UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ASM IP HOLDING B.V.,
Petitioner,

v.

KOKUSAI ELECTRIC CORP.,
Patent Owner.

Case IPR2019-00364
Patent 7,033,937 B2

Before KRISTINA M. KALAN, MICHELLE N. WORMMEESTER, and SHELDON M. MCGEE, *Administrative Patent Judges*.

KALAN, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

A. Background

ASM IP Holding B.V. ("Petitioner") filed a Petition requesting *inter partes* review of claims 1–18 of U.S. Patent No. 7,033,937 B2 (Ex. 1020, "the '937 patent"). Paper 2 ("Pet."). Kokusai Electric Corporation ("Patent Owner") filed a Preliminary Response to the Petition. Paper 7 ("Prelim. Resp."). Petitioner, with Board authorization (Paper 8), filed a Reply to Patent Owner's Preliminary Response. Paper 9 ("Reply"). Patent Owner, with Board authorization, filed a Sur-Reply to Petitioner's Reply. Paper 10 ("Sur-Reply").

We have jurisdiction under 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted "unless . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). Upon consideration of the Petition, the Preliminary Response, the Reply, the Sur-Reply, and the evidence of record, we determine Petitioner has shown a reasonable likelihood that it would prevail in showing the unpatentability of at least one of claims 1–18. Thus, we institute *inter partes* review of claims 1–18 of the '937 patent.

B. Related Proceedings

The parties identify the following proceeding as involving the '937 patent: *Hitachi Kokusai Electric Inc. v. ASM International, N.V.*, C.A. No. 17-cv-06880 (N.D. Cal.). Pet. 74; Paper 3, 3 (Petitioner's Supplemental Mandatory Notice: Related Matters); Paper 6, 1 (Patent Owner's Mandatory Notices).

C. The ’937 Patent (Ex. 1020)

The ’937 patent, titled “Apparatus and Method for Use in Manufacturing a Semiconductor Device,” issued on April 25, 2006. Ex. 1020, at [54], [45]. The ’937 patent relates to “[a]n apparatus for use in manufacturing a semiconductor device” that “comprises a reaction chamber wherein one or more substrates to be treated are disposed, a plasma source arranged outside of and in proximity to the reaction chamber, an active species supply port for providing active species generated by the plasma source to the reaction chamber . . . and an exhaust port.” *Id.* at [57]. The ’937 patent addresses a need in the art for a post-deposition technique for treating semiconductor devices on which a film has been deposited through chemical vapor deposition (CVD). *See id.* at 1:19–24. For example, a “tantalum pentoxide (Ta_2O_5) film which is used as a capacitor insulating film for semiconductor memory” requires further treatment because “carbon included in the precursor, i.e., tantalum pentaethoxide ($Ta(OC_2H_5)_5$) may be introduced into tantalum pentoxide film” leading to “the insulating characteristics of the film becom[ing] deteriorated.” *Id.* at 1:25–40. “By treating the wafer in a gaseous atmosphere including oxygen as a component thereof, carbon is removed from the film in the form of carbon dioxide.” *Id.* at 1:41–43.

The ’937 patent describes a “film deposition process and a post-deposition process” (*id.* at 11:31–12:6) that “can be performed in a same chamber without having to employ a multiple number of apparatus” and “without conveying the wafer between different process chambers.” *Id.* at 12:36–43. In an embodiment, the post-deposition process is performed “by supplying a reaction gas, e.g., O_2, O_3, N_2O or NO gas containing oxygen for removing carbon from the deposited tantalum pentoxide film . . . exciting the gas to generate plasma, and removing carbon from the tantalum pentoxide film and curing the oxygen deficiency therein with the active radicals extracted from the plasma source 2 into the reaction chamber 1." *Id.* at 11:46–53. Figure 16 of the '937 patent is reproduced below:

FIG. 16

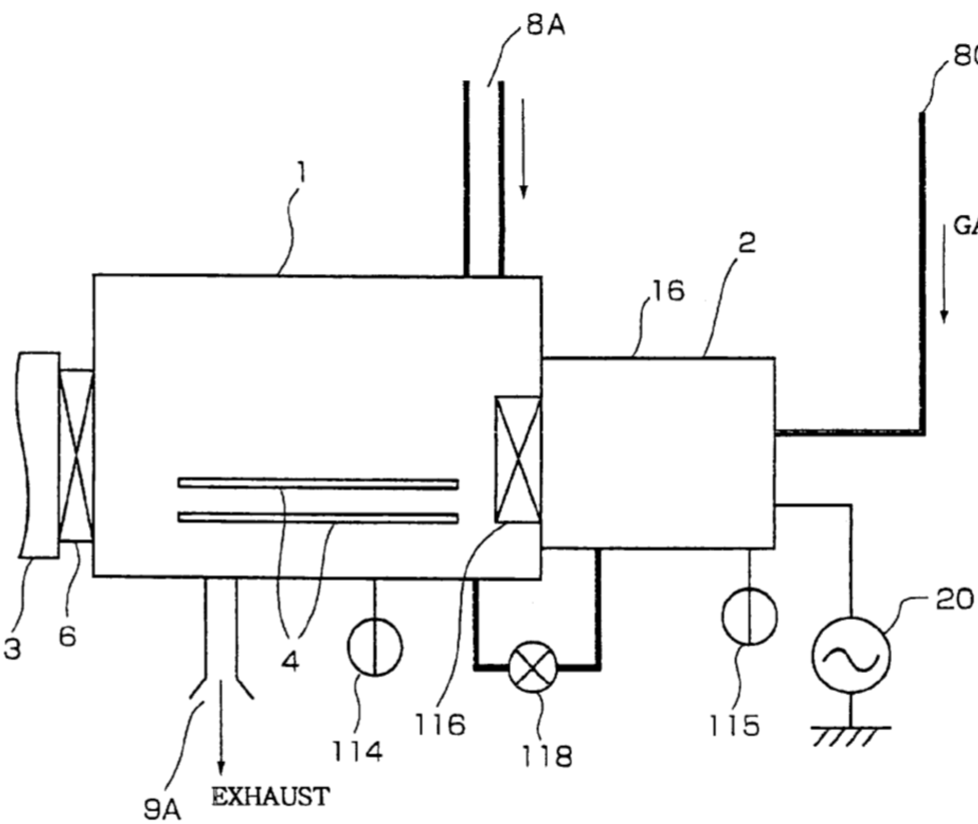

Figure 16 of the '937 patent, above, "exemplifies a schematic cross-sectional side view of a reaction chamber 1 and a plasma source 2 of a semiconductor manufacturing apparatus." *Id.* at 10:49–51.

