001 at 10:14–16; 16:28–30.

Ex. 1003 ¶¶ 108–109.

We have considered Patent Owner’s arguments to the contrary and do not agree with them for the following reasons. Patent Owner argues that Lieberman does not disclose a balun, but does not provide sufficient explanation or objective evidence to support its contentions. Specifically, we do not credit Dr. Flamm’s supporting testimony on this issue because it is conclusory in nature. Ex. 2001 ¶ 10; Ex. 2003 ¶¶ 22, 26; *see* 37 C.F.R. § 42.65(a). Dr. Flamm’s testimony is virtually identical to the arguments set forth in the Patent Owner Response, and Dr. Flamm does not provide adequate objective support for his statements. Petitioner and Dr. Graves, in contrast, provide sufficient explanation supported by the evidence of record to establish that Lieberman teaches the use of a balun and, thus, a wave adjustment circuit as claimed. *See* Pet. 30–38; Reply 15–18; Ex. 1003 ¶¶ 90–109; Ex. 1034 ¶¶ 7–8.

Moreover, as Petitioner notes, Patent Owner’s evidence contradicts the argument that “a balun ‘must be grounded to function.’” Reply 17. For example, Patent Owner points to Figure 1–4 in Exhibit 2005 to support its contention that “because a broadband balanced-unbalanced toroidal transmission line transformer has an electrical continuity between its input and output and it must be grounded to function,” Lieberman’s transformer cannot be a balun. PO Resp. 14 (citing Ex. 2003 ¶ 22; Ex. 2005, 4, Fig. 1–4). However, this reference specifically states that the circuit in Figure 1–4 “can perform four different functions depending on how the output load, R_L , is grounded,” including as “a balun when the ground is at terminal 5 or left off entirely (a floating load).” Ex. 2005, 4. Patent Owner does not explain how this description acknowledging that a circuit can function as a balun

when the ground is “left off entirely (a floating load)” is consistent with the proposition that a balun must be grounded to function. *See* PO Resp. 14; Ex. 2003 ¶ 22.

We also do not agree with Patent Owner’s argument that Lieberman’s transformer “cannot control the coil potential because it is floating” and the coils “have no voltage and no part of the coil comprises any reference voltage,” and, therefore, it would not work in the process disclosed in claim 1. PO Resp. 15–16 (citing Ex. 2001 ¶ 8; Ex. 2003 ¶ 23). First, as described above, the evidence of record establishes that a balun can have a floating load. Ex. 2005, 4. Patent Owner does not dispute that the ’221 patent teaches that a balun with open circuits is a wave adjustment circuit as required by claim 1. PO Resp. 13–14 (“One embodiment of a ‘wave adjustment circuit’ in the ’221 specification is a combination of open circuits and a broadband balanced-unbalanced toroidal transmission line transformer, typically shortened to ‘balun.’”). Second, Lieberman expressly teaches that “[t]he coil can be driven push-pull using a balanced transformer, which places a virtual ground in the middle of the coil.” Ex. 1006, 56. Petitioner persuasively explains, with supporting testimony from Dr. Graves, that a person having ordinary skill in the art “would have understood that choosing to drive the inductive coil ‘push-pull’ using a ‘balanced transformer’ meant choosing to set the ends of Lieberman’s inductive coil at equal and opposite voltages.” Pet. 33 (citing Ex. 1003 ¶¶ 93, 102); *see supra* Section II.E.1. We do not credit Dr. Flamm’s opinion to the contrary because it is conclusory and not supported by the evidence of record. Ex. 2003 ¶ 23; *see* 37 C.F.R. § 42.65(a).

Accordingly, we determine that Lieberman teaches “wherein said inductive coupling structure is adjusted using a wave adjustment circuit, said wave adjustment circuit adjusting the phase and the anti-phase portion of the capacitively coupled currents” as recited in independent claim 1.

3. *Conclusion*

After considering Petitioner’s and Patent Owner’s positions, as well as their supporting evidence,⁹ we determine that Petitioner has shown by a preponderance of the evidence that independent claim 1, and claims 5–7 that depend, directly or indirectly, therefrom, would have been obvious over Lieberman.

F. Obviousness over Lieberman and Dible

Petitioner contends that the subject matter of claims 1 and 5–7 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over the combined teachings of Lieberman and Dible. Pet. 40–48; Reply 12–13, 19–22, 25–27. Petitioner relies on the Graves Declaration and the Graves Reply Declaration in support of its contentions. *Id.* Patent Owner disagrees with Petitioner’s assertions, and relies on the Flamm Declaration and the Second Flamm Declaration. PO Resp. 9–12, 20–22.

Petitioner contends that “Lieberman itself teaches or renders obvious all the limitations of independent claim 1,” and that “Dible further teaches adjusting the phase and anti-phase portions of the capacitively coupled currents via a control circuit.” Pet. 40. Petitioner contends that it would have been obvious to a person having ordinary skill in the art to use Dible’s control circuit in Lieberman’s control circuit apparatus for three reasons:

⁹ Patent Owner did not introduce any evidence of objective indicia of nonobviousness.

(1) “Dible offers user control” that “would allow for fine-tuning of the phase and anti-phase portions, e.g., to render the device a capacitive coupling device, inductive coupling device, or a combination thereof,” “which would augment Lieberman’s design;” (2) Lieberman describes that, in certain applications, it is desirable to reduce capacitively coupled radio frequency currents flowing from the coil to the plasma, and, therefore, a person having ordinary skill in the art “would have been motivated to improve Lieberman’s system” by including Dible’s control circuit “to enable adjustment of the phase and anti-phase portions” to minimize capacitive coupling and apply power only by inductive coupling; and (3) the systems described by Lieberman and Dible “have a high degree of similarity in structure, purpose, and operation” that “would render modification of the former with aspects of the latter straightforward and well within the skill of a” person having ordinary skill in the art and would ensure a reasonable expectation of success. *Id.* at 47–48 (citing Ex. 1003 ¶¶ 132–135).