D. Challenged Claims

Of challenged claims 1–18, claims 1, 7, and 10 are independent. Claims 1 and 7 are reproduced below:

> 1. [pre] A method for use in manufacturing a semiconductor device, comprising the steps of:
>
> [a] generating a plasma in each of at least one plasma source arranged outside a reaction chamber, the reaction chamber having therein at least two substrates to be simultaneously processed; and
>
> [b] supplying active species included in the plasma into the reaction chamber through a supply port arranged at a side of the reaction chamber and
>
> [c] flowing the active species from the supply port to an exhaust port arranged at a substantially opposite side to the supply port to perform a predetermined process on the substrates,
>
> [d] the actives species flowing across the substrates in one direction substantially parallel to surfaces of the substrates.

Ex. 1020, 12:66–13:13 (bracketed annotations and formatting added).

> 7. [pre] A method for use in manufacturing a semiconductor device, comprising the steps of:
>
> [a] (b1) generating a plasma in at least one plasma source arranged outside a reaction chamber, the reaction chamber having therein at least two substrates to be simultaneously processed;
>
> [b] (b2) supplying active species included in the plasma into the reaction chamber in a direction substantially parallel to surfaces of the substrates to perform a predetermined process thereon; and
>
> [c] (a) simultaneously forming a film on each of said at least two substrates by a thermal CVD method in the reaction chamber before performing the step (b1).

Id. at 13:36–48 (bracketed annotations and formatting added).

E. Asserted Grounds of Unpatentability

Reference(s)	**Basis**	**Claims Challenged**
Shimada[1]	§ 102	1, 6, 10–12
Shimada and Chaneliere[2]	§ 103	3, 14
Shimada, Chaneliere, and Kimura[3]	§ 103	4, 15
Shimada and Noble[4]	§ 103	5, 6, 11
Watanabe[5] and Sivaramakrishnan[6]	§ 103	1, 2, 7, 10, 13, 16
Watanabe, Sivaramakrishnan, and Hautala[7]	§ 103	8, 17
Watanabe, Sivaramakrishnan, and Chaneliere	§ 103	9, 18

Petitioner relies on the declaration of Dr. Alexander Glew (Ex. 1022) in support of its contentions.

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[1] Japanese Unexamined Pat. App. No. H-251391, published September 28, 1993 (Ex. 1005).

[2] Chaneliere, C. *et al.*, *Tantalum Pentoxide (Ta_2O_5) Thin Films for Advanced Dielectric Applications*, R22 MAT. SCI. & ENG'G 269 (1998) (Ex. 1012).

[3] Kimura, H. *et al.*, *EXAFS Studies of the Difference in Local Structure of Various Tantalum Oxide Capacitor Films*, 354 MAT. RES. SOC'Y SYMP. PROC. 489 (1995) (Ex. 1007).

[4] U.S. Pat. No. 6,450,116 B1, issued September 17, 2002 (Ex. 1008).

[5] Japanese Unexamined Pat. App. No. H7-94419, published April 7, 1995 (Ex. 1006).

[6] European Pat. App. No. 0 843 347 A2, published May 20, 1998 (Ex. 1011).

[7] U.S. Pat. No. 6,268,288 B1, issued July 31, 2001 (Ex. 1013).

II. ANALYSIS

A. Claim Construction

We apply the claim construction standard articulated in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). *See Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board*, 83 Fed. Reg. 51,340 (Oct. 11, 2018) (applicable to *inter partes* reviews filed on or after November 13, 2018). The parties agree that a *Phillips*-type construction is appropriate for this proceeding. Pet. 4; Prelim. Resp. 3. Under *Phillips*, claim terms are afforded "their ordinary and customary meaning." *Phillips*, 415 F.3d at 1312. "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention." *Id.* at 1313. Only terms that are in controversy need to be construed, and then only to the extent necessary to resolve the controversy. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

Petitioner proposes a construction for the term "a distance where the concentration of the active species . . . becomes substantially constant," which is recited in dependent claims 6 and 11. Pet. 4–9. Specifically, Petitioner argues that "a distance where the concentration of the active species . . . becomes substantially constant" should "encompass distances downstream of the distance from the plasma source at which the concentration of ions decreases to zero." *Id.* at 9. Patent Owner does not contest Petitioner's construction of "a distance," but does discuss the "active species" portion of the term in its Preliminary Response. Prelim. Resp. 4–6.

Patent Owner proposes that the only term that needs to be construed is "active species," which is recited in independent claims 1, 7, and 10, and in several dependent claims. Prelim. Resp. 4–6. Specifically, Patent Owner asserts that "'active species,' as the term is used in the '937 Patent, and as acknowledged by Petitioner and its expert, means an excited gas that includes at least radicals and ions." *Id.* at 6.

Petitioner replies that the claimed "active species" includes "radicals and/or ions," and, in the context of the claims, includes only those species that are supplied to the reaction chamber. Reply 1–2. Petitioner argues that Patent Owner's construction of "active species" relies on portions of the '937 patent's specification that relate to active species formed in the plasma source, rather than active species that enter the reaction chamber. *Id.* at 2. Petitioner agrees with Patent Owner that "the 'active species' formed when a plasma is generated <u>in a plasma source</u> may include both ions and radicals," but argues that "[t]he specification makes it clear that not all of the active species that are generated in the plasma source reach the reaction chamber." *Id.* Petitioner argues that "the '937 patent teaches that the plasma source is separated from the reaction chamber to avoid ions from entering the reaction chamber and reaching the wafer in the reaction chamber." *Id.* at 2–3. Rather, Petitioner points to a preferred embodiment of the '937 patent and asserts that the specification of the '937 patent "teaches that the active species <u>**supplied to the reaction chamber include only radicals (and not ions)**</u> when the plasma source is separated from the reaction chamber by a certain distance." *Id*.

In its Sur-Reply, Patent Owner states that Petitioner, in its Petition, took the position that the term "'active species' includes ions <u>**and**</u> radicals, and applied this meaning throughout its Petition," but then changed its position in its Reply, "propos[ing] that active species need only have 'radicals and/**or** ions.'" Sur-Reply 1. Patent Owner also asserts that Petitioner improperly "attempt[s] to read a feature of a preferred embodiment into the claims," and misconstrues dependent claims 6 and 11 as requiring no ions to reach the wafer as belied by Petitioner's own evidence. *Id.* at 2–3.