Patent Owner argues that Dible is directed to methods “for variable control of the plasma generating element to achieve combinations of inductive and/or capacitive coupling.” PO Resp. 11 (quoting Ex. 1007, 1:9–12). Patent Owner argues that this is “different from the ’221’s object of selectively balancing a phase and anti-phase portion of capacitive currents.” *Id.* (citing Ex. 2003 ¶ 18). Patent Owner further argues that Dible “teaches nothing about adjusting any inductive coupling structure in order to reduce or eliminate capacitively coupled power, adjusting phase and anti-phase portions of capacitive currents from an inductive coupling structure, or any other such thing.” *Id.* at 20 (citing Ex. 2003 ¶ 28). Patent Owner argues that Dible teaches using two separate power sources “to apply two separate

excitation currents to two respective ends of a coil, and adjusting the *phase of those power sources relative to each other* which is purported to control the type of coupling generated, *i.e.*, capacitive coupling, inductive coupling or some combination thereof.” *Id.* According to Patent Owner, “Dible’s method of using two generators depends on applying unbalanced power to the ends of a coil which is incompatible [with] Lieberman’s stated principle of operation, namely to float the coil, which ensures that the amounts [of] capacitive current emanating from the coil and returning to the coil are equal.” *Id.* at 25–26 (citing Ex. 2003 ¶ 13).

Based on the record before us, we agree with Petitioner that the combined teachings of Lieberman and Dible teach or suggest all of the elements of independent claim 1. As an initial matter, we note that whether Dible has a different objective than the ’221 patent is not significant to this obviousness analysis. Prior art references must be considered as a whole for all they teach, not just the specific problems to which they are directed. *See KSR*, 550 U.S. at 420–21 (stating that “[t]he idea that a designer hoping to [solve one problem] would ignore [a reference] because [the reference] was designed to solve [a different] problem makes little sense,” since “[a] person of ordinary skill in the art is also a person of ordinary creativity, not an automaton”); *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1166 (Fed. Cir. 2006) (explaining that in an obviousness analysis, “the prior art must be considered *as a whole* for what it teaches”); *EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898, 907 (Fed. Cir. 1985) (“A reference must be considered for everything it teaches by way of technology and is not limited to the particular invention it is describing or attempting to protect. On the issue of obviousness, the combined teachings of the prior art as a whole

must be considered.” (emphasis omitted)); *In re Heck*, 699 F.2d 1331, 1333 (Fed. Cir. 1983) (stating that the “use of patents as references is not limited to what the patentee describes as their own inventions or to the problems with which they are concerned”).

Dible describes a plasma generating system that utilizes an inductive coil for plasma generation. Ex. 1007, 1:16–18. Dible further describes that its device

includes a control circuit having a control input for receiving a user-variable signal indicative of a desired phase difference between the first phase and the second phase. The control circuit, responsive to the control input, outputs a control signal to one of the first radio frequency excitation source and the second radio frequency excitation source for controlling respectively one of the first phase and the second phase, thereby causing an actual phase difference between the first phase and the second phase to substantially approximate the desired phase difference. In so doing, the device becomes essentially an inductive coupling device when the first phase and the second phase are opposite in phase. When the first phase and the second phase are in phase, the device becomes essentially a capacitive coupling device. Finally, when the first phase and the second phase differs by an angle that is between in phase and opposite in phase, the device becomes a combination inductive and capacitive coupling device.

Id. at 2:28–56. In this regard, we credit Dr. Graves’s testimony that, when Dible’s device is an inductive coupling device, “this means that the power transfer occurs by substantially only inductive coupling, as the capacitive coupled current substantially [is] effectively eliminated.” Ex. 1003 ¶ 123. We also credit Dr. Graves’s testimony that, because “Dible discloses a design that enables dynamic, adjustable control via Dible’s control circuit to select variable degrees of balance/imbalance,” it “teaches adjusting the first and second phases to be opposite in phase to reduce capacitive coupling.”

Id. ¶ 126. Neither Patent Owner nor Dr. Flamm addresses these disclosures in Dible.

Additionally, we do not find Patent Owner’s argument that “Dible’s scheme is itself fraught with problems that” a person having ordinary skill in the art “in the field of RF matching would immediately recognize,” and, without solutions to these problems, Dible’s “circuit would burn out,” to be persuasive. PO Resp. 21–22 (citing Ex. 2003 ¶ 28). As Petitioner notes, Dible is presumed to be enabled. Reply 20 (citing *Amgen Inc. v. Hoechst Marion Roussel, Inc.*, 314 F.3d 1313, 1355 (Fed. Cir. 2003)). Patent Owner’s argument in this regard also generally attacks Dible individually, rather than in combination with Lieberman. PO Resp. 20–22. Nonobviousness cannot be established by attacking the references individually when the ground of unpatentability is predicated upon a combination of prior art disclosures. *See In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986).