Patent Owner also points to the specification, which "explains that '[i]ons, radicals[,] and ozone' are in the plasma discharge, even though only 'the radicals and ozone are used in the [carbon removal] treatment'" and "clarifies the radicals of the active species 'react[] with the wafer,' confirming active species include more than just radicals." *Id.* at 3 (citing Ex. 1020, 8:30–32, 11:2). Patent Owner asserts further that dependent "claims 6 and 11 would be inoperable if no ions were introduced into the chamber" because each require the concentration of active species generated by the plasma to become "substantially constant." *Id.* at 4. Thus, Patent Owner argues that "ions must necessarily be supplied into 'the chamber'" after which the concentration of those active species "becomes substantially constant at the wafer." *Id.* Finally, Patent Owner asserts that Petitioner is bound by its admission and that of its expert in this proceeding—presumably Petitioner's statement that "[i]t was understood that the active species in a plasma included ions and radicals" (Pet. 8[8])—and that "[t]o permit Petitioner to change its position after [Patent Owner's] reliance and adoption of it, would unduly prejudice Patent Owner." *Id.* at 5.

[8] We note Petitioner's statement also appears at page 13 of the Petition (Paper 2) in IPR2019-00375, which presents similar issues to those here.

Thus, Petitioner and Patent Owner have invited us to construe the term "active species." Upon review of the '937 patent specification, the Petition, Preliminary Response, Reply, and Sur-Reply, and evidence of record in this proceeding, we construe the term "active species" as "species generated by the plasma source, such as ions, radicals, and ozone." Our reasoning follows.

To properly interpret the meaning of a given claim term, our reviewing court instructs us to "look first to the intrinsic evidence of record, *i.e.*, the patent itself, including the claims, the specification and, if in evidence, the prosecution history" which collectively "is the most significant source of the legally operative meaning of disputed claim language." *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996).

The claims themselves do not clarify the meaning of the term "active species." Thus, to determine the meaning of the term "active species," we first turn to the specification, because "'[c]laims must be read in view of the specification, of which they are a part.'" *Id*. "[T]he specification is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." *Id.* Here, we find that, although the term "active species" is not expressly defined, the specification is nevertheless informative regarding the proper construction. In particular, it states that "the type of generated active species depends on the electron temperature of the plasma" and that "the ratio of the generated active species can be adjusted in a desired manner." Ex. 1020, 6:64–7:3. In one post-deposition process, "plasma 17 is generated from the oxygen gas in the discharge tube 16 by the plasma discharge induced by the alternating electric fields. Ions, radicals[,] and ozone (O_3) are generated from the oxygen gas by the plasma discharge, among which radicals and ozone are used in the treatment." *Id.* at 8:28–33.

Extrinsic evidence may also be considered when necessary to assist in determining the proper construction of a given claim term. *Vitronics*, 90 F.3d at 1583. Here, we note that Petitioner provides a plethora of extrinsic evidence that supports a construction of "active species" as "species generated by the plasma source, such as ions, radicals, and ozone." Ex. 1005 ¶ 2 ("This plasma contains a mixture of plasma gas ions, radicals, and electrons"); Ex. 1008, 5:42–45 ("In general, plasma sources generated by, for example, an energetic excitation of gaseous molecules consist of a plasma of charged ions, radicals, and electrons."); Ex. 1011, 5:50–52 ("[T]he remote plasma cleaning system is a microwave plasma system configured to produce and deliver a select species (such as fluorine, chlorine or other radicals) to the processing chamber. The remote plasma system energizes gases by microwave radiation to create a plasma with etching radicals."); Ex. 1018, 26 ("Plasma contains highly activated species *such as* electrons, ions, and radicals." (emphasis added)).

We emphasize that our construction focuses only on the term "active species," which is what the parties have asked us to construe. Prelim. Resp. 4; Paper 9, 1. In this regard, while Patent Owner correctly observes that the specification indicates that ions may be one type of active species "generated from the oxygen gas by the plasma discharge" (Ex. 1020, 8:30–33), we are unpersuaded by Patent Owner's position that the term "active species," in isolation, must *necessarily* require the presence of ions. *See, e.g.*, Prelim. Resp. 4 (asserting that it "was well-known at the time of the '937 Patent [that] active species include at least both radicals and <u>ions</u>.").

In this regard, while we have been asked to construe the term "active species" to necessarily include ions, we decline to do so because we are not persuaded that the evidence before us at this stage of the proceeding requires the presence of ions in the active species under all circumstances.

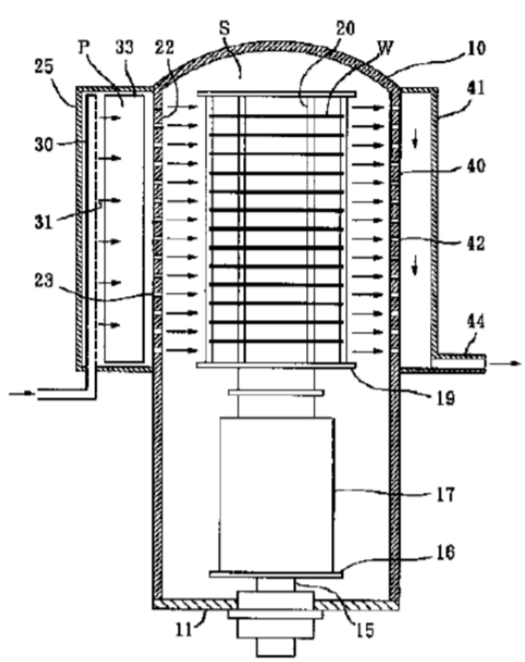
For purposes of this Decision, we determine that no other claim terms require an explicit construction.

B. Prior Art

i. Shimada (Ex. 1005)

Shimada, titled "Plasma Processing Device for Semiconductor Wafers," relates to "a plasma processing device capable of allowing a process gas that generates plasma to flow evenly in the vertical direction with respect to semiconductor wafers held in a vertically stacked state and thereby performing uniform plasma processing on each of the plurality of semiconductor wafers." Ex. 1005, at [54], [57]. Shimada's Figure 1, reproduced below, discloses a plasma processing device:

(FIG. 1)



Shimada's Figure 1, above, is a "vertical cross-sectional view . . . of a plasma processing device for semiconductor wafers." *Id.* ¶ 8. Figure 1 shows a cylindrical processing vessel 10 made of quartz, with a closed upper end and a stainless steel cap plate 11 on an opened bottom end that can be freely opened and closed. *Id.* On one side of the outer periphery of processing vessel 10, "a plasma generation vessel 25 made of quartz, for example, is provided integrally using a portion of the peripheral wall thereof as a partition wall 22 so as to divide a plasma generation space P with the partition wall 22." *Id.* ¶ 10. "Radical inlet ports 23 are then formed uniformly in the vertical direction in an area facing the entire vertical length of the wafer holding area in the partition wall 22 between the processing space S and the plasma generation space P." *Id.* "An exhaust port 41 is provided integrally on the outer periphery of the processing vessel 10 on the opposite side as the plasma generation vessel 25 using a portion of the peripheral wall thereof as a partition wall 40 so as to divide the exhaust path with the partition wall 40." *Id.* ¶ 15.

During operation of the plasma processing device, "the semiconductor wafers W to be processed are held in the wafer holding area inside the processing vessel 10" and "a process gas is supplied by the process gas supply pipe 30 while a high-frequency voltage is applied to the parallel plate type plasma generation electrode 33 so that plasma is generated by the process gas in the plasma generation space P." *Id.* ¶ 18. "The radicals of the process gas produced by the plasma are introduced into the processing space S from the radical inlet ports 23, and the target processing is achieved for the surfaces of the semiconductor wafers W by the action of these radicals." *Id.* ¶ 19. "[D]ue to the presence of the partition wall 22, ions do not penetrate directly into the processing space S and affect the semiconductor wafers W." *Id.* ¶ 27.

ii. Chaneliere (Ex. 1012)

Chaneliere, titled "Tantalum Pentoxide (Ta_2O_5) Thin Films for Advanced Dielectric Applications," discusses "[d]ifferent methods used to produce tantalum oxide layers." Ex. 1012, Abstract. Specifically, Chaneliere discusses "[s]everal post-deposition annealing treatments . . . to densify (elimination of the hydrocarbon contaminants and reduction of the oxygen vacancies) and improve the electrical properties of tantalum pentoxide thin films." *Id.* at 19–20.

iii. Kimura (Ex. 1007)

Kimura, titled "EXAFS Studies of the Difference in Local Structure of Various Tantalum Oxide Capacitor Films," discusses "the relationship between the leakage current characteristics and the local structures around Ta" in tantalum oxide capacitors. Ex. 1007, Abstract. Kimura concludes that "differences in the leakage current characteristics of tantalum oxide capacitors that are treated by various processes are not due to difference in crystalline structure, but, to the degree of deficiency of oxygen atoms adjacent to the tantalum atoms." *Id.* at 5.

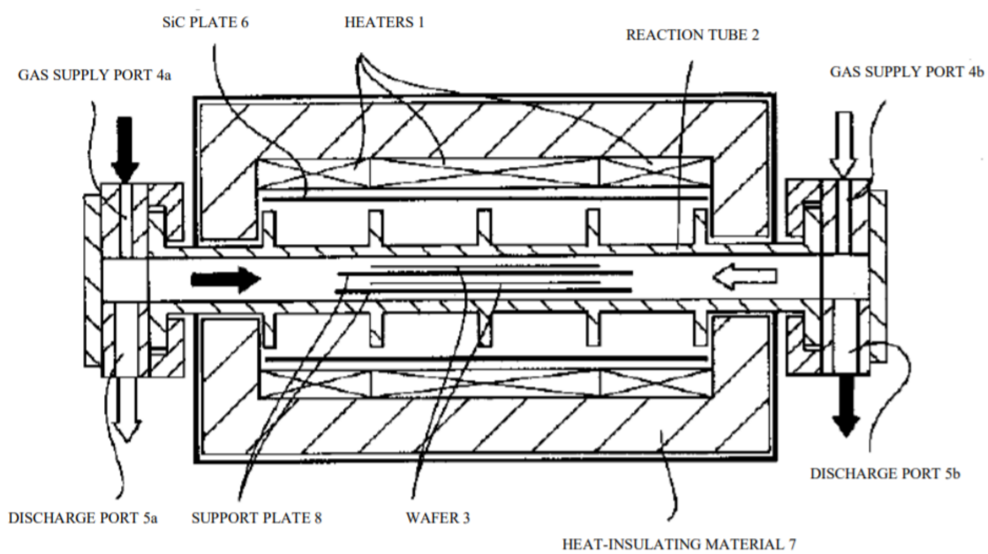
iv. Noble (Ex. 1008)

Noble, titled "Apparatus for Exposing a Substrate to Plasma Radicals," discusses "a first reaction chamber adapted to generate a plasma comprising ions and radicals and a second reaction chamber coupled to the first reaction chamber and adapted to house a substrate at a [site] in the second reaction chamber" where "[t]he second reaction chamber is coupled to the first reaction chamber by an inlet member and radicals of the plasma flow through the inlet member into the second reaction chamber." Ex. 1008, at [54], [57]. In particular, Noble discloses that "[i]n the case of a nitridation of a gate oxide, for example, the nitrogen-containing material is produced effectively in or on SiO_2 layer 110 by exposing SiO_2 layer 110 to a plasma of predominantly N^* radicals." *Id.* at 6:44–48.

v. Watanabe (Ex. 1006)

Watanabe, titled "Semiconductor Processing Device," discusses the use of "a film forming device or an etching device to perform uniform processing with high reproducibility." Ex. 1006, at [54], [57]. Watanabe's Figure 2, reproduced below, discloses a heating furnace of a CVD device:

(FIG. 2)