Furthermore, an obviousness analysis does not require bodily incorporation of one reference into another. *Allied Erecting & Dismantling Co. v. Genesis Attachments, LLC*, 825 F.3d 1373, 1381 (Fed. Cir. 2016) (“[I]t is not necessary that [the cited references] be physically combinable to render obvious [the challenged patent]. The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference. . . .” (internal quotations omitted)). Rather, the test for obviousness is “whether a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention.” *Id.* As Petitioner reiterates in its Reply, it is not arguing “that Dible’s control circuit should simply be

connected to Lieberman’s disclosed wave adjustment circuit (i.e., the balun transformer),” but instead is arguing that a person having ordinary skill in the art “would have been motivated to combine the teachings of Dible’s control circuit with ‘the plasma generating apparatus of Lieberman.’” Reply 25–26; see Pet. 46–47. We agree with Petitioner that “[t]his combination does not require a direct connection of Dible’s control circuit to Lieberman’s balun.” Reply 26.

Patent Owner also argues that Petitioner’s contention “that the systems described by Lieberman and Dible ‘have a high degree of similarity in structure, purpose, and operation’ that ‘would render modification of the former with aspects of the latter straightforward and well within the skill of a person having ordinary skill in the art’” is “purely conclusory,” and, therefore, Petitioner fails to establish a motivation to combine Dible with Lieberman. PO Resp. 27. We disagree. Petitioner provides a number of reasons, supported by rational underpinnings, as to why a person having ordinary skill in the art would have been prompted to combine or modify the teachings of Lieberman and Dible. Pet. 47–48 (citing Ex. 1003 ¶¶ 132–135); see *In re Kahn*, 441 F.3d 911, 988 (Fed. Cir. 2006) (stating that the relevant inquiry is whether there is “some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”). With respect to degree of similarity between the systems disclosed in Lieberman and Dible, Petitioner persuasively argues, with citations to evidence of record, that both references “are directed to inductively-coupled plasma generation for semiconductor processing, specifically including etching and deposition,” and “also discuss the manipulation of phase and

anti-phase portions of an RF field.” Pet. 48 (citing Ex. 1006, 5, 56; Ex. 1007, 1:15–19, 2:42–56, Fig. 5(a)–5(b)); Ex. 1003 ¶ 135.

Petitioner also argues that “Dible offers user control” that “would allow for fine-tuning of the phase and anti-phase portions, e.g., to render the device a capacitive coupling device, inductive coupling device, or a combination thereof” that a person having ordinary skill in the art would have recognized “would augment Lieberman’s design.” Pet. 47 (citing Ex. 1007, Abs., 2:39–46; Ex. 1003 ¶ 133). Specifically, Petitioner points to Dible’s teaching that “inductively coupled plasma generates higher plasma density that is more suitable for certain low pressure processes.” *Id.* (citing Ex. 1007, 1:52–54). Dr. Graves further testifies that “capacitively coupled plasma has known uses, e.g., for relatively high pressure applications,” which “can result in faster etch rates,” and, “[a]ccordingly, Dible’s user control provides greater flexibility for different processes and fabrication techniques.” Ex. 1003 ¶ 133 (citing Ex. 1025, 1:15–23; Ex. 1026, 1:5–50, 2:42–57).

Additionally, Petitioner notes that “Lieberman specifically describes, for certain applications, the desirability for reducing capacitively coupled radio frequency currents flowing from the coil to the plasma,” and that Dible similarly “describes the possibility of adjusting relative proportions of inductive and capacitive coupling components of the coil to the plasma by adjusting the relative phases on the ends of the coil.” Pet. 47 (citing Ex. 1006, 56; Ex. 1007, 2:39–42). Based on these disclosures, we find Petitioner’s argument that a person having ordinary skill in the art “would have been motivated to improve Lieberman’s system with Dible by including Dible’s control circuit to enable adjustment of the phase and anti-

phase portions to control the proportions of inductive and capacitive coupling currents, e.g., to minimize the capacitive coupling and apply power only by inductive coupling” to be persuasive. *Id.* at 47–48; Ex. 1003 ¶ 134.

Accordingly, we find that a person having ordinary skill in the art would have looked to Dible when determining how to control the adjustment of the phase difference in Lieberman’s system. We also have reviewed the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that all of the elements of independent claim 1, and claims 5–7 that depend, directly or indirectly, therefrom, are disclosed in the combined teachings of Lieberman and Dible. Pet. 41–45.

After considering Petitioner’s and Patent Owner’s positions, as well as their supporting evidence, we determine that Petitioner has shown by a preponderance of the evidence that independent claim 1, and claims 5–7 that depend, directly or indirectly, therefrom, would have been obvious over the combined teachings of Lieberman and Dible.

G. Obviousness over Lieberman and Hanawa, or Lieberman, Dible, and Hanawa

Petitioner contends that the subject matter of claims 2 and 3 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over the combined teachings of Lieberman and Hanawa, or Lieberman, Dible, and Hanawa.¹⁰ Pet. 49–55; Reply 22–25. Petitioner relies on the Graves Declaration and the Graves Reply Declaration in support of its contentions.

¹⁰ Petitioner states that its argument “refers to only Lieberman in combination with Hanawa,” but that “the same argument applies to Lieberman in view of Dible, and further in view of Hanawa.” Pet. 49 fn. 5. We address the challenges as presented in the Petition.

Id. Patent Owner disagrees with Petitioner’s assertions, and relies on the Flamm Declaration and the Second Flamm Declaration. PO Resp. 22–25.

Claim 2 depends from claim 1 and further recites that “the wave adjustment circuit selectively adjusts a frequency of an rf power supply.” Claim 3 also depends from claim 1 and additionally requires that “the high frequency field is adjusted using a variable frequency power supply.” Petitioner relies on Hanawa to meet these additional limitations of claims 2 and 3. Pet. 49–55. With respect to claim 2, Petitioner contends that “Hanawa discloses a control circuit that enables adjusting the variable frequency RF power source to match the impedance,” wherein computer 58 continuously monitors the RF power reflected from or transmitted to the plasma using sensor 50 and generates frequency control input 54 to vary the frequency of RF power supply 52. *Id.* at 50. Petitioner further contends, with respect to claim 3, that “Hanawa discloses a variable frequency power supply that enables adjusting the frequency of the power supply, which in turn adjusts the high frequency field emanating from the inductive coupling structure coupled to the power supply.” *Id.* at 51.

Petitioner argues that it would have been obvious to a person having ordinary skill in the art “to adapt Lieberman to include a variable frequency power supply and a control circuit and sensor as part of the wave adjustment circuit for adjusting the frequency of the power supply as taught by Hanawa” in order “to improve coupling of RF power into the plasma by minimizing reflected power or maximizing transmitted power.” Pet. 51–52. Petitioner argues that “Hanawa and Lieberman address the same technical problem, namely, impedance matching in the context of applying power to plasma to effect plasma etching.” *Id.* at 52. Petitioner further argues that

“[a]dapting Lieberman to include Hanawa’s control circuit and sensor and/or variable frequency power supply would have been understood to provide well-known benefits that would have motivated” a person having ordinary skill in the art to do so, such as “eliminat[ing] the use of variable capacitors and electric servos” by providing “a control circuit that changes the frequency of a variable RF power supply to precisely match the impedance,” and “minimiz[ing] process time while maintaining yield.” *Id.* at 52–54.

Patent Owner makes three arguments in response to Petitioner’s contentions. First, Patent Owner argues that Hanawa does not teach the claimed wave adjustment circuit. PO Resp. 23 (citing Ex. 2003 ¶ 30). Petitioner, however, does not rely on Hanawa as disclosing a wave adjustment circuit. *See, e.g.*, Pet. 49–50 (“It would have been obvious to include Hanawa’s control circuit and power sensor and variable frequency RF power supply in Lieberman (or adapt Lieberman accordingly) so that the wave adjustment circuit could adjust the power supply frequency for impedance matching.”). Petitioner relies on Lieberman, or Lieberman in combination with Dible, with respect to the elements of independent claim 1, which includes the claimed wave adjustment circuit. *See* Pet. 49 fn. 5 (“[B]oth Lieberman (Ground 1) and Lieberman in view of Dible (Ground 2) invalidate claim 1. Each of these grounds in combination with Hanawa renders obvious claims 2 and 3.”). Petitioner only relies on Hanawa with respect to the additional elements of dependent claims 2 and 3. *See id.* at 49–51; Reply 23 (“Nothing in any of Petitioners’ obviousness arguments requires Hanawa to disclose a wave adjustment circuit, and so [Patent Owner’s] argument is irrelevant.”). Moreover, Patent Owner’s argument in this regard also generally attacks Hanawa individually, rather than in

combination with Lieberman. PO Resp. 23–24; *see also In re Keller*, 642 F.2d 413, 426 (CCPA 1981) (“But one cannot show non-obviousness by attaching references individually where, as here, the [ground of unpatentability] are based on combinations of references.”).

Second, Patent Owner argues that “Hanawa requires that the coil be electrically connected to a power sensor that can sense at least transmitted power to the plasma or power that is reflected to the source,” and a person having ordinary skill “in the art of RF power matching would have recognized that the electrical connections to the points would impose a ‘voltage’ on the coil, which is contrary to and would thereby defeat Lieberman’s apparatus and method to ‘float’ the coil using an isolation transformer.” PO Resp. 24. The test for obviousness, however, is “whether a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention,” which does not require bodily incorporation of one reference into another. *Allied Erecting*, 825 F.3d at 1381. Petitioner argues that a person having ordinary skill in the art would have been motivated to combine “Hanawa’s variable frequency teachings with Lieberman” in order to adapt Lieberman “to include a variable frequency power supply and a control circuit and sensor as part of the wave adjustment circuit for adjusting the frequency of the power supply as taught by Hanawa to improve coupling of RF power into the plasma by minimizing reflected power or maximizing transmitted power.” Pet. 51–52 (citing Ex. 1003 ¶ 140). We are not persuaded that adapting Lieberman with Hanawa’s teachings as proposed by Petitioner would “defeat Lieberman’s purpose” as Patent Owner contends. *See also* Ex. 1034 ¶ 23 (Dr. Graves describing how Hanawa’s power sensor would function in Lieberman).

Third, Patent Owner argues that a person having ordinary skill in the art “would not consider that Hanawa and Lieberman addressed the same technical problem, and therefore [would] not combine them together in any manner.” PO Resp. 25 (citing Ex. 2003 ¶ 11). In that regard, Patent Owner notes that Petitioner contends that Hanawa and Lieberman address impedance matching in the context of applying power to plasma to effect plasma etching. *Id.* at 24. Patent Owner argues that Lieberman “is concerned with the magnitude of a circulating capacitive current,” and does “not concern any impedance matching.” *Id.* at 24–25 (citing Ex. 2003 ¶ 11). Patent Owner further argues that Hanawa “is in fact impedance matching to optimize the transfer of power,” and its “methods for transferring power requir[ing] single ended power application and a grounded coil . . . are inconsistent with the principles of operation (floating the coil) taught by Lieberman.” *Id.* at 25. Patent Owner’s only support for this argument, however, is Dr. Flamm’s testimony that

[t]he capacitive currents referenced in Lieberman are not the same thing as the capacitive currents referenced in the ‘221 patent. The “capacitive current” Lieberman refers to is only the magnitude of that portion of capacitive current which flows from the coil to the plasma and returns to the coil. In Lieberman, this is the entire capacitive current emanating (or returning) to the coil, because Lieberman’s coil has been isolated. That is not the subject of Claim 1, and Lieberman does not teach a phase and anti-phase portion of capacitive currents in the manner claimed.