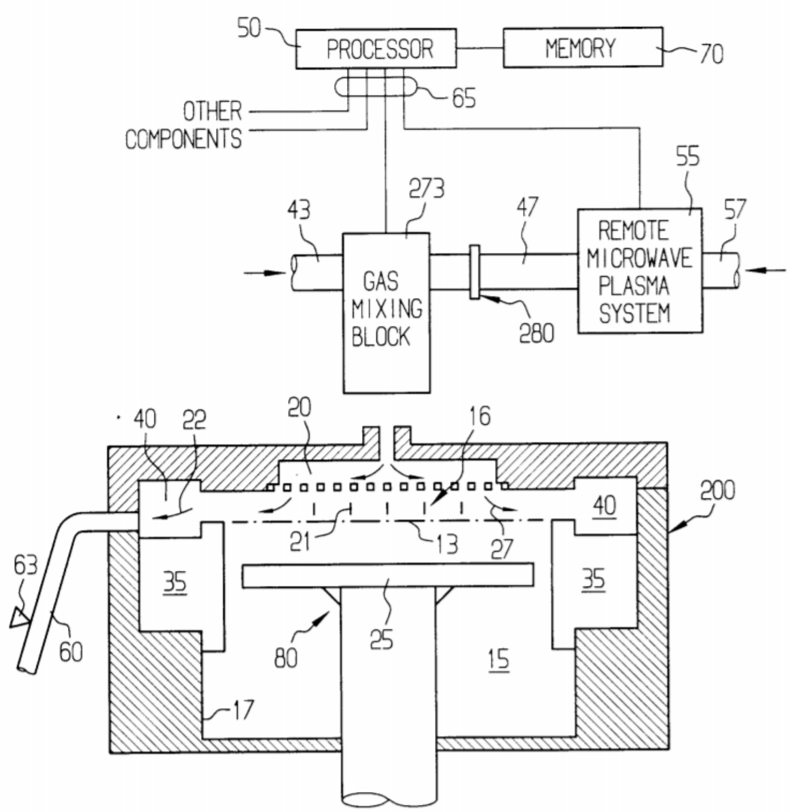


Watanabe's Figure 2, above, "is a cross-sectional view of the heating furnace" of a CVD device. *Id.* ¶ 22. During operation of the CVD device, "a wafer 3 is inserted into the reaction tube 2 in a horizontal state and mounted on the support plate 8." *Id.* ¶ 23. The wafer "is heated by the heater 1, and a gas is simultaneously supplied from one of the gas supply ports 4a and b while being discharged from one of the discharge ports 5a and b similarly formed at both ends of the reaction tube 2" resulting in "the production of a film or epitaxial growth on the surface of the wafer 3." *Id.* The CVD device may have multiple support plates so that "one or two wafers 3 are processed simultaneously" where "[t]he gas flows roughly parallel to the surface of the wafer 3." *Id.*

vi. Sivaramakrishnan (Ex. 1011)

Sivaramakrishnan, titled "Method and Apparatus for Processing a Semiconductor Substrate," discusses "high temperature (at least about 500-800°C) processing of semiconductor wafers" that "allow[s] multiple process steps to be performed <u>in situ</u> in the same chamber to reduce total processing time and to ensure high quality processing for high aspect ratio devices." Ex. 1011, at [54], [57]. Sivaramakrishnan's Figure 1A is reproduced below:

FIG 1 A



Sivaramakrishnan's Figure 1A, above, is "a vertical, cross-sectional view of one embodiment of a CVD apparatus." *Id.* at 8:22–23. Figure 1A shows "an enclosure assembly 200 housing a vacuum chamber 15 with a gas reaction area 16," where "[a] gas distribution plate 20 is provided above the gas reaction area 16 for dispersing reactive gases through perforated holes in plate 20 to a wafer (not shown) that rests on a vertically movable heater 25 (also referred to as a wafer support pedestal or susceptor)." *Id.* at 8:33–36. "Reactive and carrier gases are supplied through supply line 43 into a gas mixing box (or gas mixing block) 273 (Fig. 5), where they are preferably mixed together and delivered to plate 20." *Id.* at 8:48–49. "During deposition processing, gas supplied to plate 20 is vented toward the wafer surface (as indicated by arrows 21), where it may be uniformly distributed radially across the wafer surface, typically in a laminar flow." *Id.* at 8:53–55. A "[r]emote microwave plasma system 55 integrally provided in CVD apparatus 10" can "perform cleaning or etching of native oxides or residues from the surface of the wafer, depending on the desired application." *Id.* at 9:15–18. The "remote microwave plasma system 55 receives gases via input line 57, which are energized by microwave radiation to create a plasma with etching radicals which are then sent via conduit 47 for dispersion through plate 20 to chamber 15." *Id.* at 9:21–23.

vii. Hautala (Ex. 1013)

Hautala, titled "Plasma Treated Thermal CVD of TaN Films from Tantalum Halide Precursors," discusses a "plasma treated chemical vapor deposition (PTTCVD) method for depositing high quality conformal tantalum nitride (TaN_x) films from inorganic tantalum halide (TaX_5) precursors and a nitrogen containing gas." Ex. 1013, at [54], [57].

Particularly, in Hautala's method, "[t]he deposition is halted to plasma treat the film surface, then deposition is resumed." *Id.* at 2:44–45. "The plasma treatments are performed at regular intervals in the thermal CVD process (PTTCVD) until a desired film thickness is obtained." *Id.* at 2:46–48.

C. Asserted Anticipation Based on Shimada (Ground 1)

Petitioner asserts that claims 1, 6, and 10–12 of the '937 patent are unpatentable as anticipated by Shimada under 35 U.S.C. § 102. Pet. 12–27. In asserting that claim 1 is unpatentable as anticipated by Shimada, Petitioner points to Shimada's Figure 1 as well as portions of the specification. *Id.* at 12–19. Petitioner alleges that Shimada discloses:

1[pre] "A method for use in manufacturing a semiconductor device" (*id.* at 12) (citing Ex. 1005 ¶¶ 6, 62);

1[a] "generating a plasma in each of at least one plasma source arranged outside a reaction chamber, the reaction chamber having therein at least two substrates to be simultaneously processed" (*id.* at 13–15) (citing Ex. 1005, Fig. 1, ¶¶ 2, 8, 10, 12, 18, 19, 27);

1[b] "supplying active species included in the plasma into the reaction chamber through a supply port arranged at a side of the reaction chamber" (*id.* at 15–16) (citing Ex. 1005, Fig. 1, ¶ 19);

1[c] "flowing the active species from the supply port to an exhaust port arranged at a substantially opposite side to the supply port to perform a predetermined process on the substrates" (*id.* at 17–19) (citing Ex. 1005 ¶¶ 5, 7, 15, 25, 35); and

1[d] "the active[] species flowing across the substrates in one direction substantially parallel to surfaces of the substrates" (*id.* at 19) (citing Ex. 1005, Fig. 1, ¶ 20).

Petitioner also points to Shimada's Figure 1 as well as portions of the Shimada specification in asserting that claims 6 and 10–12 are anticipated by Shimada. *Id.* at 19–27.

Patent Owner argues that Shimada does not disclose the independent claim 1 limitation 1[b] "supplying active species included in the plasma into the reaction chamber through a supply port arranged at a side of the reaction chamber" or the similar limitation in independent claim 10. Prelim. Resp. 7–10. Specifically, Patent Owner argues that "while *Shimada* teaches the generation of a plasma process gas, rather than allow the generated plasma's **active species** into the reaction space, *Shimada's* 'partition wall 22' physically **blocks ions** from entering the reaction chamber" (Prelim. Resp. 9), where Patent Owner's construction of "active species" necessarily includes ions as well as radicals, as discussed *supra* § II.A.