Ex. 2003 ¶ 11. Not only does Dr. Flamm’s testimony lack reference to any underlying facts or data on which his opinion is based, it does not address Hanawa at all. Thus, we do not credit Dr. Flamm’s testimony on this issue.

Petitioner persuasively argues, with supporting testimony from Dr. Graves, that a person having ordinary skill in the art “would have looked

to Hanawa to provide an improvement over the impedance matching network taught in Lieberman.” Reply 25 (citing Pet. 52–55; Ex. 1034 ¶ 25).

Dr. Graves explains that

[i]mpedance matching is the practice of designing the input impedance of an electrical load (e.g., plasma) or the output impedance of its corresponding signal source (e.g., RF power source) to maximize the power transfer or minimize signal reflection on the load. See Ex. 1016 at 480–81 (definition of “impedance matching.”) As applied to plasma, the goal is to maximize the power transfer to the plasma and to minimize the reflected power from the plasma. Basic electrical engineering principles illustrate that impedance matching maximizes the power transfer as, for example, varying the impedance of the load illustrates maximum power transfer will occur when the load and input impedances are equal.

Ex. 1003 ¶ 141. Dr. Graves further states that

Hanawa teaches “changing the frequency of the variable frequency RF power source so as to either increase the transmitted power or decrease the reflected power, so as to provide an accurate RF match instantly responsive to changes in plasma impedance.” Ex. 1010 at Abstract. Lieberman likewise includes a “matching network” to ensure an RF match to the plasma impedance. Ex. 1006 at p. 56. It would have been understood that Lieberman’s “matching network” refers to a network that matches the impedance of the power source to the load.

Id. ¶ 142. In light of Dr. Graves’s testimony, which we credit, we are persuaded that Lieberman and Hanawa address the same technical problem such that a person having ordinary skill in the art would have thought to combine them, as Petitioner contends. See Pet. 52–55; Ex. 1003 ¶¶ 141–145.

Petitioner provides a number of reasons, supported by rational underpinnings, as to why a person having ordinary skill in the art would

have been prompted to combine or modify the teachings of Lieberman and Hanawa. Pet. 51–55; Ex. 1003 ¶¶ 140–150. For example, Petitioner argues that adapting Lieberman with Hanawa’s teachings “would have been understood to provide well-known benefits,” including minimizing processing time while maintaining yield, increasing the reliability of the system, and allowing for precise impedance matching without the need for expensive and heavy equipment. *Id.* at 52–54; Ex. 1003 ¶¶ 141–147. Accordingly, we find that a person having ordinary skill in the art would have looked to Hanawa to improve Lieberman’s wave adjustment circuit. We also have reviewed the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that all of the elements of claims 2 and 3 are disclosed in the combined teachings of Lieberman and Hanawa, or Lieberman, Dible, and Hanawa. Pet. 49–51.

After considering Petitioner’s and Patent Owner’s positions, as well as their supporting evidence, we determine that Petitioner has shown by a preponderance of the evidence that claims 2 and 3 would have been obvious over the combined teachings of Lieberman and Hanawa, or Lieberman, Dible and Hanawa.

H. Obviousness of Lieberman and Collins, or Lieberman, Dible, and Collins

Claim 4 depends from claim 1, and further requires that “the wave adjustment circuit comprises a transmission line.” Petitioner contends that Lieberman, or Lieberman combined with Dible, teaches or suggests all of the limitations of independent claim 1, and that Collins teaches this additional limitation in claim 4 when it describes a matching network that comprises a plurality of transmission lines, which matches the output impedance of a source with the input impedance of a load. Pet. 56–57;

Ex. 1003 ¶¶ 152–154. Petitioner contends that, “[l]ike Lieberman and Dible, Collins is directed to the problem of coupling RF power to a load, such as a plasma,” and that “[b]oth Lieberman and Dible, as well as Collins, teach the use of matching networks.” Pet. 58 (citing Ex. 1006, 55–56; Ex. 1007, 5:38–43; Ex. 1008, 2:41–44). According to Petitioner, a person having ordinary skill in the art “seeking to operate a plasma apparatus above 30 MHz would have been motivated to combine the transmission line stub topology of Collins with the plasma apparatus of Lieberman,” and “using transmission lines in adjusting a waveform was well known and well within the skill of” a person having ordinary skill in the art. *Id.* (citing Ex. 1003 ¶¶ 155–159).

Patent Owner does not address separately Petitioner’s explanations and supporting evidence as to how the teachings of Lieberman and Collins, or Lieberman, Dible, and Collins, account for all of the limitations of dependent claim 4. *See generally* PO Resp. 3–19. We have reviewed Petitioner’s explanations and supporting evidence as to how the combined teachings of Lieberman and Collins, and Lieberman, Dible, and Collins, account for all the limitations recited in this dependent claim, as well as its reasons as to why a person having ordinary skill in the art would have been prompted to combine or modify the respective teachings, and we agree with and adopt Petitioner’s analysis. Pet. 55–58; Ex. 1003 ¶¶ 151–159.

Based on the record developed during trial, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the subject matter of claim 4 would have been obvious over the combined teachings of Lieberman and Collins, or Lieberman, Dible, and Collins.

I. Obviousness over Qian

Petitioner contends that the subject matter of claims 1 and 5–7 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over Qian. Pet. 59–68; Reply 11–12, 18–19. Petitioner relies on the Graves Declaration and the Graves Reply Declaration in support of its contentions. *Id.* Patent Owner disagrees with Petitioner’s assertions, and relies on the Flamm Declaration and the Second Flamm Declaration. PO Resp. 3–12, 19–20.

Petitioner contends, with supporting testimony from Dr. Graves, that Qian discloses or suggests all of the limitations of claim 1. Pet. 59–67; Ex. 1003 ¶¶ 162–185. For example, Petitioner contends that “Qian discloses choosing to drive an inductive coil with a balanced transformer (i.e., a wave adjustment circuit), which creates a phase configuration that is selectively balanced, i.e., substantially equally distributed,” satisfying the “a phase portion and an anti-phase portion of capacitive currents coupled from the inductive coupling structure are selectively balanced” limitation of claim 1. Pet. 60. Specifically, Petitioner contends that “Qian teaches that the isolation transformer reduces the RF current induced by capacitive coupling by at least a factor of two, the same reduction accomplished by Lieberman’s ‘balanced transformer,’” and, therefore, a person having ordinary skill in the art “would have understood that Qian’s ‘isolation transformer’ is a balanced transformer that drives the inductive coil ‘push-pull’ and transforms an unbalanced coaxial feed line into a balanced output, providing equal and opposite voltages on its outputs.” *Id.* at 63; see Ex. 1003 ¶¶ 168–175. Petitioner further contends that a person having ordinary skill in the art “would have understood that driving the inductive coil ‘push-pull’ with Qian’s isolation transformer places a virtual ground near the middle of the

coil for the same reasons that Lieberman's balanced transformer 'place[d] a virtual ground in the middle of the coil.'" Pet. 63 (citing Ex. 1003 ¶ 174; Ex. 1006, 56).

Patent Owner argues that Qian teaches the use of an isolation transformer, the purpose of which "is to isolate a 'coil antenna' from the RF power source," and that "the result of this isolation is that 'the potential of the coil antenna is floating' to reduce capacitive coupling from the antenna to the plasma." PO Resp. 4 (citing Ex. 2003 ¶ 9). Patent Owner argues that "[n]one of this has anything to do with any balancing, adjusting or wave adjustment circuits." *Id.* (citing Ex. 2003 ¶ 9). Patent Owner also argues that the object of Qian is "different from the '221's object of selectively balancing a phase and anti-phase portion of capacitive currents." *Id.* at 11 (citing Ex. 2003 ¶ 18). According to Patent Owner, because Qian states that it is "a principal object of the invention to reduce any stray capacitive coupling from the coil antenna to the plasma," Qian "is focused on a different aspect of plasma processing than that of claim 1 of the '221 patent." *Id.* at 11–12 (quoting Ex. 1009, 1:40–42; citing Ex. 2003 ¶ 19).

Patent Owner further argues that "Qian's isolation transformer is not a balun and does not produce a balanced output," because "[t]he isolation transformer has an output that is not balanced[,] it is merely isolated." PO Resp. 19 (citing Ex. 2003 ¶ 27). Patent Owner argues that "[t]he isolation transformer outputs only impose a potential difference that does not relate to balancing." *Id.* at 20 (citing Ex. 2003 ¶ 27).

Based on the record before us, we agree with Petitioner that Qian teaches or suggests all of the elements of independent claim 1. As an initial matter, we note that whether Qian has a different objective than the '221

patent is not significant to this obviousness analysis. Prior art references must be considered as a whole for all they teach, not just the specific problems to which they are directed. *See KSR*, 550 U.S. at 420–21; *Medichem*, 437 F.3d at 1166; *EWP Corp.*, 755 F.2d at 907; *In re Heck*, 699 F.2d at 1333. Moreover, as Petitioner notes, Patent Owner does not explain how Qian’s stated object of reducing stray capacitive coupling from the coil antenna to the plasma “differs from the [’221 patent’s] purpose of reducing ‘capacitive coupling between high voltage selections [sic] of the coil and the plasma discharge.’” Reply 12 (citing Ex. 1009, 1:40–42; Ex. 1001, 2:64–3:2; Ex. 1003 ¶¶ 17–19). Patent Owner’s unexplained and unsupported contentions are not persuasive.

Patent Owner’s argument that Qian does not disclose a balun is similarly unsupported. For example, Patent Owner argues that Qian’s isolation transformer “has an output that is not balanced[,], it is merely isolated,” and “[w]here an output is floating, it is neither balanced nor unbalanced.” PO Resp. 19 (citing Ex. 2003 ¶ 27). Although Patent Owner cites to the Second Flamm Declaration to support this argument, Dr. Flamm’s testimony repeats this argument without providing further explanation or objective evidence to support his statements. *See* Ex. 2003 ¶ 27 (“Qian’s balanced transformer is not a balun and does not produce a balanced output. The isolation transformer has an output that is merely isolated, and floating. Where an output is floating, it is neither balanced nor unbalanced.”). We do not credit Dr. Flamm’s testimony on this issue because it is conclusory in nature. Furthermore, the evidence of record establishes that a balun can have a floating load. Ex. 2005, 4 (describing a circuit that can perform as a balun when the ground is “left off entirely (a

floating load)"); *see supra* Section II.E.2 (citing Ex. 2005, 4). In particular, Exhibit 2005, as Petitioner notes, explicitly states that a balun “can be constructed from a ‘conventional magnetically coupled transformer that transmits energy to the output circuit by flux linkage’” and “can function with ‘a floating load,’ wherein ‘the ground . . . is left off entirely.’” Reply 18–19 (quoting Ex. 2005, 1, 4; citing Ex. 1029, 7).