As discussed above, we interpret "active species" as "species generated by the plasma generator, such as ions, radicals, and ozone." This construction, in and of itself, does not require that any particular species enter the reaction chamber. This interpretation is consistent with the specification of the '937 patent, which provides numerous examples in which only certain active species are indicated as entering the reaction chamber, such as: "Oxygen radicals activated by the plasma 17 are supplied into the reaction chamber 1 through the supply outlet 23 and then onto the tantalum pentoxide film formed on the wafer 4" (Ex. 1020, 8:20–23); "A gas is supplied to the plasma source 2 and excited therein. Thereafter, active radicals generated in the plasma source 2 are supplied to the reaction chamber 1 and reacted with the wafer 4 to be treated" (*id.* at 10:66–11:2); "[E]xciting the gas to generate plasma, and removing carbon from the tantalum pentoxide film and curing the oxygen deficiency therein with the active radicals extracted from the plasma source 2 into the reaction chamber 1" (*id.* at 11:49–53). Notably, while there are multiple instances in the specification that describe supplying radicals into the reaction chamber of the '937 patent, Patent Owner has not pointed to a specific instance that explicitly describes supplying ions into the reaction chamber.

The '937 patent specification, on the contrary, indicates a preference against ions reaching the wafer to be treated in the reaction chamber: "[i]n order to prevent the wafer 4 and the film from being damaged or attacked by the collision of ions, the plasma source 2 is separated from the reaction chamber 1." *Id.* at 8:33–35. Patent Owner's proposed construction, as discussed above, unnecessarily requires ions to be among the "active species" supplied to the reaction chamber. Use of the term "active species" in independent claims 1, 7, and 10, and several dependent claims, however, does not require ions be provided to the reaction chamber.

We understand Patent Owner's argument that Shimada's partition wall 22 physically blocks ions from entering the reaction chamber. Prelim. Resp. 9. Shimada indicates that "*radicals* produced in the plasma generation space P are introduced into the processing space S with high efficiency." Ex. 1005 ¶ 27 (emphasis added). "Due to the presence of the partition wall 22, ions do not penetrate directly into the processing space S and affect the semiconductor wafers W. Therefore, defects in the semiconductor wafers due to the effect of ions," which are "observed when ions act directly on the semiconductor wafers W, do not occur." *Id*. Thus, Shimada expressly states that ions—which Petitioner seemingly admits are among the "active species generated by the plasma source"—do not penetrate directly[9] into the processing space S containing wafers W. *Id.* This is not inconsistent with the language of claim 1 "supplying active species included in the plasma" (i.e., not necessarily all of the "active species" generated by the plasma source) to the reaction chamber, in view of our construction of the term "active species." We also read Shimada as consistent with the '937 patent specification, in that both focus on the provision of radicals to the reaction chamber.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that Shimada anticipates claims 1, 6, and 10–12. Petitioner presents arguments that the limitations of independent claims 1 and 10, and dependent claims 6, 11, and 12, are present in Shimada, and presents evidence supporting the same. Pet. 12–27. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner's arguments. Ex. 1022 ¶¶ 39–99. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 1, 6, and 10–12 are unpatentable as being anticipated by Shimada.

D. Asserted Obviousness Based on Shimada and Chaneliere (Ground 2)

Petitioner asserts that claims 3 and 14 of the '937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Shimada and Chaneliere. Pet. 27–30.

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[9] Petitioner does not contend that Shimada's ions somehow penetrate *in*directly into the processing space S. Rather, Petitioner focuses on the presence of radicals in Shimada's processing space S. Pet. 14–16, 18–20.

Patent Owner argues that Chaneliere does not remedy the deficiencies of Shimada identified with respect to Ground 1, and therefore Ground 2 should be denied for the same reasons as Ground 1. Prelim. Resp. 23.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that Shimada and Chaneliere render claims 3 and 14 obvious. Petitioner presents arguments that the limitations of dependent claims 3 and 14 are present in Shimada and Chaneliere, and presents evidence supporting the same. Pet. 27–28. Further, Petitioner sets forth a motivation for combining Shimada and Chaneliere. *Id.* at 28–30. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner's arguments. Ex. 1022 ¶¶ 100–110. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 3 and 14 are unpatentable as being obvious over Shimada and Chaneliere.

E. Asserted Obviousness Based on Shimada, Chaneliere, and Kimura (Ground 3)

Petitioner asserts that claims 4 and 15 of the '937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Shimada, Chaneliere, and Kimura. Pet. 30–36.

Patent Owner argues that Chaneliere and Kimura do not remedy the deficiencies of Shimada identified with respect to Ground 1, and therefore Ground 3 should be denied for the same reasons as Ground 1. Prelim. Resp. 23.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that

Shimada, Chaneliere, and Kimura render claims 4 and 15 obvious. Petitioner presents arguments that the limitations of dependent claims 4 and 15 are present in Shimada, Chaneliere, and Kimura, and presents evidence supporting the same. Pet. 30–32. Further, Petitioner sets forth a motivation for combining Shimada, Chaneliere, and Kimura. *Id.* at 32–36. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner's arguments. Ex. 1022 ¶¶ 111–124. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 4 and 15 are unpatentable as being obvious over Shimada, Chaneliere, and Kimura.

F. Asserted Obviousness Based on Shimada and Noble (Ground 4)

Petitioner asserts that claims 5, 6, and 11 of the '937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Shimada and Noble. Pet. 36–42.

Patent Owner argues that Noble does not remedy the deficiencies of Shimada identified with respect to Ground 1, and therefore Ground 4 should be denied for the same reasons as Ground 1. Prelim. Resp. 23.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that Shimada and Noble render claims 5, 6, and 11 obvious. Petitioner presents arguments that the limitations of dependent claims 5, 6, and 11 are present in Shimada and Noble, and presents evidence supporting the same. Pet. 36, 38–41. Further, Petitioner sets forth a motivation for combining Shimada and Noble. *Id.* at 37–38, 41–42. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner's arguments. Ex. 1022 ¶¶ 125–146. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 5, 6, and 11 are unpatentable as being obvious over Shimada and Noble.

G. Asserted Obviousness Based on Watanabe and Sivaramakrishnan (Ground 5)

Petitioner asserts that claims 1, 2, 7, 10, 13, and 16 of the '937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Watanabe and Sivaramakrishnan. Pet. 42–68. In asserting that claim 1 is unpatentable as obvious over Watanabe and Sivaramakrishnan, Petitioner points to Watanabe's Figures 2, 19, and 20 as well as portions of the specification, and Sivaramakrishnan's Figures 1A and 17A–17C as well as portions of the specification. *Id.* at 42–49, 55–57. Petitioner alleges that Watanabe and Sivaramakrishnan depict or describe:

1[pre] "A method for use in manufacturing a semiconductor device" (*id.* at 42–43) (citing Ex. 1006, Abstract, Figs. 2, 19, 20, ¶¶ 19, 20, 62);

1[a] "generating a plasma in each of at least one plasma source arranged outside a reaction chamber, the reaction chamber having therein at least two substrates to be simultaneously processed" (*id.* at 43–49) (citing Ex. 1006, Fig. 20, ¶¶ 3, 4, 10, 19, 20, 22, 23, 31, 32, 61, 62; Ex. 1011, Abstract, Fig. 1A, 8:22–36, 8:48–50, 8:52–53, 9:17–18, 9:21–23, 10:7–8, 25:8–10, 25:14–31, 26:7–13, 26:24–28);

1[b] "supplying active species included in the plasma into the reaction chamber through a supply port arranged at a side of the reaction chamber" (*id.* at 55) (citing Ex. 1006, Fig. 2; Ex. 1011, Figs. 1A, 17A–17C);

1[c] "flowing the active species from the supply port to an exhaust port arranged at a substantially opposite side to the supply port to perform a predetermined process on the substrates" (*id.* at 56) (citing Ex. 1006 ¶¶ 13, 16, 22, 23, 31, 32, Claims 8–14); and

1[d] "the active[] species flowing across the substrates in one direction substantially parallel to surfaces of the substrates" (*id.* at 56–57) (citing Ex. 1006, Fig. 2, ¶¶ 13, 16, 22, 23, 31, 32, Claims 8–14).

In asserting that claim 7 is unpatentable over Watanabe and Sivaramakrishnan, Petitioner specifically points to Watanabe's Figure 2 as well as portions of Watanabe's specification, and portions of Sivaramakrishnan's specification. *Id.* at 59–62. Petitioner alleges that Watanabe and Sivaramakrishnan depict or describe:

7[pre] "A method for use in manufacturing a semiconductor device" (*id.* at 59);

7[a] "(b1) generating a plasma in at least one plasma source arranged outside a reaction chamber, the reaction chamber having therein at least two substrates to be simultaneously processed" (*id.*);

7[b] "(b2) supplying active species included in the plasma into the reaction chamber in a direction substantially parallel to surfaces of the substrates to perform a predetermined process thereon" (*id.* at 59–60) (citing Ex. 1006, Fig. 2, ¶ 23); and

7[c] "(a) simultaneously forming a film on each of said at least two substrates by a thermal CVD method in the reaction chamber before performing the step (b1)" (*id.* at 60–62) (citing Ex. 1006, Fig. 2, ¶ 62; Ex. 1011, 9:5–6, 9:21–23, 26:10–11, 26:15, 26:25–28).

Petitioner further points to Watanabe's Figures 2 and 7 as well as portions of the specification, and portions of Sivaramakrishnan's specification, in asserting that claims 2, 10, 13, and 16 are obvious over Watanabe and Sivaramakrishnan. *Id.* at 57–59, 62–68.

Petitioner argues that there would have been a motivation to combine Sivaramakrishnan with Watanabe with a reasonable expectation of success. *Id.* at 49–54, 62. Specifically, Petitioner argues that one of ordinary skill in the art "would have been motivated to modify Watanabe using the teachings of Sivaramakrishnan to allow Watanabe's batch reactor to implement both CVD and remote-plasma treatment in the same chamber (as taught by Sivaramakrishnan)." *Id.* at 50. In particular, Petitioner argues "skilled artisans would have connected one or more of Sivaramakrishnan's microwave plasma systems 55 and gas mixing boxes 273 to Watanabe's gas supply ports 4a, 4b to create a reactor capable of CVD and remote-plasma treatment in the same reaction tube 2." *Id.* at 52.

Patent Owner argues that the combination of Watanabe and Sivaramakrishnan does not disclose the independent claim 1 limitation 1[b], "supplying active species included in the plasma into the reaction chamber through a supply port arranged at a side of the reaction chamber" or the similar limitations in independent claims 7 and 10. Prelim. Resp. 10–14. Specifically, Patent Owner argues that, because Watanabe's plasma is generated inside the reaction chamber, Watanabe "necessarily cannot '**supply**[] active species included in the plasma **into** the reaction chamber,'" as required by claims 1 and 7, or "'**supply**[] . . . active species generated by the plasma source **into** . . . the reaction chamber **through a supply port**,' as required by claim 10." *Id.* at 11. Patent Owner further argues that

Sivaramakrishnan "discloses introducing **only radicals into the chamber**, as it states that it is undesirable to introduce **ions** into the chamber" (*id.* at 13), where Patent Owner's construction of "active species" necessarily includes ions as well as radicals, as discussed *supra* § II.A.

Patent Owner also argues that one of ordinary skill in the art would not have combined Watanabe and Sivaramakrishnan. *Id.* at 14–23. Specifically, Patent Owner argues that Watanabe already supports both CVD and plasma treatments and, therefore, one would not have been motivated to combine Sivaramakrishnan with Watanabe to add a second plasma source. *Id.* at 15–17. Patent Owner also argues that Petitioner's proposal to combine two of Sivaramakrishnan's remote microwave plasma systems and two of Sivaramakrishnan's gas mixing boxes with Watanabe would result in the unnecessary duplication of Sivaramakrishnan's components. *Id.* at 17–23.

At this point in the proceeding, we are not persuaded by Patent Owner's position that ions would not be present in the reaction chamber of the combined reactor of Watanabe and Sivaramakrishnan. Prelim. Resp. 10–14. On the record developed thus far, both Patent Owner and Petitioner have agreed that ions are among those active species that are generated by a plasma.[10] *See* Pet. 8 ("It was understood that the active species in a plasma included ions and radicals"); Reply 2 ("The parties agree that the 'active species' formed when a plasma is generated <u>in a plasma source</u> may include

[10] We observe that these statements may ultimately conflict with the specification's teaching that "the type of generated active species depends on the electron temperature of the plasma." Ex. 1020, 6:64–7:3. Because "the electron temperature can be controlled," it is unresolved on this preliminary record whether it is possible to eliminate ions from those "active species generated by the plasma source" as recited in independent claims 1, 7, and 10. The parties may wish to address this issue in future briefing.

both ions and radicals"); Prelim. Resp. 5 ("[I]t is clear from the intrinsic record that supplying 'active species' included in the plasma into the reaction chamber means supplying 'an excited gas that includes at least ions and radicals' into the reaction chamber."); Sur-Reply 3 ("[T]he specification is clear that the active species includes both ions and radicals.").