Petitioner and Dr. Graves, unlike Patent Owner and Dr. Flamm, provide sufficient explanation supported by the evidence of record to establish that Qian teaches the use of a balun and, thus, selectively balancing a phase portion and an anti-phase portion of capacitive currents coupled from the inductive coupling structure using a wave adjustment circuit, as is required by claim 1. *See* Pet. 60–67; Reply 11–12, 18–19; Ex. 1003 ¶¶ 160–185; Ex. 1034 ¶¶ 17–22. In particular, we credit Dr. Graves’s testimony that “Qian, just like the 221 Patent, discloses employing a push-pull transformer between the RF power supply and coil to balance the capacitively coupled currents,” and that

Qian teaches that it was known in the art to drive an inductive coil with a RF power source through a matching network. Ex. 1009 at 1:14–19 (“An inductively coupled RF plasma reactor typically includes a reactor chamber with a wafer pedestal for supporting a semiconductor wafer inside the chamber and a coil inductor or antenna over the chamber ceiling connected through an RF impedance match network to an RF power source.”). Qian further teaches choosing to drive the inductive coil with an “isolation transformer” 80 in Figure 2 having “a primary winding 82 and a secondary winding 84” wound on a “ferrite core 90” which “may be circular.” Ex. 1009 at 2:21–51. This isolation transformer is a flux linked balun and produces a balanced output. *See, e.g.*, Ex. 1022 at p.3 (illustrating balanced output); Ex. 1023 at p. 1 (describing Ruthroff baluns with such configurations with citations to 1940–50s references); Ex. 1016

at pp. 79–81 (definition of “balanced output transformer”: “An output transformer with a grounded center tap on its secondary winding”; definition of “balun”: “A device used for matching an unbalanced coaxial transmission line to a balanced two-wire system.”). As discussed above in Sections IX.A.1.c [¶ 100], [s]uch transformers were known in the art to function over wide bandwidths (from a few kilohertz to over 200 MHz) with minimal losses. See Ex. 1029 at p. 7 (describing performance of flux linked broadband transformer).

Ex. 1003 ¶ 169. We further credit Dr. Graves’s testimony that “Qian teaches choosing to employ this structure (the isolation transformer) to balance the anti-phase and phase capacitively coupled currents, and to reduce the overall capacitive coupling from the antenna (i.e., equally distribute them around the mid-point[]),” and that Qian’s “isolation transformer reduces the RF current induced by capacitive coupling by at least a factor of two, the same reduction accomplished by Lieberman’s ‘balanced transformer.’” *Id.* ¶ 172 (citing Ex. 1009, 1:45–56, 2:65–67, 3:33–48).

As to the other elements of claims 1 and 5–7, we have reviewed the entirety of the evidence and the arguments presented in the Petition and find that Petitioner has shown sufficiently that those elements are disclosed as arranged in the claims. Pet. 59–68. Accordingly, after considering Petitioner’s and Patent Owner’s positions, as well as their supporting evidence,¹¹ we determine that Petitioner has shown, by a preponderance of the evidence, that independent claim 1, and claims 5–7 that depend, directly or indirectly, therefrom, would have been obvious over Qian.

¹¹ Patent Owner did not introduce any evidence of objective indicia of nonobviousness.

J. Obviousness over Qian and Hanawa

Petitioner contends that the subject matter of claims 2 and 3 is unpatentable under 35 U.S.C. § 103(a) as having been obvious over the combined teachings of Qian and Hanawa, and relies on the Graves Declaration in support of its contentions. Pet. 69–75. Claim 2 depends from claim 1, and further requires that “the wave adjustment circuit selectively adjusts a frequency of an RF power supply.” Claim 3 depends from claim 1, and additionally recites that “the high frequency field is adjusted using a variable frequency power supply.” Petitioner relies on Hanawa as teaching these additional limitations of the claims. *Id.*

With respect to claim 2, Petitioner argues that Hanawa “teaches using a control circuit (computer 58) to continuously monitor the RF power reflected from or transmitted to the plasma using a sensor (5) and to generate a frequency control signal (54) input to vary the frequency of the RF power supply.” Pet. 70 (citing Ex. 1010, Abstract, 2:1–8, 4:27–40). Petitioner argues that it would have been obvious to a person having ordinary skill in the art “to include Hanawa’s control circuit and sensor in the wave adjustment circuit of Qian and replace Qian’s 13.56 MHz power supply with Hanawa’s variable frequency RF generator and amplifier to adjust the frequency.” *Id.* With respect to claim 3, Petitioner argues that “Hanawa discloses a variable frequency power supply that enables adjusting of the frequency of the power supply, which in turn adjusts the high frequency field emanating from the inductive coupling structure coupled to the power supply.” *Id.* at 71 (citing Ex. 1010, Abstract, 2:1–8, 3:28–47, 4:27–40; Ex. 1003 ¶ 193).