Based on this preliminary record, we are not persuaded that Sivaramakrishnan's repeated reference to "radicals" in the processing chamber necessarily means that the chamber is devoid of ions. Here, we note Sivaramakrishnan's disclosure that "ion implantation causes damage to the semiconductor surface" because "ions bombarded at relatively high energy levels *have a tendency to* tunnel or channel through the semiconductor material and *cause damage such as point defects*." Ex. 1011, 2:49–52 (emphasis added). Such point defects, if created, "*may* lead to irregular and nonuniform junction depths." *Id.* at 2:52–53 (emphasis added). Sivaramakrishnan explains that it was "well known [that] conventional substrate processing systems using in situ plasma during processing experience physical *sputtering of ions which attack chamber surfaces, such as aluminum walls, resulting in metal contamination of the substrate,*" making "[u]se of in situ plasma . . . undesirable." *Id.* at 2:30–33 (emphasis added). Sivaramakrishnan therefore teaches that a "substrate processing system, which does not use in situ plasma, is needed." *Id.* at 2:33–34. Sivaramakrishnan then discusses a preferred embodiment where a remote plasma system is provided instead of an *in situ* plasma process in order "to *lower* metal contamination," and to "ensure effective and uniform dopant diffusion from the doped dielectric layer without causing *significant* surface damage to the silicon wafer." *Id.* at 5:35–49 (emphasis added). Thus, Sivaramakrishnan discusses how, in some instances, the negative effects of ions could be potentially minimized (i.e., not eliminated) by placing the plasma system remote from the reaction chamber. Other than recite the numerous instances that Sivaramakrishnan refers to "radicals" (Prelim. Resp. 11–13), Patent Owner points to no evidence within Sivaramakrishnan that sufficiently establishes that ions are eliminated from Sivaramakrishnan's reaction chamber.

We also do not agree with Patent Owner that one of ordinary skill in the art would not have combined Watanabe and Sivaramakrishnan. *Id.* at 14–23. Petitioner asserts that one of ordinary skill in the art "would have been motivated to implement Sivaramakrishnan's remote microwave plasma system 55 with Watanabe's CVD reactor for improved wafer quality, while retaining the benefits of equipment cost savings, improved wafer quality, and reduced cycle times." Pet. 50. Upon review of the record, we find Petitioner's proffered rationale to combine the teachings of Watanabe and Sivaramakrishnan sufficient to establish a reasonable likelihood that at least one of the challenged claims 1, 2, 7, 10, 13, and 16 is unpatentable. Petitioner presents arguments that the limitations of independent claims 1, 7, and 10, and dependent claims 2, 10, 13, and 16, are present in Watanabe and Sivaramakrishnan, and presents evidence supporting the same. *Id.* at 42–49, 55–57. Further, Petitioner sets forth a motivation for combining Watanabe and Sivaramakrishnan. *Id.* at 49–54, 62. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner's arguments. Ex. 1022 ¶¶ 147–246. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 1, 2, 7, 10, 13, and 16 are unpatentable as being obvious over Watanabe and Sivaramakrishnan.

H. Asserted Obviousness Based on Watanabe, Sivaramakrishnan, and Hautala (Ground 6)

Petitioner asserts that claims 8 and 17 of the ’937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Watanabe, Sivaramakrishnan, and Hautala. Pet. 68–72.

Patent Owner argues that Hautala does not remedy the deficiencies of Watanabe and Sivaramakrishnan identified with respect to Ground 5, and therefore Ground 6 should be denied for the same reasons as Ground 5. Prelim. Resp. 23–24.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that Watanabe, Sivaramakrishnan, and Hautala render claims 8 and 17 obvious. Petitioner presents arguments that the limitations of dependent claims 8 and 17 are present in Watanabe, Sivaramakrishnan, and Hautala, and presents evidence supporting the same. Pet. 68–69. Further, Petitioner sets forth a motivation for combining Watanabe, Sivaramakrishnan, and Hautala. *Id.* at 70–72. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner’s arguments. Ex. 1022 ¶¶ 247–258. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 8 and 17 are unpatentable as being obvious over Watanabe, Sivaramakrishnan, and Hautala.

I. Asserted Obviousness Based on Watanabe, Sivaramakrishnan, and Chaneliere (Ground 7)

Petitioner asserts that claims 9 and 18 of the ’937 patent are unpatentable as obvious under 35 U.S.C. § 103 over Watanabe, Sivaramakrishnan, and Chaneliere. Pet. 72–74.

Patent Owner argues that Chaneliere does not remedy the deficiencies of Watanabe and Sivaramakrishnan identified with respect to Ground 5, and therefore Ground 7 should be denied for the same reasons as Ground 5. Prelim. Resp. 23–24.

Based on this preliminary record, we are persuaded Petitioner has demonstrated a reasonable likelihood of prevailing on its contentions that Watanabe, Sivaramakrishnan, and Chaneliere render claims 9 and 18 obvious. Petitioner presents arguments that the limitations of dependent claims 9 and 18 are present in Watanabe, Sivaramakrishnan, and Chaneliere, and presents evidence supporting the same. Pet. 72–73. Further, Petitioner sets forth a motivation for combining Watanabe, Sivaramakrishnan, and Chaneliere. *Id.* at 73–74. Petitioner relies on the testimony of Dr. Glew to support its contentions, and at this stage in the proceeding, we credit his testimony in support of Petitioner’s arguments. Ex. 1022 ¶¶ 259–269. For these reasons, based on the record currently before us, we are satisfied Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 9 and 18 are unpatentable as being obvious over Watanabe, Sivaramakrishnan, and Chaneliere.

III. CONCLUSION

For the foregoing reasons, we are persuaded that the Petition establishes a reasonable likelihood that Petitioner would prevail on its challenge to at least one challenged claim of the ’937 patent.

Although we exercise our discretion and institute review, we remind the parties that we have not yet made a final determination as to the patentability of any of the challenged claims.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314, an *inter partes* review is hereby instituted as to all challenged claims 1–18 of the ’937 patent with respect to all grounds set forth in the Petition; and

FURTHER ORDERED that pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial commencing on the entry date of this decision.

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