Petitioner argues that it would have been obvious to a person having ordinary skill in the art “to adapt Qian to include a variable frequency power supply and a control circuit and sensor as part of the wave adjustment circuit for adjusting the frequency of the power supply” as taught by Hanawa in order “to improve coupling of RF power into the plasma by minimizing reflected power or maximizing transmitted power.” Pet. 71 (citing Ex. 1003 ¶ 194). Petitioner argues that “Hanawa and Qian address the same technical problem, namely, impedance matching in the context of applying power to plasma to effect plasma etching.” *Id.* (citing Ex. 1003 ¶¶ 195–196). Petitioner further argues that “[a]dapting Qian to include Hanawa’s control circuit and sensor and/or variable frequency power supply would have been understood to provide well-known benefits that would have motivated” a person having ordinary skill in the art to do so, such as “eliminat[ing] the use of variable capacitors and electric servos” by providing “a control circuit that changes the frequency of a variable RF power supply to precisely match the impedance,” and “minimiz[ing] process time while maintaining yield.” *Id.* at 72–74 (citing Ex. 1003 ¶¶ 197–204).

Patent Owner does not address separately Petitioner’s explanations and supporting evidence as to how the teachings of Qian and Hanawa account for all of the limitations of dependent claims 2 and 3. *See generally* PO Resp. We have reviewed Petitioner’s explanations and supporting evidence as to how the combined teachings of Qian and Hanawa account for all the limitations recited in these dependent claims, as well as its reasons as to why a person having ordinary skill in the art would have been prompted to combine or modify the respective teachings, and we agree with and adopt Petitioner’s analysis. Pet. 69–75; Ex. 1003 ¶¶ 190–204.

Based on the record developed during trial, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the subject matter of claims 2 and 3 would have been obvious over the combined teachings of Qian and Hanawa.

K. Obviousness over Qian and Collins

Petitioner contends that the subject matter of claim 4 would have been obvious under 35 U.S.C. § 103(a) over the combined teachings of Qian and Collins, and relies on the Graves Declaration in support of its contentions. Pet. 75–78. Petitioner contends that Collins teaches “the wave adjustment circuit comprises a transmission line” limitation of claim 4 when it describes a matching network that comprises a plurality of transmission lines, which matches the output impedance of a source with the input impedance of a load. *Id.* at 76. Petitioner contends that a person having ordinary skill in the art “would have understood from this disclosure that a transmission line represents a type of wave adjustment circuit, and that Collins teaches the use of transmission lines to adjust the phase of power between an RF source and a load, such as a plasma.” *Id.* (citing Ex. 1003 ¶ 206).

Petitioner further contends that a person having ordinary skill in the art would further understand from Collins’s description of “electronic tuning using ‘a transmission line stub 45 and a transmission line stub 46, arranged in the shown topology [of Figure 1]’” that Collins teaches “the wave adjustment circuit comprises a transmission line” element of claim 4. Pet. 76 (citing Ex. 1003 ¶ 207). According to Petitioner, a person having ordinary skill in the art “would have had reasons to use, and would have been motivated to use, Collins’[s] transmission line stub topology with the plasma generating apparatuses of Qian” because “[l]ike Qian, Collins is

directed to the problem of coupling RF power to a load, such as plasma” and “Qian and Collins teach the use of matching networks.” *Id.* at 77 (citing Ex. 1003 ¶¶ 209–213).

Patent Owner does not address separately Petitioner’s explanations and supporting evidence as to how the teachings of Qian and Collins account for all of the limitations of dependent claim 4. *See generally* PO Resp. We have reviewed Petitioner’s explanations and supporting evidence as to how the combined teachings of Qian and Collins account for all the limitations recited in this dependent claim, as well as its reasons as to why a person having ordinary skill in the art would have been prompted to combine or modify the respective teachings, and we agree with and adopt Petitioner’s analysis. Pet. 75–78; Ex. 1003 ¶¶ 205–213.

Based on the record developed during trial, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the subject matter of claim 4 would have been obvious over the combined teachings of Qian and Collins.

III. CONCLUSION

After reviewing the record and weighing evidence offered by both parties, we determine that Petitioner has shown, by a preponderance of the evidence, that: (1) claims 1 and 5–7 would have been obvious over (a) Lieberman, (b) Lieberman and Dible, and (c) Qian; (2) claims 2 and 3 would have been obvious over (a) Lieberman and Hanawa, (b) Lieberman, Dible, and Hanawa, and (c) Qian and Hanawa; and (3) claim 4 would have been obvious over (a) Lieberman and Collins, (b) Lieberman, Dible, and Collins, and (c) Qian and Collins.

IV. ORDER

In consideration of the foregoing, it is
ORDERED that claims 1–7 of the '221 patent are *unpatentable*; and
FURTHER ORDERED that, because this is a Final Written Decision,
parties to the proceeding seeking judicial review of the Decision must
comply with the notice and service requirements of 37 C.F.R. § 90.2.

IPR2017-00391
Patent 6,071,221

PETITIONER:

Jonathan McFarland
Chad Campbell
Philip A. Morin
PERKINS COIE LLP
jmcfarland@perkinscoie.com
cscampbell@perkinscoie.com
pmorin@perskinscoie.com

Jeremy Jason Lang
Jared Bobrow
ORRICK, HERRINGTON & SUTCLIFFE, LLP
PTABDocketJJL2@orrick.com
PTABDocketJ3B3@orrick.com

David M. Tenant
Nathan Zhang
WHITE & CASE LLP
dtenant@whitecase.com
nathan.zhang@whitecase.com

Naveen Modi
Joseph E. Palys
Chetan R. Bansal
PAUL HASTINGS LLP
naveenmodi@paulhastings.com
josephpalys@paulhastings.com
chetanbansal@paulhastings.com

PATENT OWNER:

Justin J. Lesko
LAW OFFICES OF STEVEN G. LISA, LTD.
justinlesko@patentit.com

Rolf O. Stadheim
STADHEIM & GREAR
stadheim@stadheimgear.com